CORE OUTCOMES FOR OPEN LOWER LIMB FRACTURE STUDY

(CO-OLLF)

A dissertation submitted to the University of Oxford in partial fulfilment for the Degree of Doctor of Philosophy

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Abstract

Open Lower Limb Fracture (OLLF) is a life-altering injury affecting 11.5 per 100,000 adults each year. OLLF causes significant morbidity, mortality and resource demand on the UK trauma infrastructure and deeply affects patient's state of physical, mental and social well-being. Treatment is complex and multifaceted, such that an optimal treatment pathway for these devastating injuries remains unclear. Inconsistency in outcome-reporting and poor-quality studies hamper attempts to evaluate new interventions to improve function, recovery experience, and investigation into the effects of regional variation of treatment on recovery.

In order to improve research in this field, CO-OLLF recommends a Core Outcome Set (COS), where patients and key stakeholders established consensus over what outcomes are most important, and how to measure them. A COS will reduce outcome heterogeneity, outcome-reporting bias and promote better quality research meaningful to patients.

Candidate core outcomes were identified by; 1. A systematic review on outcome-reporting in the published literature on OLLF (82 outcomes), and 2. A secondary Thematic Analysis of 25 in-depth patient interview transcripts exploring the lived experience of recovery from OLLF (88 outcomes). Outcomes were sorted into 121 themes that were categorised to create an Inventory of Outcomes for OLLF. Outcomes were sequentially refined and reduced in number using a healthcare professional Structured Discussion Group (SDG) (121 to 77 outcomes), a patient SDG (77 to 71 outcomes) and a review by the Study Management Group (71 to 68 outcomes). A multi-stakeholder, two-round Delphi survey resulted in eleven outcomes reaching consensus for inclusion, following which, stakeholders were invited to a consensus meeting where a modified Nominal Group Technique was used; this found consensus for four core outcomes: 1. 'Walking, gait and mobility'; 2. 'Being able to return to life roles'; 3. 'Pain or discomfort'; and 4. 'Quality of life'.

A further systematic review was undertaken to identify which outcome instruments may best measure the COS. Eleven candidate instruments were identified demonstrating good face validity for measuring core outcomes. Following quality assessment, they were presented to a group of patients, healthcare professionals and researchers with experience in outcome measurement at a second consensus meeting.

Consensus was found for the EuroQol 5-Dimensions 5-levels (EQ-5D-5L) and the Lower Extremity Functional scale for use in future trials and routine clinical assessment to measure: 'Quality of life' and 'Walking, gait and mobility', respectively. Consensus was not met for the remaining two core outcomes. However, the EQ-5D-5L also demonstrates good face validity for measuring 'Being able to return to life roles' and 'Pain or discomfort'. Therefore, it could be used pragmatically to measure these two outcomes whilst accepting limitations in its sensitivity. This study demonstrates that 'Pain or discomfort' is a fundamentally important outcome to measure and that there is a dearth of adequate OMIs capable of measuring its variability and complexity following OLLF. As such future PROM development work in lower limb trauma should consider creating region-specific measure for pain and discomfort.

Failure of this study to reach a consensus for all four core outcomes reflects a relative lack of adequately validated instruments for use in orthopaedic trauma. Next steps of the CO-OLLF study will include a multi-site feasibility trial collecting the OLLF COS, with a view toward implementation within the Trauma, Audit and Research Network.

Acknowledgements

I want to express my deep gratitude to my supervision team Professors Xavier Griffin, Matt Costa, Ray Fitzpatrick and Dr Elizabeth Tutton for making this project a possibility and for their support and high levels of patience. Xavier, thank you for being my lead supervisor, for providing guidance and enforcement of a deadline when I needed it. Matt, thank you for creating such a fantastic opportunity for me to come to, and experience being part of the University of Oxford. Elizabeth, you have been brilliant in your support and guidance throughout this project. Your belief that I could get to this point helped drive me to submission. Ray, thank you for your wisdom in casting light when the next steps appeared unclear.

This project would not have been possible if it were not for the involvement of the patients recruited along the way, each of whom so generously gave up their time to share their views and experiences. I would particularly like to thank Elizabeth Baird, who has acted as the study Patient and Public Involvement advocate, whilst also providing linguistic support when called upon. Patient recruitment would not have been possible if it were not for the NIHR CRN's support, my site PIs and their extended research nursing teams.

I would like to thank Professor Afsie Sabokbar for her encouragement and assistance when life took challenging turns.

I would also like to acknowledge the University of Oxford Clarendon Scholarship Fund and AO research UK for their financial support.

Thank you, Judy, for your diligent proofreading and attention to detail.

My final acknowledgement is to my family. Thank you, Dad, for looking after me during my write up and always being there when called upon. Mum, I dedicate this thesis to you, your bravery in the last year has been an inspiration.

Lastly, I want to thank my wife, Kiri, from the bottom of my heart. Your love and unwaveringly loyalty in supporting me through this degree and in the bleak moments over the last four and a half years has been phenomenal and indispensable.

Declaration

The work submitted in this thesis is wholly my own except where otherwise stated. A summary of contributions from colleagues is outlined below:

Chapter 2: The search strategy was written with support from Mr Neal Thurley, Information Specialist based at the Cairns Library, University of Oxford. Title and abstract screening was undertaken in duplicate to the DPhil candidate by Dr Harry Claireaux (HC) and Mr Christian Aquilina (CA), in addition, they also conducted a full-text review and data extraction on a random sample of 15% and 10% of articles shortlisted, respectively.

Chapter 3: Dr Elizabeth Tutton (ET) conducted a Thematic Analysis on five interview transcripts in duplicate to the candidate.

A number of patient quotes included in Chapter 3 have been published in separate work using the same data set by Rees *et al.* 2019 (1).

Chapter 4: ET co-chaired two Structured Discussion Groups.

Chapter 5: Professor Mathew Costa (MC) chaired the Core Outcome Set consensus meeting, and ET and Ms Julie Wright (JW) facilitated group sessions in addition to (MC).

Chapter 6: HC undertook title and abstract screening, full-text review and data extraction and assessment of measurement instruments in duplicate to the DPhil candidate. MC chaired the Core Outcome Measurement Instrument Set consensus meeting.

Research training undertaken by the DPhil candidate as part of this project is detailed in Appendix 1.

Prizes, publications and presentations arising from this work are detailed in Appendix 2.

Members of the Study Management Group and their backgrounds are detailed in Appendix 3.

The role of Patient and Public Involvement used throughout this project is detailed in Appendix 4.

Ethical approval and sources of funding for this project are detailed in Appendix 6 and Appendix 7, respectively.

Abbreviations used in this thesis

AA	Mr Alexander Aquilina (DPhil candidate)
BAPRAS	British Association of Plastic, Reconstructive and Aesthetic Surgeons
BOA	British Orthopaedic Association
BOAST	British Orthopaedic Association Standards for Trauma and Orthopaedics
CA	Mr Christian Aquilina
CDC	Centers for Disease Control and Prevention
COMET	Core Outcomes Measures in Effectiveness Trials Initiative
COMIS	Core Outcome Measurement Instrument Set
CONSORT	Consolidated Standards of Reporting Trials
COS	Core Outcome Set
COS-STAD	Core Outcome Set-STAndards for Development
COSMIN	COnsensus-based Standards for the selection of health Measurement INstruments
CTT	Classical Test Theory
EB	Ms Liz Baird (PPI representative/lead)
EQUATOR	Enhancing the QUAlity and Transparency of health Research
ET	Dr Elizabeth Tutton (DPhil Supervisor)
FAAM	Foot and Ankle Ability Measure
FDA	United States Food and Drug Administration
GA	Gustilo and Anderson
GOSE	Extend Glasgow Outcome Scale

GRADE	Grading of Recommendations Assessment, Development and Evaluation
HC	Dr Harry Claireaux (Collaborator)
HOME	Harmonising Outcome Measures for Eczema
HR-PRO	Health Related-Patient-reported Outcome
HTA	Health Technology Assessment
IMMPACT	Methods, Measurement, and Pain Assessment in Clinical Trials
IRT	Item Response Theory
JLA	James Lind Alliance
JW	Ms Julie Wright (Consultant Nurse)
LEFS	Lower Extremity Functional Scale
MC	Prof Matthew Costa (DPhil Supervisor)
MeSH	Medical Subject Headings
MTC	Major Trauma Centre
NG37	National Institute for Health and Clinical Excellence guideline 37
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NIHR	National Institute for Health Research
NOC	Nursing Outcome Classification
NPWT	Negative Pressure Wound Therapy
OLLF	Open lower limb fracture(s)
OMERACT	Outcome Measures in Rheumatology
ORB	Outcome-Reporting Bias
ORBIT	Outcome-Reporting Bias in Trials

OTS	Orthopaedic Trauma Society
PCORI	Patient-Centered Outcomes Research Institute
PPI	Promote Patient and Public Involvement
PPM	Physical Performance Measure
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QALY	Quality Adjusted Life Year
QUOROM	QUality Of Reporting Of Meta-analyses
RA	Rheumatoid Arthritis
RCT	Randomised Controlled Trial
REC	Research Ethics Committee
REWARD	Reduce Research Waste and Reward Diligence
RF	Prof Ray Fitzpatrick (DPhil supervisor)
RTC	Road Traffic Collision
RUST	Radiographic Union Score for Tibial fractures
SDG	Structured Discussion Group
SMG	Study Management Group
SPIRIT	Standard Protocol Items: Recommendations for Interventional Trials
SSI	Surgical Site Infection
TARN	Trauma Audit and Research Network
UK	United Kingdom
USA	United States of America
USD	United States Dollars

WaLLTR	Wales Lower Limb Trauma Recovery scale
WHIST	Wound Healing in Surgical Trauma
WHO	World Health Organisation
WOLLF	Wound management of Open Lower Limb Fractures Trial
WS	Workstream
XG	Prof Xavier Griffin (DPhil Supervisor)

Glossary of Important terms

Outcome

Refers to 'what' is being measured. It is also referred to as a Construct, Domain or Concept. In a clinical trial, it refers to what is being measured or reported by participants which is used to examine the effect of the intervention (2).

Outcome Measurement Instrument (OMI)

Refers to 'how' the outcome is being measured. It is a tool to measure the quality or quantity of an outcome. The tool can be a definition, a single question, a questionnaire, a score obtained through physical examination, a laboratory measurement, a score obtained through observation of an image, etc. (2).

Core Outcome Set (COS)

An agreed standardised grouping of outcomes representing the minimum that should be measured and reported in all clinical trials, audits of practice or other forms of research for a specific condition. A COS may be disease or population specific, covering a subset of or all interventions, but is not trial specific. This means that core outcomes should be measured in all trials conducted in that disease/population, but they do not necessarily have to include the primary outcome of the trial (2).

Core Outcome Measurement Instrument Set (COMIS)

A minimum set of OMIs used to measure core outcomes identified in a COS. This is also referred to as a portfolio of measurement instruments (2,3).

Open Lower Limb Fracture (OLLF)

A fracture in a lower limb bone resulting in exposure of the bone to the outside world.

Long Bones

Long bones are long and narrow. They consist of a long diaphysis with widenings at each epiphysis. These include the femur, tibia, fibula, humerus, and the radius and ulna.

Chapter 1. Introduction, aims and objectives

1.1 Chapter summary

Trauma is a leading cause of death and disability worldwide (4) and is the most common cause of death in people under 40 years of age in England (5). The approximate UK annual incidence of open fracture is 11.5 per 100,000 adults.

Open Lower Limb Fractures (OLLF) are a significant cause of morbidity and mortality, and have a profound effect on patients' lives. Treatment is complex and multifaceted, such that an optimal treatment pathway for these devastating injuries remains unclear. Treatment pathways often cross many different medical specialities, including Trauma and Orthopaedics, Plastics, Vascular and other surgical specialities when a patient sustains other associated traumatic injuries such as Neurosurgery, General Surgery and Cardiothoracic Surgery, as well as General Practice, Care of the Elderly and Psychiatry/Phycology in the non-acute stages of recovery.

Currently, clinical trials evaluating new technologies to improve function and survival following OLLF fail to use standardised outcomes when measuring the effectiveness of interventions. This increases the risk of outcome-reporting bias and makes it difficult to compare results between studies.

These problems can be addressed by developing a Core Outcome Set (COS) addressing 'what' outcomes should be measured in recovery from OLLF. A COS will improve research design and efficiency, and, if developed in partnership with patients will ensure core outcomes are meaningful to both patients and healthcare professionals.

Following COS development, a corresponding set of core Outcome Measurement Instruments (OMIs) will be required: a Core Outcome Measurement Instrument Set (COMIS). A COMIS addresses 'how' core outcomes should be measured and forms a concise tool kit of OMIs that are feasible to measure in the OLLF patient population. A COMIS should include patient-reported outcome measures (PROMs) which will allow future research studies to better, more consistently evaluate the patient experience of recovery and ultimately lead to improving patient care through research and audit.

This thesis introduction presents COSs in the context of measurement in medicine and discusses how COS development may address recognised weaknesses in the established evidence-based research model; and in particular, trauma research. The severity of sustaining an open fracture is illustrated with a brief historical account of their treatment leading to modern-day best practice. The Core Outcome Measures in Effectiveness Trials (COMET) initiative Taxonomy of Outcomes is introduced, which forms a key component to the organisational structure of outcomes presented throughout this thesis. A rationale is demonstrated for why a COS for OLLF would be beneficial, the scope of the project is defined, and the project aims, and objectives are stated.

1.2 Core outcome sets and why they are important

1.2.1 Measurement in medicine

Measurement is essential to the clinical practice and management of medicine and is central to health research. Measuring health underlies the basis of diagnosis, prognosis and evaluation of the results of clinical interventions (6). In 1871,

Professor John Young described the aim of medical practice as *'the application of common sense to treat disease and the preservation and improvement of health'*, the principles of which still apply to this day (7). The World Health Organisation (WHO) defines health as:

'A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.' (8)

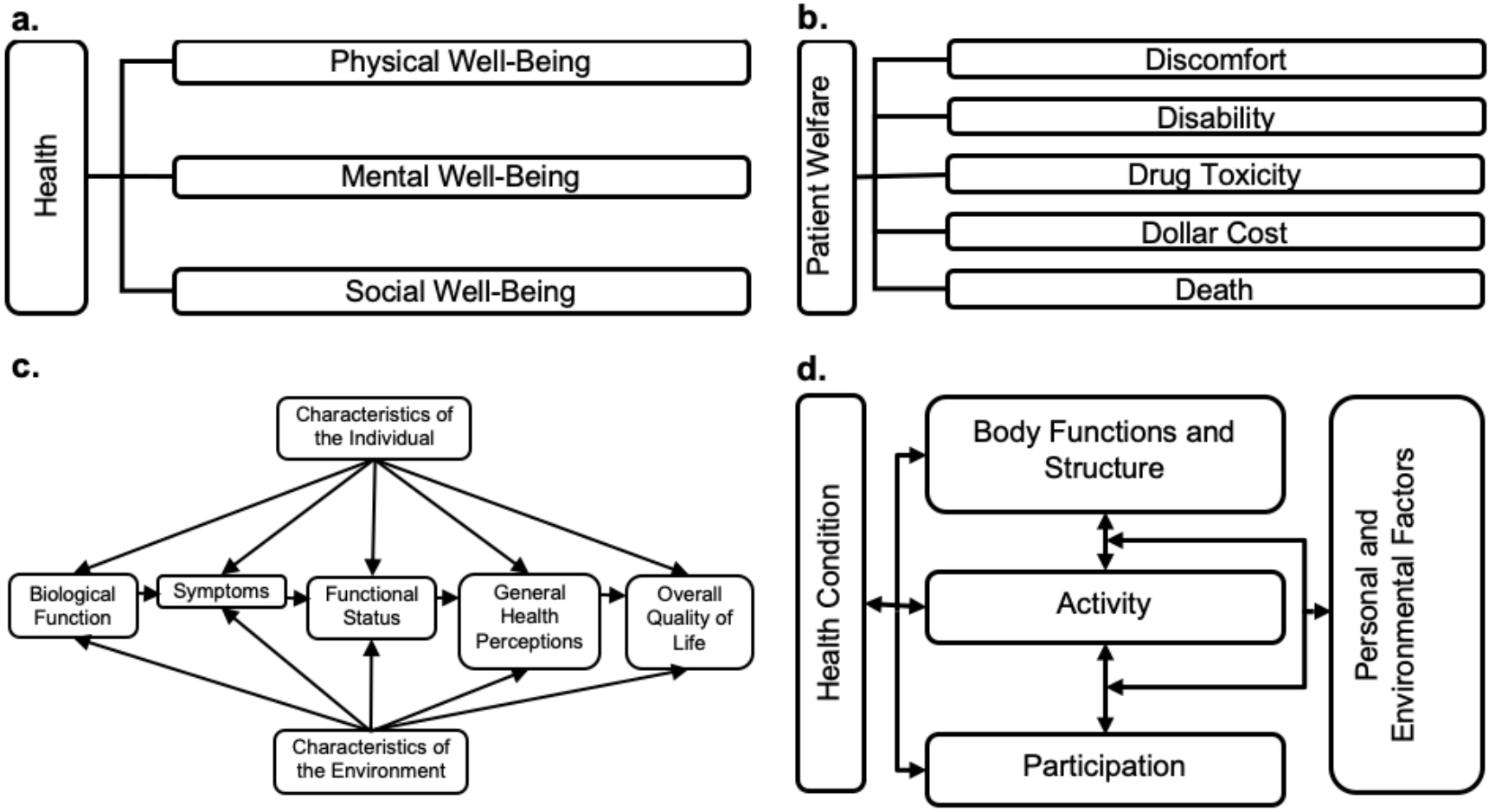
To quantify, if a medical practice is preserving or improving a patient's health in a reliable and reproducible manner, measurement of health is essential. Measurement also informs healthcare payment and provision; it allows economic analyses (9) and epidemiological comparisons (9,10). The field of medicine is extensive and diverse, and so are the methods used to measure its effect. Measurements vary from questions asked when taking a medical history, performing a physical examination, conducting laboratory and physiological tests, and assessing anatomical imaging to self-reported questionnaires, among others. (6).

Not only is health an abstract and challenging concept to define; attracting a variety of definitions (11), it is challenging to measure. To provide structure, and to conceptualise the different components of health, disease and outcome, a variety of conceptual frameworks have been devised to help define health and facilitate its measurement. Table 1.1 and Figure 1.1 detail and conceptualise several frameworks of health that are commonly used when attempting to measure health (12). Measurement of health is challenging; since multiple health frameworks exist, no one framework is perfect, and they must each be assessed on their relative merits.

Six commonly used frameworks of Health	
Framework	**Description**
The WHO definition of health (8).	The WHO definition of health can be considered a conceptual framework of health. It contains the three overarching concepts; physical well-being, mental well-being and social well-being (see Figure 1.1). The WHO definition of health is often used as a broad foundation from which to build more complex conceptual models of health (13).
The 5 Dimensions (5Ds) (14)	The 5Ds refers to death, discomfort, disability, drug or therapeutic toxicity and dollar cost (see Figure 1.1). Fries *et al*. developed the 5Ds framework in 1980 (14) to measure health in rheumatic diseases. Each overarching concept is claimed to relate directly to patient welfare. Fries' aim in developing the 5Ds was to provide a patient oriented-system that would provide multiple outcome data on key aspects of health (13).
The Wilson and Cleary Model of Health-Related Quality of Life (15)	In 1995 Wilson and Cleary proposed a taxonomy or classification system modelling health-related quality of life. They identified that other models of health fail to recognise how outcomes may interrelate. Outcomes are divided into five related levels, biological and physical variables, symptom status, functioning status, general health perceptions and overall quality of life. Wilson and Cleary believe that there are specific causal relationships between their five levels of outcomes that link traditional clinical outcomes to health-related quality of life. The model was revised in 2005 to enhance characterisation of the relationships between the five outcome levels (16) (see Figure 1.1).
The WHO International Classification of Functioning, Disability and Health (ICF) (17)	The ICF was endorsed by the WHO member states in 2001. It offers a framework for classifying health and health-related outcomes for the measurement of health at individual and population levels. The overarching themes include functioning and disability, body structure, body function, activities and participation. It is based on the bio-psycho-social model to assess and compare functional outcomes. The ICF contains over 1,400 categories which have been broken down into core sets for clinical areas where the most relevant ICF outcomes for that area have been identified. The ICF is internationally recognised and widely used (18) (see Figure 1.1).

Outcome Measures in Rheumatology (OMERACT) Filter 2.0 (3)	Following a review of existing health frameworks in 2014, the OMERACT group developed a bespoke framework designed to facilitate Core Outcome Set development in rheumatology (13). The OMERACT Filter 2.0 is a framework for the measurement of rheumatological health conditions in the setting of interventions over three core areas, death, life impact and pathophysiologic manifestations, with a recommendation to measure resource use (see Figure 1.1) (3).
Patient-reported Outcomes Measurement Information System (PROMIS) (19)	The PROMIS framework was developed to measure health in adults and children by expanding on the three overarching concepts in the WHO definition of health (see Figure 1.1). Concepts are arranged into a hierarchy where self-reported health is at the top (13). The PROMIS initiative was started by a cooperative of researchers in 2004 with funding from the USA Institutes of Health aiming to transform the way patient-reported outcomes are chosen and used in research and clinical practice (13,20). The PROMIS Initiative now offers over 300 measures of physical, mental and social health, they are free to access and can be delivered in a variety of ways including short forms, computer adapted tests, and profiles (a fixed collection of short forms covering multiple areas of health) (21).

Table 1.1. Six commonly used Frameworks of Health.


a.
Health
Physical Well-Being
Mental Well-Being
Social Well-Being
b.
Patient Welfare
Discomfort
Disability
Drug Toxicity
Dollar Cost
Death
c.
Characteristics of the Individual
Biological Function
Symptoms
Functional Status
General Health Perceptions
Overall Quality of Life
Characteristics of the Environment
d.
Health Condition
Body Functions and Structure
Activity
Participation
Personal and Environmental Factors

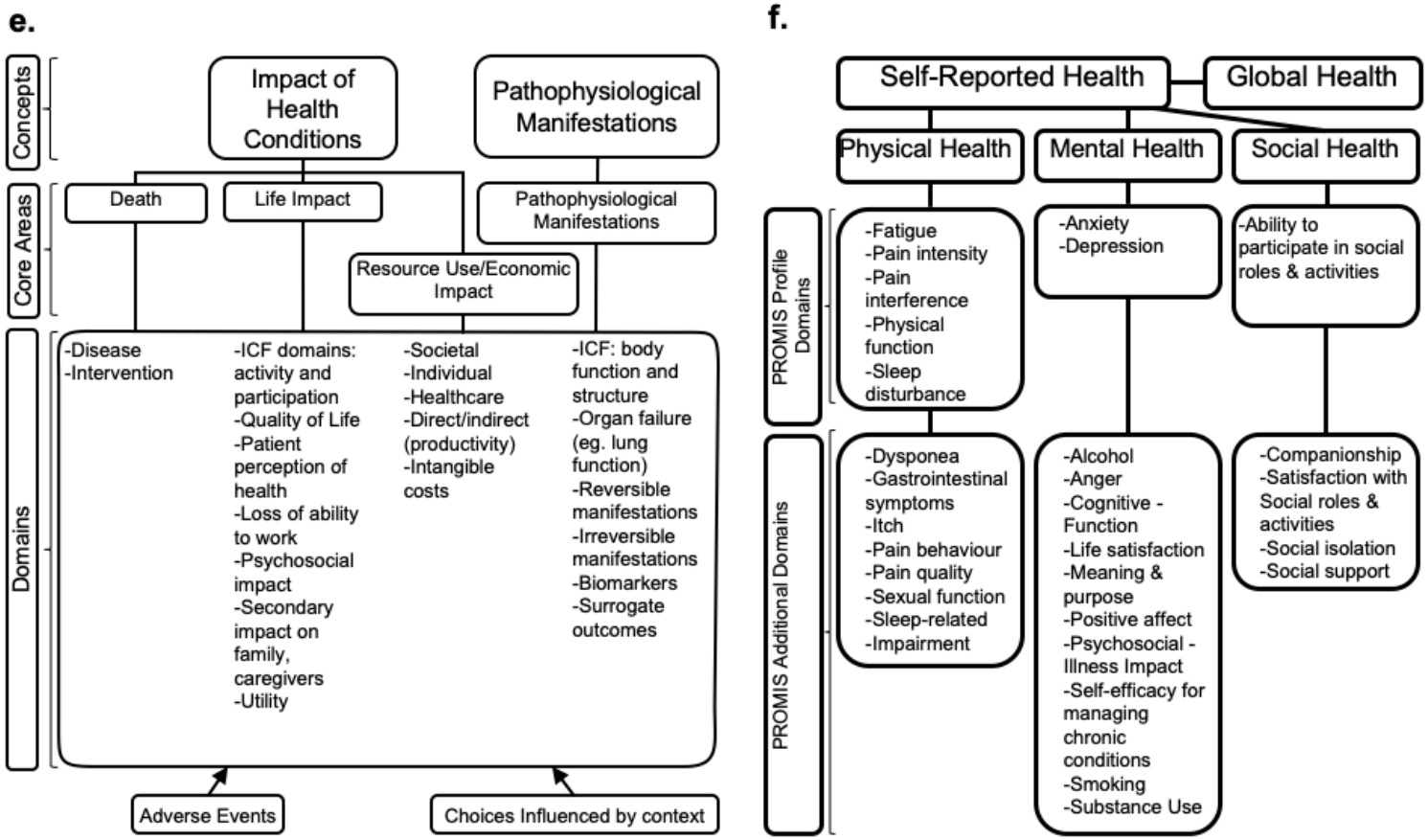


Figure 1.1. Six commonly applied conceptual frameworks of health. a. The WHO definition of health represented as a conceptual framework (8,13). b. The 5 Ds conceptual framework (13,14). c. The Wilson and Cleary Model of Health-Related Quality of Life (15,16). d. The WHO International Classification of Functioning, Disability and Health (ICF) (13,17). e. OMERACT conceptual of core areas of outcome measurement (3). f. PROMIS conceptual framework for patient-reported outcome measurement information system for adults (19,22). Figures adapted from source references.

1.2.2 Outcomes and Outcome Measurement Instruments (OMIs)

When attempting to measure health, it is essential to ask two questions (23):

***What to measure*? & *How to measure it*?**

An outcome refers to **'what'** is being measured and is stable over time. For example, blood glucose concentration has long been recognised as an essential outcome to measure in patients with diabetes, but how it is measured is continuously evolving (23). An outcome forms a global definition and demarcation of the subject of measurement (6). Outcomes can be considered under headings such as a construct, domain or concept; however, for the purpose of this thesis, it will only be referred to as an outcome. In a clinical trial, it refers to what is being measured, to examine the effect of the intervention on participants (2). An outcome can be specific (e.g. testing the blood sugar levels of a diabetic) or broad when demonstrating the effect of an intervention on an aspect of health (e.g. pain or health-related quality of life) (24).

An Outcome Measurement Instrument (OMI) refers to '**how**' the outcome is being measured; it is the method of measurement. An OMI is a tool to measure the quality or quantity of an outcome. The tool can be a definition, a single question, a questionnaire, a score obtained through physical examination, a laboratory or physiological measurement, or a grading obtained through observation of an image, etc. (2). There may be multiple OMIs suitable to measure a single outcome, and the best OMI to use may change with evolving clinimetric research and technology (23).

1.2.3 Clinical Trials

Evidenced-based medical practice demands the conscientious, explicit, and judicious use of current and longstanding best evidence in making decisions about the care of individual patients to provide optimum medical management (25). The highest form of evidence for measuring an intervention's clinical effectiveness is the results of well-conducted Randomised Controlled Trials (RCT), systematic reviews and meta-analyses of RCTs (26).

RCTs are often recognised as the gold-standard method for evaluating the treatment effect of interventions (27). However, they are only as methodologically robust as the outcomes they measure. The selection of appropriate outcomes and OMIs are central to RCT design. RCTs and meta-analyses thereof can only evaluate the intervention's effect on a set of pre-determined outcomes. Therefore, the outcomes chosen should be meaningful to the patient population whose health the study aims to improve. The OMIs selected to measure outcomes of interest should also demonstrate good measurement properties, for example, good validity, reliability, and responsiveness in the target population. An increasing move towards the democratisation of medical research in the UK supports shared decision making with patients when designing trials, choosing outcomes and deciding how they should be measured. As such, the choice of outcome measure when assessing a healthcare intervention or performance should be representative of patient concerns, experience or expectations.

'Clinical trials are only as credible as their endpoints' Tugwell *et al.* 1993 (28)

1.2.4 Problems with outcomes in research

It is increasingly acknowledged that the selection of outcomes in clinical trials and audit has failed to be representative of key areas of recovery from the patient perspective (28,29). Most importantly, outcomes need to be relevant to patients in addition to clinicians, researchers, commissioners and policymakers. Frequently, the choice of outcome is guided by clinician familiarity resulting in a surgeon-centred measurement for the researcher's ease. Often, this approach yielded well-measured and reported outcomes, although seldom were these sensitive to the patient's experience or the broader impact of care interventions on the healthcare sector.

To meta-analyse studies reporting on interventions in the same field of disease, outcomes and OMIs need to be consistently reported. Inconsistent outcomes and OMIs leads to data heterogeneity, hampering meta-analyses. Failure to include all relevant studies in a meta-analyses leads to research waste and may inadvertently conceal the true treatment effect of an intervention. Disparities in outcome-reporting were highlighted by Tovey *et al*. 2010, reporting that the single most cited and top five most accessed Cochrane reviews in 2009 all stated issues with data heterogeneity (29,30).

Historically there has been widespread publication and outcome-reporting bias. Outcome-reporting bias is an under-reported problem, and it has been demonstrated to affect the conclusions of a significant number of Cochrane reviews (31,32). This bias increases the risk of exposing readers to exaggerated treatment effects due to the likely failure to appropriately power studies. A study's primary outcome must be selected before recruitment starts to inform calculations

on an appropriate sample size (33). Where primary outcomes have not been predefined, and power calculation not undertaken, studies are exposed to type two error; this has historically been an issue in orthopaedic trauma trials (34). Lochner *et al*. (2001) conducted a systematic review that identified over 90% of 117 included studies conducted in orthopaedic trauma were exposed to type II error (34).

In addition to clinical trial registries, several other initiatives have developed guidelines, recommendations and grading criteria to reduce risks of bias and aid transparent conduct, reporting and evaluation of evidence from clinical trials, systematic reviews and meta-analyses, including:

1. The Enhancing the QUAlity and Transparency of health Research (EQUATOR) network (35).
2. The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) Working Group (36-38).
3. The Cochrane handbook from the Cochrane Collaboration (39).

   See Appendix 12 for summaries of the work undertaken by the above key organisations promoting good research practices.

Clinical trial registries and reporting guidance have helped to improve research rigour and reduce the risk of bias in clinical trials. However, inconsistent outcome selection, data heterogeneity and publication bias continue to contribute to research waste (40).

1.2.5 Research waste

Broadly, there are four leading causes of research waste; the conduct of research that is unnecessary (repetition of work) or not important to end-users (patients, clinicians or other stakeholders), including failing to collect important outcomes for patients, poor study design and methodology, the incomplete publication of all research within a field of healthcare and prevalence of bias (commonly publication and outcome-reporting bias as discussed above) (41,42). See Figure 1.2 for a schematic diagram illustrating the stages of research waste production.

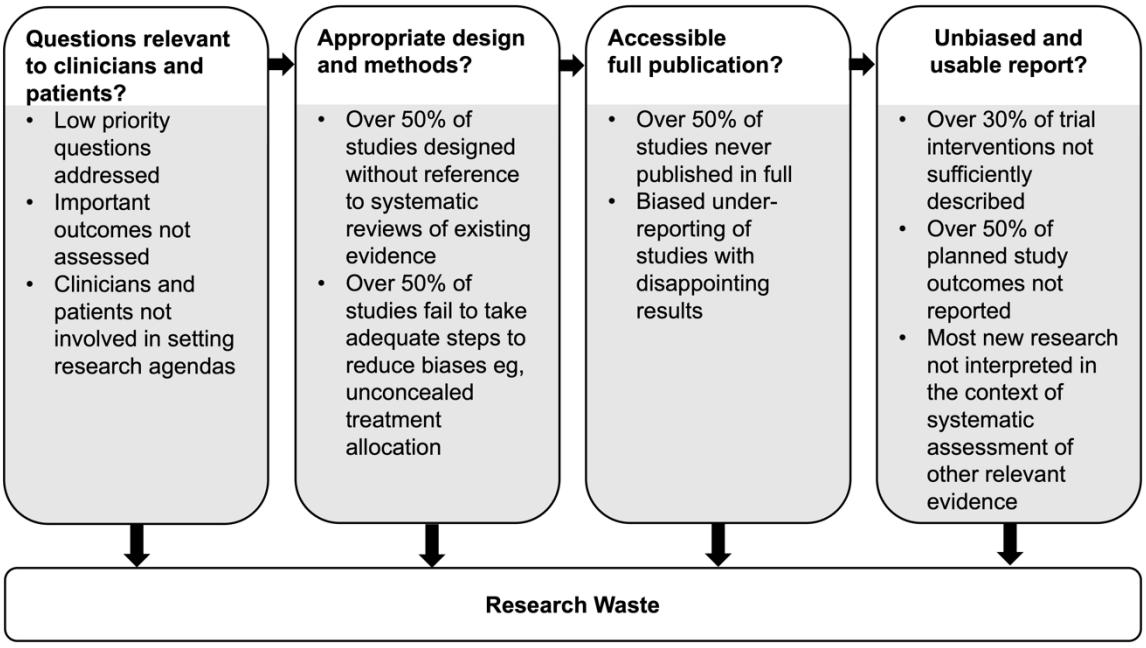


Figure 1.2. Stages of Waste in the production and reporting of research. Figure adapted from Chalmers and Glasziou 2009 (41).

In 1994, Professor Doug Altman, Chief Statistical advisor to the British Medical Journal, gave the research community a wakeup call in an editorial entitled *'The scandal of poor medical research'*, where he claimed that *'huge sums of money'* were being wasted (43). To follow up on Altman's claim, it is estimated that 85% of more than 200 billion United States Dollars (USD) spent on medical research

each year was avoidably wasted (41,42,44). Research waste and the problems associated with it have been recognised by the global healthcare research community for many years, and steps have been taken to address avoidable waste. Work undertaken by the Core Outcomes in Effectiveness Trials (COMET) initiative promoting the agreement, dissemination and adoption of core outcome measures to reduce inconsistency of outcome-reporting when assessing the effects of interventions in clinical trials was recognised by the Reduce Research Waste and Reward Diligence (REWARD) Alliance as a step towards the reduction of research waste (42,45).

1.2.6 Core Outcome Sets

To address many of the problems discussed above (data heterogeneity, publication bias, outcome-reporting bias and research waste), the concept of defining the most important outcomes to measure in clinical trials within a specified area of disease/health has emerged. This concept has been coined the 'Core Outcome Set'.

A Core Outcome Set (COS) is an agreed standardised set of outcomes reflecting patient and stakeholder interests that should be reported, as a minimum, in a specific disease or trial population. These outcomes represent **'*what*'** should be measured (2).

To further define ***'how'*** these outcomes are measured, a Core Outcome Measurement Instrument Set (COMIS) is required. This is an agreed minimum set of OMIs that should be used to measure core outcomes identified in a COS. This is also referred to as a portfolio of measurement instruments (2,3). COMIS development should not be static or exclude the use of other disease or study-

specific measurement instruments trial designers may wish to include or use as the primary outcome (46).

1.2.6.1.1 A brief history of COS development

The WHO first proposed outcome standardisation for clinical trials in 1981 after a series of consensus meetings between 1977 and 1979 (47). An agreement was established that clinical trials in oncology should report as a minimum; patient data, treatment information, the response of tumour and metastases, acute and chronic adverse effects of treatment and duration of response to treatment, including recurrence (47). This was a pioneering first step toward the use of consensus methods among stakeholders to increase outcome standardisation.

The next most notable development in the field of unifying outcomes came with the formation of the Outcomes Measures in Rheumatology (OMERACT) Collaboration. Researchers in the field of rheumatology have been aware of the limitations caused by the reporting of heterogeneous outcomes for over 30 years (48-52), which culminated in the first WHO endorsed OMERACT meeting in 1992 (53). Consensus was found for a COS for Rheumatoid Arthritis (RA), and after a later meeting of the American College of Rheumatologists, a COMIS was agreed (52).

OMERACT was the first outcomes collaboration to have utilised meaningful patient involvement in the identification of important outcomes and consensus processes since 2002 (54). OMERACT has been a key mover in the field of COS methodological advancement, particularly around the involvement of patients, international consensus methods, conceptual frameworks for COS development, dissemination and implementation of COSs (55,56).

Since published work on outcome standardisation in 1981, the number of core outcome sets have grown along with their wider usage amongst different medical specialities (see Figure 1.3) (57). Following OMERACT's first COS publication in 1994 (53) other COS development groups have included the Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT) initiative (58), the Core Outcomes in Women's and Newborn Health (CROWN) initiative (59) and the Harmonising Outcome Measures for Eczema (HOME) Initiative (60). These initiatives have proactively developed and implemented disease-specific COSs through patient involvement and consensus to provide excellent examples of best practice. The IMMPACT, CROWN and HOME initiatives debut their first COSs for clinical trials in chronic pain, eczema and maternity care in 2003, 2007 and 2011, respectively (61-63).

With increasing recognition of the beneficial impact of COS implementation to improve health research, a growing number of COS studies have been developed since 1981 (see Figure 1.3a). The importance of COS studies was recognised early in the field of Trauma and Orthopaedic Surgery research, having the fifth-highest number of published COS studies by medical speciality (see Figure 1.3b). Trauma and Orthopaedics as a speciality have a reputation for early adoption of new methods, techniques and technologies. However, there are still many injuries where future research would benefit from the development of a COS. In recognition of the importance and growing use of COS studies, the UK Medical Research Council (MRC) funded the COMET Initiative's establishment in 2010.

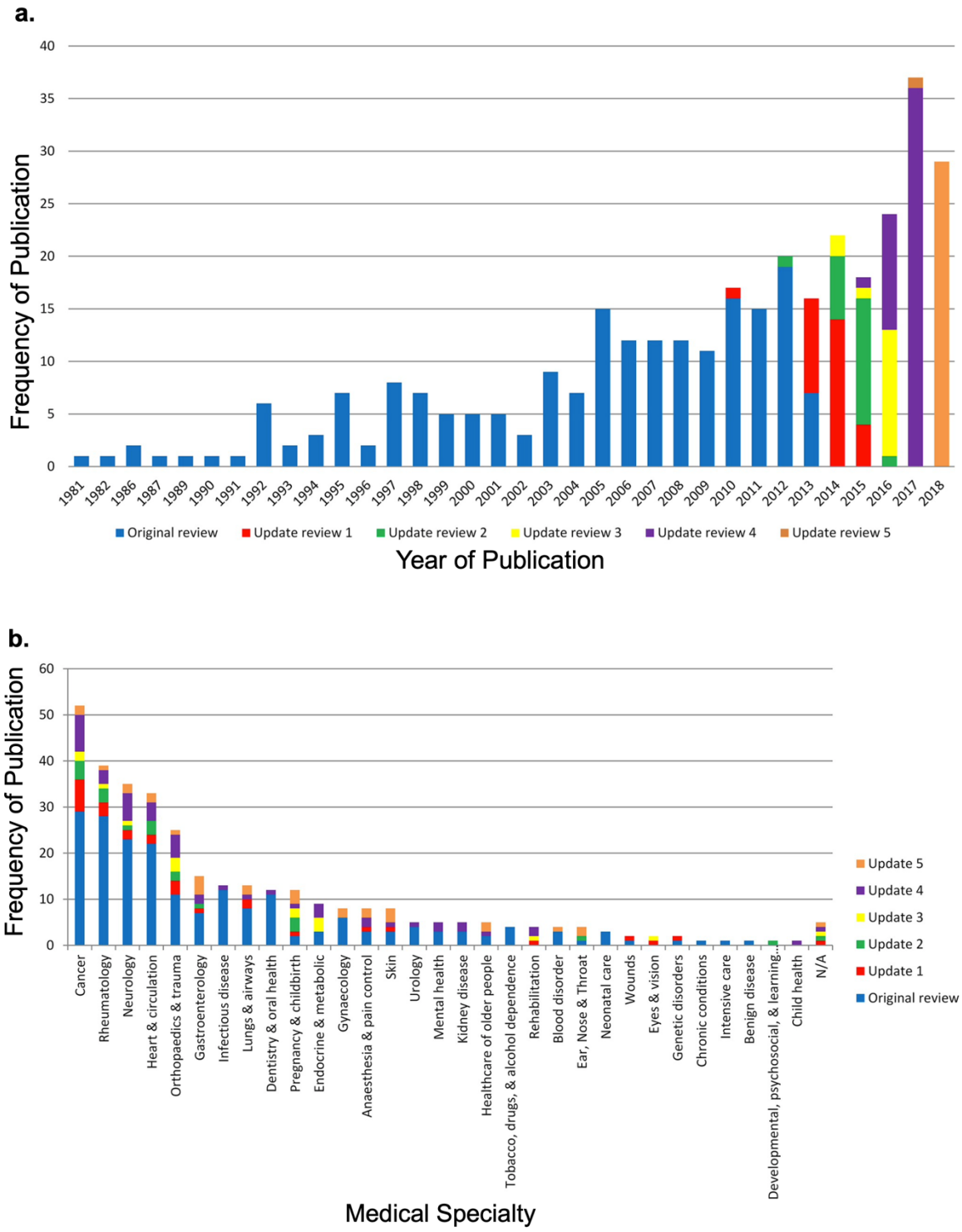


Figure 1.3. a. Year of first publication of each COS set study from 1981 to 2018. (n=337). b. Number of COSs developed in each medical speciality. (n=337). COMET systematic reviews of COS for research: Original review (2014) (57), update 1 (2016) (64), update 2 (2016) (65), update 3 (2018) (66), update 4 (2018) (67), update 5 (2019) (68). Figure adapted from Gargon *et al,* 2019 (68).

1.2.6.2 The COMET initiative

The COMET initiative was launched in January 2010 at a conference in Liverpool funded by the MRC North West Hub for Trials Methodology. Over 110 trialists, systematic reviewers, journal editors, research funders, policymakers, trials registry staff, clinicians and health service users attended. A consensus was found for the need to create an initiative to bring together people interested in the development and application of COS studies. A second meeting followed in July 2011, consolidating the view that COS studies are needed across broad areas of healthcare, and that COMET should have a role in helping develop guidance and coordinate international efforts to help unify outcome measurement in clinical trials (69). See Table 1.2 for COMET aims and objectives.

COMET aims and Objectives
COMET aim:
COMET aims to collate and stimulate relevant resources, both applied and methodological, to facilitate the exchange of ideas and information, and to foster methodological research in COS development.
COMET specific objectives:
1. Raise awareness of current problems with outcomes in clinical trials. 2. Encourage COS development and uptake. 3. Promote Patient and Public Involvement (PPI) in COS development. 4. Provide resources to facilitate these aims. 5. Avoid unnecessary duplication of effort. 6. Encourage evidence-based COS development.

Table 1.2. COMET aims and objectives (69).

1.2.6.2.1 COMET guidance

To date, COMET have developed several key guidance documents that outlay the COMET methodological approach to COS development and standards for reporting which have helped increase the methodological quality of COS studies (68,70-73). These guidelines, including the COMET Handbook, have directed the approach of this project (70) (see Appendix 9 for a detailed description of all current COMET guidance used to direct work and referenced throughout this thesis).

1.2.6.2.2 The COMET database

The COMET website and database was launched in August 2011 and has had annual increases in use and number of registered COS studies (74). The database provides a resource for researchers and COS developers to search the COMET registry for COS studies prospectively, and to register their COS projects' detailing proposed methodology.

1.2.6.2.3 Uptake of COS

In order to unify outcomes as discussed above, COS studies need to be implemented in research and clinical practice. Work undertaken by the COMET initiative, and the recognition and promotion of the COS concept, is actively supported by many key research organisations including, the National Institute of Health Research (NIHR), National Institute for Health and Care Excellence (NICE) and the Cochrane collaboration. See Appendix 10 for list of organisations actively supporting COS development and the COMET initiative. The OMERACT COS for RA is an excellent example where widespread implementation has been achieved (75-77).

1.2.6.3 The importance of PPI in research and COS development

Including the patient perspective in healthcare research is now considered a core principle of good research practice and is supported by policymakers, funders and international regulators (78). The many benefits of involving patients in research are recognised by the NIHR. The NIHR funds the INVOLVE national advisory group, established in 1996, to support greater public involvement in NHS, public health and social care research (79). Such benefits include improving the relevance of research questions, improving recruitment and increasing the likelihood of successful study funding and dissemination of results (80-83).

"No matter how complicated the research, or how brilliant the researcher, patients and the public always offer unique, invaluable insights. Their advice when designing, implementing and evaluating research invariably makes studies more effective, more credible and often more cost-efficient as well."

Professor Dame Sally Davies (2009) (84)

As well as the benefits to the design, conduct and dissemination of healthcare research, the involvement of patients and the public upholds the inclusion of democratic principles; these encompass the broad concepts of citizenship, accountability and transparency. This is an acknowledgement of the right of patients to have a say over 'what' and 'how' publicly funded research is undertaken (84). INVOLVE is a major supporter of COS development and the COMET initiative. The development and implementation of COS studies provide an exemplar of PPI working in research practice.

As discussed, a significant contributor to the research waste scandal is the failure to undertake research answering questions that are important to patients. To address this issue, INVOLVE and the Royal Society of Medicine supported the

establishment of the James Lind Alliance (JLA) in 2004 (85). The JLA aims to bring patients and clinicians together to identify and address the most important uncertainties faced around the effects of care and treatments (85). The JLA priority Setting Partnership (PSP) process was conceived to facilitate the identification of research priorities shared by patients, carers and clinicians. The philosophies and values underpinning the PSPs are the inclusion of a range of patient and clinician perspectives, transparency of the methods, outcomes and vested interests of those taking part in prioritisation, and an evidence-base on which to base prioritisation (86). A PSP results in the identification and prioritisation of a top 10 list of unanswered questions or evidence uncertainties that are the most important to patients, carers and clinicians (87). The first PSP was completed for Asthma in 2007. There are now over 95 top 10 priorities for research which include two PSPs in orthopaedic trauma (88,89). Many of the JLA's philosophies and values, including the approach to PSP development, are shared by COMET. There is currently an ongoing PSP development process in complex fractures that aims to identify top research priorities in OLLF among other areas of extremity trauma (90).

The COMET PPI vision is to facilitate the involvement of patients, parents, carers and members of the public as key stakeholders in the development of all core outcome sets (69). The inclusion of patients in COS development studies has key methodological benefits recognised by the OMERACT experience (55) (see Table 1.3). The COMET annual systematic review updates on COS have demonstrated an increase in PPI involvement from 16% to 71% from 2014 to 2019 (57,68), suggesting that patient involvement is increasingly recognised as an indispensable component of COS development.

Three key benefits of inclusion of patients in COS development studies. From the OMERACT experience (55).
1. Patient input is an indispensable part of identifying and defining outcomes that are important from a patient perspective and assessing the feasibility of OMIs.
2. Involvement of patients throughout the entirety of the COS development process affords face validity.
3. Patient involvement grounds theoretical discussions over the relative importance of outcomes to the lived experience of patients with the disease. This also allows for concepts to be easily communicated back to patients, which enhances understanding in therapeutic decision making.

Table 1.3. Key benefits of patient inclusion in COS studies.

1.2.6.4 The COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) initiative

COMET is partnered with the COSMIN initiative based in the Netherlands who provide guidance on how to select OMIs for core outcomes.

The COSMIN initiative is led by an international multidisciplinary team of researchers with a background in epidemiology, psychometrics, medicine, qualitative research, and health care, who have expertise in the development and evaluation of outcome measurement instruments (91). COSMIN was founded in 2005 in response to a lack of clarity in the literature over the terminology and definitions of measurement properties, a dearth of evidence on the measurement properties of many OMIs, and inconsistency in methods used to determine measurement properties (91). COSMIN have developed a number of consensus-

driven tools to help the selection of the most appropriate OMIs for research and clinical practice, which are detailed in Appendix 11. COSMIN tools guide work in Chapter 6 of this thesis.

COSMIN recognises that numerous OMIs exist, with many instruments measuring the same outcome in the same patient population. Despite an apparent abundance of OMIs, new instruments continue to be developed further contributing to research waste. As such, researchers are faced with a difficult choice over which OMIs are most suitable to use when designing studies. The process of OMI selection is complex. Choices involve conceptual considerations over the definition of the outcome of interest, practical aspects of OMI choice, including cost, the burden the OMI will place on patients and researchers, and the quality aspects of the OMI must be considered.

1.2.7 Clinical Guidelines

Healthcare professionals often lack the skills to critically appraise evidence or have access to the resources and time to gather and appraise evidence. Therefore many clinicians turn to clinical guidelines as pre-appraised evidence-based summaries (92). The development of clinical guidelines has been facilitated by organisations, including the Cochrane collaboration and the GRADE working group. Cochrane has pioneered methodology around the systematic search for, appraisal, and meta-analysis of evidence. GRADE has developed robust systems for the grading of evidence and generation of evidence-based guidelines (see Appendix 12 for a summary of guidance promoting evidence-based practice).

An increasing reliance on clinical guidelines and a recognised need for nationalised healthcare systems to deliver standardised, consistent, measurable

and high-quality care has led to the development of several national guideline bodies. The establishment of guideline development groups and standardised evidence-based guideline development methods has permitted a move away from an over-reliance on expert opinion.

NICE develops clinical, public and social care guidelines for use in England. NICE guidelines are accessed and used widely throughout the NHS and are often used in other healthcare systems owing to their sound methodological approach. As discussed below, NICE guides standards of care in treating patients with open fractures (93,94).

Involvement of patients and members of the public in clinical guidance development is important and implementable with a view towards further improving patient care. PPI ensures that guidelines are patient-centered, address patient needs and preferences, and are subsequently implementable. The Guidelines International Network and NICE now mandate that PPI is part of their standard approach to guideline development.

Systematic review is the cornerstone of guideline development, and the NICE methods manual advocates for a PICO approach when designing systematic reviews. To help ensure the patient voice is heard in guidelines, NICE endorses the use of COS studies when selecting outcomes to design search strategies for evidence.

1.3 How outcomes were categorised and organised throughout this study: The COMET Taxonomy of Outcomes Framework

The COMET initiative developed a Taxonomy of Outcomes to provide a hierarchical classification system that gives sufficient scope and granularity to classify all outcomes listed in the COMET database, trial registries, trial reports and systematic reviews (12). The taxonomy delivers a comprehensive framework from which all outcomes identified in the literature and patient narratives of recovery can be categorised and organised.

A taxonomy typically consists of a controlled vocabulary with a hierarchical structure (95), which forms a classification system that follows general laws or principles, for example, the classification of species (12,96).

Identification, interpretation, analysis and management of large numbers of outcomes undertaken throughout this study demanded a suitable framework to provide structure. The COMET Taxonomy of Outcomes met this requirement and is justified below.

1.3.1.1 Development of the COMET Taxonomy of Outcomes

On review of the literature and existing outcome classification systems, Dodd *et al.* 2017 found that none provided an explicit classification system with structured hierarchical differentiation between high-level outcome types, or the necessary granularity for comprehensive classification of all possible trial outcomes (see Appendix 13 for detail and critique of other outcome classification systems reviewed by Dodd *et al.*2017). Therefore, it was concluded that there was a lack of

a suitable taxonomy to classify all trial and systematic review outcomes leading to the justification of developing the COMET Taxonomy of Outcomes (12).

The COMET taxonomy was developed using an iterative process based on a 15-category scale created by Smith *et al.* (2015) for classifying outcomes reported in Cochrane reviews (12,97). Following piloting and refinement, the taxonomy was further developed to add 'physiological/clinical' functioning and resource use as additional core areas. The result was the creation of a 38-outcome domain taxonomy grouped into five core areas (see Table 1.4 below detailing relevant outcome domains that are later used in this study, and Appendix 14 for the full COMET Taxonomy of Outcomes and instructions for recommended use with examples provided) (12).

Core area	**Outcome domain (1-38)**
Death	1. Mortality/survival
Physiological/ clinical	2. Blood and lymphatic system outcomes
	9. General outcomes
	15. Musculoskeletal and connective tissue outcomes
	19. Renal and urinary outcomes
Life impact	25. Physical functioning
	26. Social functioning
	27. Role functioning
	28. Emotional functioning/wellbeing
	29. Cognitive functioning
	30. Global quality of life
	31. Perceived health status
	32. Delivery of care
	33. Personal circumstances
Resource use	34. Economic

	35. Hospital
	36. Need for intervention
	37. Societal/carer burden
Adverse events	38. Adverse events/effects

Table 1.4. Relevant outcome domains of the COMET Taxonomy of Outcomes to this CO-OLLF, adapted from Dodd *et al.* 2017 (12).

1.3.1.2 The rationale for the use of the COMET Taxonomy of Outcomes

COMET developed and piloted a 'made for purpose' outcome classification taxonomy system that is both hierarchical and comprehensive. Given that a group of experienced systematic reviewers at COMET failed to identify a pre-existing adequately comprehensive classification system, and that the methods used in this study are predominantly guided by COMET, it is sensible to also adopt the COMET Taxonomy of Outcomes. More broadly, the underlying aim of COS studies is the unification of outcomes; given this, it is also logical to promote the adoption of the COMET Taxonomy of Outcomes in future COS studies with a view towards unifying outcome categorisation systems across all COS studies, systematic review databases and trial registries.

On review of the COMET Database, Dodd *et al.* 2017 demonstrated that 99 of the 299 COS studies registered conducted a systematic review of the literature to identify relevant outcomes; and where a systematic review was conducted, developers typically categorised outcomes by:

1. Generating frameworks using a data-driven approach, creating broad categories with common 'themes' from which to categorise outcomes. This approach was used in 21/299 studies (12,98).

2. Use of pre-established classification systems or frameworks of health. Four studies used the ICF terms (17), one study used a simplified version of the Wilson and Cleary model (15), and one study used outcome categories specific to a disease area defined by previous authors (12,99,100).

Inconsistencies in outcome classification make it challenging to link recommended outcomes from COS studies to systematic reviews (e.g. the Cochrane database of systematic reviews) and trial registries. The COMET Taxonomy of Outcomes aims to address this issue and be designed to facilitate ease of searching electronic databases by outcome and disease area (12). Therefore, an advantage of using the COMET Taxonomy of Outcomes to categorise outcomes in this study is that:

1. This study's resulting recommendations may be more easily accessible when undertaking future electronic database searching by condition and outcome, e.g. 'open fracture' and 'pain' or 'discomfort'.
2. By making the CO-OLLF study recommendations more easily identifiable, future researchers designing studies on OLLF may be more likely to find and implement the COS when considering what outcomes to measure and how to measure them, enhancing study dissemination.

Dodd *et al.* 2017 provides a comprehensive outcome taxonomy that has been piloted, classifying outcomes in systematic reviews, trial registries, and retrospectively applied to a sample of completed COS studies in the COMET database (12). However, it is a contemporary framework with little other validation evidence. Despite recent publication, the COMET Taxonomy of Outcomes, is increasingly used by COS developers. Undertaking a citation search of Dodd *et al.* 2017 using PubMed Central to search the MEDLINE database, identified 35

articles at the time of searching (26th October 2020) (see Appendix 15). Of the articles identified, eight and one were systematic reviews or systematic review protocols, respectfully, four were completed COS studies, 17 were protocols thereof, and four articles cited the Taxonomy of Outcomes but did not use it. Increasing use of the Taxonomy by COS developers supports recognition of good utility.

This study consulted EB, PPI partner for advice when choosing between the ICF terms or the COMET Taxonomy for categorising and organising outcomes. The framework structures, usability and understandability, were discussed. It was agreed that the COMET Taxonomy was more intuitive, and therefore, outcome meanings may be easier to interpret by other patients compared to the ICF terms. The COMET Taxonomy was also favoured as it provides clear guidance for the categorisation of outcomes (see Appendix 14) and is comprehensive. Also, outcome domains within the taxonomy can be further subdivided, facilitating flexibility to sub-classify outcomes themes and subthemes (12).

1.3.1.3 How the COMET Taxonomy of Outcomes was used throughout this study

The COMET Taxonomy of Outcomes was used throughout this study to categorise and organise outcomes identified or interpreted from:

1. The published literature on patients following OLLF; where verbatim outcomes were reported, or where use of specific outcome measurement instruments (OMIs) were described.
2. Thematic Analysis of interview transcripts exploring the lived experience of recovery from OLLF.

All outcomes identified were used to create an Inventory of Outcomes for patients recovering from OLLF, which was hierarchically structured using the COMET Taxonomy of Outcomes. The taxonomy forms the backbone of this study as it was used to structure and organise all lists of outcomes and OMIs presented to patients at each crucial reviewing and consensus generating stage of this project. Figure 1.4 provides a schematic illustration of how the COMET Taxonomy was used to categorise outcomes throughout this study.

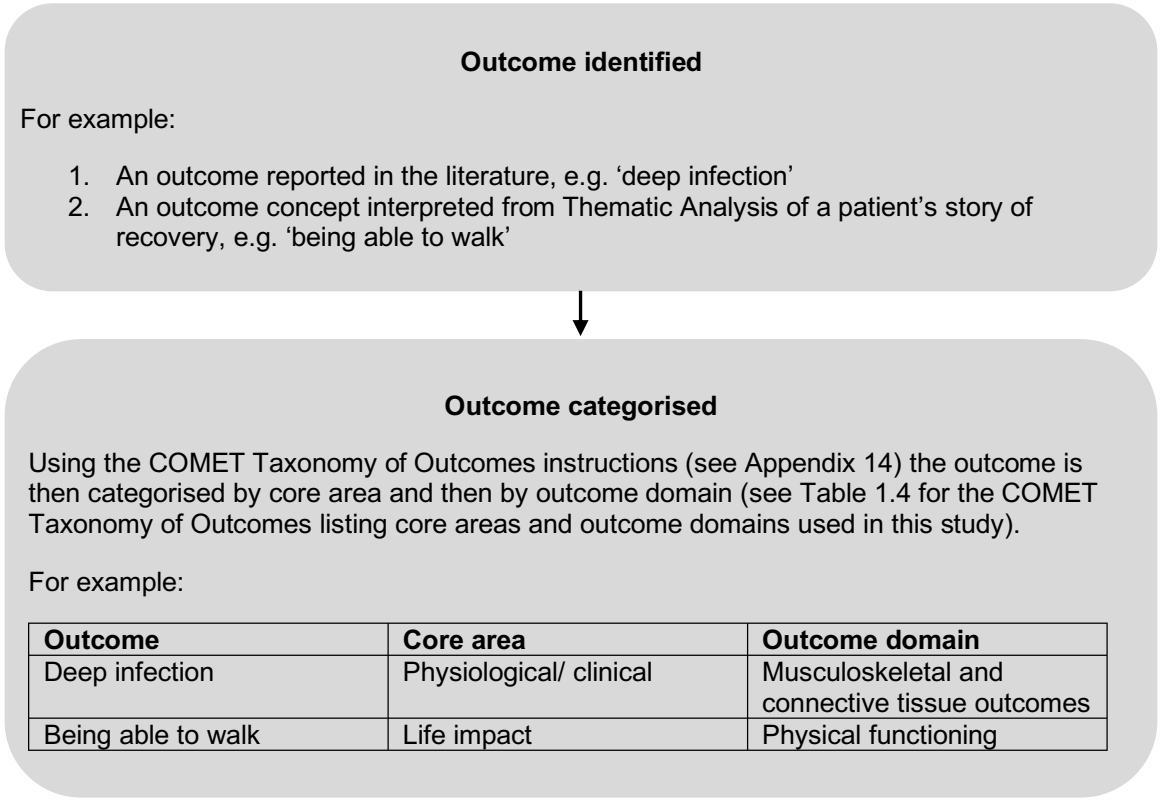


Figure 1.4. Schematic diagram illustrating how outcomes were categorised using the COMET Taxonomy of Outcomes.

1.4 Open fractures; characterising the nature of the injury

1.4.1 What is an open fracture?

An open fracture is a break in a bone where the soft tissue envelope is breached, and the bone is exposed to the outside world; this can be direct where bone physically protrudes through the skin or indirect where holes in the skin allow communication with the bone. Open fractures are often associated with a significant soft tissue injury which exposes the bone to contamination from the environment, greatly increasing the risk of infection (101,102). The soft tissue structures damaged include skin, muscle, fascia, tendons, and nerves and blood vessels in the most severe cases on a spectrum of severity with increasing overall injury burden. It is often helpful to conceptualise an open fracture as a major soft tissue injury with an underlying fracture of a bone; this puts into context the relative severity and complexity of the soft tissue component of these injuries when treating and managing patients. This is a serious life-changing injury which may lead to a limb or life-threatening illness and later disability.

1.4.2 Open fractures, a brief history

The dire prognosis of open fractures was recognised in ancient times (103), and documentation of treatment goes back as far as 1,800BC, where Ancient Egyptian papyrus records explain the need to cover exposed bone with ‘meat’ (104). Soft tissue infection and subsequent systemic sepsis were the most feared complications in patients following trauma which persist to the present day. Hippocratic physicians recognised the importance of injury characteristics, including neurovascular status, fracture pattern and wound size, and further

identified that these factors affected the eventual outcome. They treated these injuries by removing debris, including bone fragments, achieving a stable reduction and undertaking regular dressing changes (103). In an era where amputation formed the mainstay of treatment for open fractures to save life over limb, two surgeons, each key to the evolution of modern medicine; Ambroise Paré (1510-1590) and Percivall Pott (1714-1789), both sustained an open tibial fracture in horse riding accidents (103). Paré was famed for his pioneering use of ligatures in amputation, rejection of boiling oil for the cautery of gunshot wounds and describing intracapsular fractures of the femoral neck, to name a few of his contributions. Pott was a renowned English surgeon and recognised as one of the fathers of orthopaedic surgery from his publication ‘Some few remarks on fractures and dislocation’ (103). Both surgeons had extensive experience in treating open fractures from time spent on European battlefields; they were also insightful and sceptical of the classically taught dogma of their times. They each rejected amputation of their leg against advice and instead took a risk and opted for treatment with fracture reduction, splinting and wound management with dressings and ointments. They were both documented to recover and walk without a limp (103). This practice cemented the modern approach to the reconstructive management of open fractures. Further advances in treatments came later with the discovery and mass production of modern antibiotics in 1945 (105). This was then followed by reconstructive microvascular surgery techniques, developed through pioneering work in the 1970s resulting in the first groin to ankle flap by O'Brien in 1973 (106). Together with the traditional knowledge of fracture management, these advancements formed the grounding for the contemporary approach to limb reconstruction. Due to the seriousness, high morbidity and

requirement of complex, multifaceted treatment of OLLF, it is a traumatic injury that has historically attracted innovative approaches to management that continue to present times.

To this day, open fractures remain a significant cause of morbidity and mortality, having a profound effect on patients' lives (101). Unfortunately, the best way of treating these devastating injuries remains unclear. To support ongoing efforts to investigate optimal treatment strategies recommendation of a COS will reduce inconsistencies in outcome-reporting and enhance the utility of future research studies by promoting use of outcomes important to key stakeholders.

1.4.3 Epidemiology of open fractures

Trauma is one of the most common causes of death and disability worldwide (4). In England, trauma is the most common cause of death for those aged under 40 years, with many survivors suffering long-term disability (5). The National Audit Office estimates there are greater than 20,000 cases of major trauma each year in England associated with 5400 deaths (107).

Fractures are extremely common and represent a substantial public health burden. The incidence of fracture in the UK is 3.6 per 100 people per year, and the estimated age-standardised life-time prevalence of sustaining a fracture is 38.2% (108). The cost of fracture care is enormous; the approximate cost to the NHS and Social Services of treating patients following hip fractures alone is over £1 billion per annum or around 1% of the NHS annual budget (109,110). Fortunately, the proportion of open fractures is relatively small at around 3% of all fracture presentations in the UK population (111).

There is limited national epidemiological data on the incidence of open fractures. A sizeable 15-year cohort study by Court-Brown *et al*. 2012 on patients presenting to the Royal Infirmary of Edinburgh with open fractures between 1995 and 2009 estimates that there are 30.7 open fractures per 100,000 adults per year in the UK (111). The tibia and fibula are the most common long bones to sustain open fractures in the UK, while open fractures of the finger phalanges are the most prevalent open fractures at 11.2% and 45.5% of all open fractures, respectively (111). Open fractures of the fingers, tibia and fibula, distal radius, toes and ankle account for approximately 75% of all open fractures presenting in the UK (111). There is an estimated incidence of 11.5 open long bone fractures per 100,000 people each year in the UK civilian population (112-114), and this is higher in the military population (115). From a conservative estimate, there are likely over 4100 Open Lower Limb Fractures (OLLFs) presenting to Major Trauma Centers (MTCs) in England each year.

Open fractures typically occur following trauma resulting in high energy transfer, with Road Traffic Collision (RTC) being the most common mode of injury in the UK (101,111,116). A recent study showed that 61% of the most severe open fractures (Gustilo-Anderson (GA) Classification grade IIIB and C) presented to English MTCs following an RTC (117). Open fractures are often associated with other injuries; the Wound management of Open Lower Limb Fractures Trial (WOLLF HTA-10/57/20) showed that 29% of patients recruited with OLLFs had another significant injury, of which 5.4% included a head injury (101,118). Data from the Lower Extremity Assessment Project (LEAP) Study, a large cohort of open fractures with embedded randomised controlled trials undertaken in the United States of America (USA) showed that over 13% of patients with an open fracture

presented with an Injury Severity Score (ISS) of greater than 18 (119). Historical UK data by Court-Brown *et al.* 1998 also demonstrated that over 20% of patients presenting with an open fracture had a concomitant ISS of greater than 15; which decreased with increasing patient age of presentation (112).

An ISS of 15 or higher is recognised as a criterion of major trauma and has a predictive in-hospital mortality of 15.5% from analysis of Trauma Audit and Research Network (TARN) data (120). This highlights the likely severity of associated injuries in patients presenting with open fractures.

Court-Brown *et al.* 2012 show that 81.3% of patients presenting with open upper limb fractures had isolated injuries compared to 62.8% of those presenting with OLLFs. The overall average ISS was 7.1, with an average of 5.1 and 11.1 for those presenting with upper and lower open limb fractures, respectively. This demonstrates that patients presenting with OLLF have a relatively more severe overall injury resulting from higher-energy forces compared to those with upper limb open fractures (111).

Court-Brown *et al.* 2012 estimate the mean age of patients in the UK sustaining open fractures is 45.5 years, with 69.1% occurring in males and 30.9% occurring in females with an average age of 40.8 and 56 years, respectively (111). The highest incidence of open fractures in males occurred between the age of 15-19 years at 54.5 per 100,000 per year with a linear decline with increasing age. In females, a unimodal distribution is demonstrated, increasing from 9.2 per 100,000 per year in the 15-19 years old age group to 53.0 per 100,000 per year in the 80-89 year group (111). This data demonstrates a bimodal age distribution for males and females, with younger males more likely to sustain high-energy open fractures

and older females more likely to sustain low-energy fragility type open fractures commonly by falling from standing height which is particularly the case for open tibia fractures (see Figure 1.5). This observation is further supported by Costa *et al.* 2018 in the WOLLF Trial, which recruited 460 adults following OLLF from July 2012 to December 2015 in the UK (101). The single largest group of recruited patients were young men in their 20s following RTCs, many of which involved motorcycles. Only 30% of patients recruited to WOLLF were females who were commonly in their 70s. Costa *et al.* 2018 hypothesise that the mode of injury is usually different between men and women, with women more at risk from low-energy trauma in combination with osteoporosis (101). These results are also reflected more recently by Young *et al.* 2019 analysing TARN data on all patients presenting to one of the twenty-seven MTCs in England from October 2014 to January 2016 with a Gustilo Anderson (GA) grade IIIB-C open tibia fracture (the most severe). From 646 patients with 661 open tibia fractures, the male to female ratio was 2.3:1 with a mean age of 40.5 years and 62.1 years for males and females, respectively. The primary mechanism of injury was RTC accounting for 61% of open tibias, while a fall from less than two meters accounted for 22% (117). With an increasingly ageing population, the proportion of low-energy osteoporotic related fragility open fractures will likely increase, adding further burden to UK trauma and social care infrastructures. UK compliance with national standards of open fracture care is poor in the elderly and has been identified as an area for improvement (117).

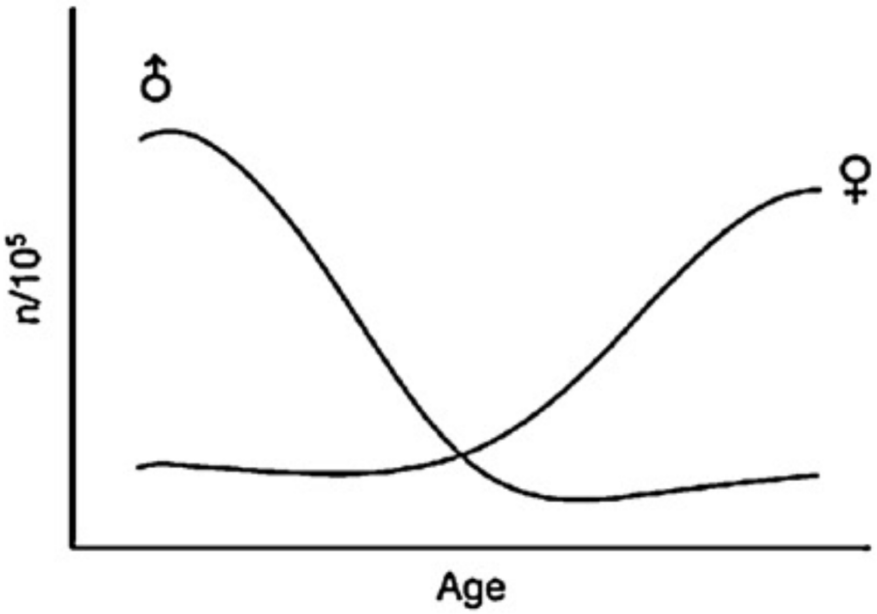


Figure 1.5. A graph to demonstrate a unimodal young male and unimodal older female fracture distribution curve typical of the presentation of open tibia fractures (excluding open ankle fractures). Age is on the X-axis and incidence (number per 100,000) on the Y-axis (111,121). Graph adapted from Court-Brown *et al.* 2006 (121).

Persistent demonstration of a marked bimodal age distribution of patients by sex in the OLLF population constituted a significant challenge to ensuring the COS for OLLF was relevant to both disparate populations. This observation necessitated the need for representation and engagement of both patient groups throughout this project.

1.4.4 Treatment of open fractures

Treatment of patients suffering from open fractures in the UK has improved over the last ten years due, in part to, two significant changes in practice; the introduction of the MTC network and the dawn of orthoplastic operating lists (5).

The London MTC network was established in April 2010, and by April 2012, networks were established throughout the rest of England. There are currently 27 MTCs across England; 11 for adults and children, 10 for adults only, 5 for children only and one collaborative center (5). The MTC network operates a hub and spoke model where patients that are screened for major trauma are taken directly to the nearest MTC, often bypassing local Trauma Units or are referred directly to an MTC from a Trauma Unit Emergency Department.

TARN requires MTCs to report routine prospective data on all major trauma patients for their national audit. MTCs must submit outcome data to TARN in order to receive the Best Practice Tariff, which partly funds the increased costs of running an MTC. As well as collecting data on processes of care TARN collect PROMs in an effort to measure quality of life and global functioning in patients following major trauma. TARN is a key target for the implementation and routine collection of the COS for OLLF as part of an ongoing national audit of trauma care.

By mandating that Orthopaedic Trauma and Plastic Surgical specialities are housed together, the introduction of the MTC network opened the door for the second significant improvement in open fracture care, the orthoplastic center. A ‘combined orthoplastic approach’ to patients at the assessment of soft tissue injury and those requiring soft tissue coverage is considered best practice by NICE (93,94). The orthoplastic approach to open long bone fracture management has been demonstrated to significantly improve outcomes, including reduced infection, non-union and amputation rates (122,123), number of unnecessary operative procedures (124-126), time to soft tissue coverage (122,125,127,128), hospital stay and cost (125,127,128) and the time to functional recovery (129). It is worth noting that an orthoplastic center does not necessarily have to be an MTC, i.e. a

patient could present to an MTC be stabilised before transfer to an orthoplastic center for ongoing care.

Drawing on the evidence synthesis undertaken to generate the NG37 NICE guideline, the British Orthopaedic Association and British Association of Plastic, Reconstructive and Aesthetic Surgeons (BOA/BAPRAS) published joint standards for open fracture management in 2009 (130,131), which were updated in 2017 (131). The BOA/BAPRAS standards for open fractures provides an evidenced-based summary of the currently best-known approaches to managing open fractures and should be used as a minimum standard of care. Current guidelines focus on the initial assessment and management of patients with open fractures. They do not offer guidance on what type of fracture fixation or soft tissue coverage is best for different injury patterns. They also do not guide clinicians on which patients may have a better outcome with delayed early amputation over limb reconstruction. The evidence base to guide treatment decision in the management of OLLF is lacking.

1.4.5 Open fracture severity

Open fractures vary in their severity. The most widely used open fracture classification system is the Gustilo and Anderson (GA) classification system (see Table 1.5). The GA classification system was initially developed to classify open tibia fractures and is now widely used for all open fracture grading (132,133). Grading open fractures is essential to assess the severity of the injury, direct treatment and, to a limited extent, determine prognosis. An accurate open fracture classification is only possible during surgical exploration and wound excision, where the extent of soft tissue damage can be adequately assessed (134). It is

recommended that an open fracture should also be classified by mechanism of injury, the condition of the soft tissue envelope, the likely level of bacterial contamination and specific characteristics of the fracture (135). An increasing fracture severity is associated with a poorer prognosis, more complex reconstructive surgery, and a higher risk of complications, including infection and ultimately amputation. The GA classification has been shown to demonstrate prognostic value for predicting infection (135). However, the grading does have limitations when used in this respect and has a relatively weak interobserver reliability (136).

The Gustilo-Anderson classification system for open fractures (132,133)	
Grade	**Description**
I	Open fracture with a clean wound that is less than 1 cm in length.
II	Open fracture, without extensive soft tissue damage, flaps, avulsions with a wound greater than 1 cm but less than 10 cm in length.
III	An open fracture with extensive soft tissue damage; a traumatic amputation, or an open segmental fracture. It can also include specific categories of open fracture such as those caused by farm injuries, fractures requiring vascular repair, or fractures that have been open for eight hours prior to treatment. Grade III fractures can be further subclassified into three types: **IIIA**: type III fracture with adequate coverage of the fractured bone, despite extensive soft tissue damage.

	IIIB: type III fracture with extensive soft tissue loss and periosteal stripping and bone damage (usually associated with massive contamination). **IIIC**: type III fracture associated with an arterial injury requiring repair.

Table 1.5. The Gustilo-Anderson classification system for open fractures (132,133). Table adapted from Young *et al.* 2019 (117).

Classifications systems for OLLF are typically limited by using subjective descriptors of the extent of the injury, .e.g. 'extensive degloving' or 'massive' contamination, resulting in misclassification (135-139). They were also constructed to help predict complications such as infection (132) and amputation (140). However, it is increasingly recognised that patients have a broader perspective of what constitutes a successful recovery (139). To address these limitations, Trompeter *et al.* 2020 have developed the Orthopaedic Trauma Society (OTS) classification of open fractures to modernise the classification of open fractures to better align with contemporary clinical practice (137,138) (see Table 1.6).

The OTS open fracture classification system (139)
Based on the open fracture wound's objective assessment at the end of the first wound excision (debridement).
Simple A simple open fracture is one in which the primary closure of the open fracture wound is achieved following wound excision.
Complex

A complex open fracture is one in which closure of the wound requires a reconstructive procedure; these injuries are then subclassified into three objective groups to reflect the extent of the reconstructive intervention:	
Complex A	The wound is closed primarily, but bone deformation or acute bone shortening is required to facilitate closure.
Complex B	Where a soft-tissue reconstructive procedure is required to cover the wound.
Complex C	Or repair/reconstruction of vascular injury is required in association with the open fracture.

Table 1.6. The OTS classification of open fractures (139). Table adapted from Trompeter *et al.* 2020 (139).

OLLFs tend to be more severe than open upper limb fractures. Court-Brown *et al*. 2012 showed that 42.6% of lower limb and only 18.6% of upper limb open fractures were grade III (111). This can be explained by the most common mode of trauma being a high-energy injury, e.g. RTC for OLLFs and crush injury for open upper limb fractures. Owing to the tibia being the most superficial of all the long bones with only a modest soft-tissue envelope for protection anteromedially, it is the most common long bone to sustain an open fracture, and up to 21% of all tibia fractures present open (111).

1.4.6 Complications of open fractures

Infection is widely regarded as the most feared and challenging complication in the treatment of open fractures. Due to bone exposure and periosteal stripping, organisms can quickly form a biofilm on devitalised bone, soft tissues and fixation

devices, all of which have a limited or complete lack of blood supply preventing normal phagocytosis and action of intravascular antimicrobial agents (141).

Infection rates for open fractures are both widely reported and widely variable from 3.7% (142,143) to 28% (144) even in specialist trauma centers (145). Infection rates in the 1980-90s were commonly reported to be over 30% (146,147). However, there is increasing evidence that they have been dropping over the last 20 years (148). The WOLLF Trial provides more recent data applicable to the UK OLLF population. Using the Centers for Disease Control and Prevention (CDC) definition of deep Surgical Site Infection (SSI) (149) within one year of OLLF, 7.6% (35 of 460 patients) of participants developed a deep SSI, which is low compared to other international patient series and is considered encouraging (101). TARN data analysed by Young *et al.* 2019 from a series of 646 patients treated at MTCs in England with grade IIIB-C open tibia fractures showed a return to theatre for infection rate during the index admission of 4.3% (117). This is equally encouraging as only the most severe open tibia fractures were analysed, and return to theatre rate for infection is a good surrogate outcome measure for early-onset infection. Return to theatre rate for infection will have included both deep SSI and superficial SSI that required surgical intervention.

There is currently no consensus over what criteria should be used to diagnose infected open fractures (147,150). The CDC guidelines for the diagnosis of surgical site infection are often used, but they fail to address the complexity of infected open fractures adequately (147,151). More often, in clinical practice, a pragmatic approach is taken making use of the multidisciplinary team; however, this approach is challenging to translate into research practice.

A predisposal to infection and often a high-energy transfer mechanism of injury increases the likelihood of open fracture non-union (152,153). A non-union can be thought of as an arrest in the fracture repair pathway; as for infection, there is no consensus on how it is defined. When assessing bone union, a combination of clinical factors such as pain on walking/hopping and radiological factors such as visible callus bridging at least three cortices are often used. A delayed union is generally thought to occur if a fracture has not united by 6 to 8 months, and in the case of an open fracture, it is helpful to be considered secondary to deep insidious infection until proven otherwise (152,154). The risk of fracture non-union following OLLF is estimated to be as high as 20%, with an average time to union of 7.5 months (155). If complications, such as infection or non-union occur, treatment frequently continues for years after the index fracture (156).

One of the most severe complications of OLLF is amputation. Recent TARN data on GA grade IIIB-C open tibia fractures shows an amputation rate at English MTCs of 8.7% (117). The decision to proceed to primary amputation over limb reconstruction is extremely difficult to make. It is a decision that is compounded by evidence demonstrating that, where secondary amputation is necessitated due to failure of reconstruction, patients may have achieved a better outcome from an initial delayed primary amputation (157). Unfortunately, there is insufficient evidence to support reliable and reproducible decision making around amputation. Increasingly planned early amputation (less than 72 hours after injury) is being considered part of the reconstructive lower limb toolkit. Several studies demonstrate comparable results of limb salvage and amputation of the most severe open tibia fractures; unfortunately, they all show high rates of permanent disability reported in each group (158-160).

In addition to the historically reported objective clinical outcomes representative of complications discussed above, including infection, bone union and amputation, OLLF has been demonstrated to have a marked detrimental effect on disability and quality of life. This was highlighted through the reporting of the Disability Index Rating (DRI) and the EuroQol 5-Dimensions (EQ-5D) scales at 12 months in the WOLLF trial (118) and at 6 months in the open fracture sub-group of patients in the Wound Healing in Surgical Trauma (WHIST) trial (161). The WOLLF trial demonstrated a mean DRI (range,0 [no disability] to 100 [completely disabled]) score in the Negative Pressure Wound Therapy (NPWT) group of 45.5 vs 42.4 in the standard dressing group, and a mean EQ-5D-3L (1 indicating the best state of health) score in the NPWT group of 0.55 vs 0.56 in the standard dressing group. The open fracture sub-group of patients in the WHIST demonstrated a mean DRI score in the NPWT group of 40.6 vs 40.2 in the standard dressing group, and a mean EQ-5D-5L score of 0.58 in both groups.

These studies represent an increasing recognition of the importance of reporting patient-centered outcomes and a step change towards using PROMs as primary outcome measures in large RCTs on orthopaedic trauma.

1.4.7 Treatment costs of OLLF

There has been little work to date investigating the economic burden to healthcare providers and patients following open lower limb fracture. MacKenzie *et al.* 2006 reported outcomes from 601 participants who underwent reconstruction or amputation following severe, lower limb trauma in the LEAP study (162). The LEAP study made the first detailed economic evaluation of the associated healthcare treatment cost of sustaining an open lower limb fracture by comparing the lifetime

cost of reconstruction vs amputation. MacKenzie *et al.* 2007 estimated a direct healthcare cost for open tibia fractures within two years of injury treated with reconstruction or amputation of 81,000 and 91,000 USD, respectively. The difference is significantly higher when estimating the lifetime projected cost; projections were between 160,000 and 500,000 USD where the leg was reconstructed or amputated, respectively (163).

A more recent economic evaluation investigating the cost of treating severe OLLF in the UK was undertaken as part of the WOLLF Trial to estimate the cost-effectiveness of NPWT compared with standard wound dressings in patients following OLLF (101). A cost-utility analysis was undertaken and expressed in terms of incremental cost attributable to the NPWT per Quality-Adjusted Life Year (QALY) gained as recommended by NICE. The health economic evaluation demonstrated that at the individual level, cost of OLLF treatment has a considerable variation. Patients that underwent successful primary delayed wound closure and definitive fixation incurred lower costs, while those requiring free-flap reconstructive surgery or multiple surgeries for complications incurred starkly increased costs. In most cases, it was shown that the primary operative procedure determined the index hospital admission cost, and that free flap surgery was both the most expensive and most commonly performed primary procedure following wound excision surgery. Over the 12 months of follow up, the WOLLF Trial calculated that the average NHS and Personal and Social Services cost for severe OLLF was approximately £14,000, where unit costs were inflated/deflated to 2014/2015 prices. No significant difference in overall cost at 12-months follow up was shown for the two trial treatment arms; NPWT vs standard dressings (101).

These cost analyses are likely to conservatively estimate the total cost of OLLF due to failure to take into account hidden costs. They are also diminutive in comparison to the societal and lifelong personal costs associated with such a severe injury.

Of note is the observation that there is a significant void between the quality and accuracy of health economic evaluation between areas of healthcare such as cancer care which has historically been well investigated compared to musculoskeletal care where evidence of cost-effectiveness is significantly lacking. This apparent void is likely in part due to the difficulty in accurately assessing the cost of musculoskeletal care due to wide-ranging heterogeneity in management, which has resulted in a situation of almost uncontrolled spending. Nowhere is this more apparent than in the management of open fractures.

1.4.8 Outcome Measurement Instruments (OMIs) in OLLF

OMIs used in clinical studies on patients following OLLF can be broadly divided into three different types:

1. Objective clinical measures (see Table 1.7 for examples)
2. Patient-reported outcome measures (PROMs)
    a. General health and quality of life
    b. Disease/region-specific
3. Physical performance measures (PPMs)

1.4.8.1 Objective clinical measures

Many studies on OLLF are limited by only collecting objective clinical measures (see Table 1.7). As discussed earlier, it is increasingly expected that current and

future studies are powered on outcome measures that have been shown to be meaningful to patients, e.g. PROMs.

Assessment of severity of femoral and tibial shaft fractures:
1. fracture displacement 2. fracture comminution 3. soft tissue injury (e.g. Gustilo Anderson classification) 4. energy of injury 5. mangled extremity scores
Assessment of adverse events, e.g. bone and soft tissue healing complications Commonly used outcomes in the OLLF population have consisted of:
1. time to fracture union 2. malunion 3. infection 4. flap failure 5. secondary amputation

Table 1.7. Examples of objective clinical measures.

1.4.8.2 PROMs

PROMs are self-reported questionnaires that elicit responses to measure either patients' perceptions of their general health or function in relation to specific diseases or conditions (164). The Short Form 36 (SF-36) health survey (165), for example, is a generic questionnaire that assesses self-perceived health status by using 36 questions relating to eight broad areas (or "domains") of wellbeing. The Lower Extremity Functional Scale (LEFS) (166) is an example of a broad region-specific OMI suitable for patients with musculoskeletal disorders of the hip, knee,

leg, ankle, or foot. The LEFS contains 20 items, specifically assessing the ICF model domains of activity and participation.

Responses to questions in a PROM are scored to provide a quantitative measure of an assumed underlying domain of health, known as the latent trait, which can be used as the estimated instantaneous status of that trait in that patient (164). PROMs are powerful OMIs that allow the patient's voice to help evaluate healthcare (167), provided they can accurately and meaningfully capture the patient perspective (168,169). It has become standard practice to include patients in the development, application, evaluation and interpretation of PROMs; this increases quality and validity (170,171) and is supported by institutions such as the (Food and Drugs Administration) FDA and Patient-Centered Outcomes Research Institute (PCORI) (169,172). Despite calls for increased PPI in all stages of PROM development, concerns remain that patient involvement has been cursory, poorly reported and has not increased over time (168,173). To address these shortcomings, frameworks have been introduced to aid the incorporation of PPI in PROM development (174).

When investigating a specific condition, such as OLLF, disease or region-specific PROMs provide a greater clinical focus than generic health measurement instruments as they are tailored to the symptoms and disability of the condition of interest (10). A systematic review of outcome measurement tools used for leg, ankle and foot conditions identified 12 distinct OMIs (175). The two most widely validated OMIs identified were the Foot and Ankle Ability Measure (FAAM) (176) and LEFS (166), reported in two and six studies, respectively (10).

1.4.8.3 Physical performance measures

Physical performance measures (PPMs) are defined as clinician-observed measures of physical function that assess a task (177). PPMs of mobility can quantify the ability of an individual with an OLLF to perform certain tasks that require movement. PPMs focus on the assessment of the ICF domain classed as 'activities' and relate to 'the ability to move around' (178) and 'the ability to perform daily activities' (179) rather than direct tests of body structure, function, or impairment (177). PPMs are often assessed directly by an observer while the activity is being performed by timing, counting, or distance measurement (177). One such method of assessment is the Enneking Score (180).

1.4.8.3.1 Quantitative physical performance measures

Perhaps the most fundamental goal of functional recovery from an OLLF is walking. This can be assessed easily and directly in a variety of ways, including a simple 10-m timed walk test, self-paced walk test, or 6-minute walk test (177). There are also PPMs of other mobility tasks such as the stair climbing, chair stand, and timed up and go tests (177); however, these activities can be viewed as extensions of walking (181). Typically, simple walking measures focus on gait speed, which has been demonstrated to be a strong indicator of pathology (182,183). This can be performed on patients with cognitive impairments where PROMs may not be feasible. Despite the practicalities of performing simple timed walk tests in the clinic, these are limited by an inability to discriminate between normal and pathological gait in situations where patients adopt a compensatory gait pattern in order to maintain velocity (184). This inability can be overcome by comprehensive gait analysis using modern measurement apparatus, thus enabling

the capture of detailed aspects of movement on walking (181). Following lower limb pathology, highlighted by studies of ankle fractures, the primary disturbance of walking gait is asymmetry (185,186).

Many of the methods for assessing gait symmetry are currently not practical for use in routine clinical follow-up and clinical trials on patients with OLLF as they require specialist training and facilities and cannot be performed remotely. However, measuring gait symmetry in the clinic and in the community may be an increasingly realistic option in the future by use of temporospatial footfall analysis systems and affordable wearable inertial motion sensors, as these systems are portable and increasingly user friendly or can be integrated into personal smart devices.

1.5 The rationale for a COS focusing on OLLFs?

The lower limb is principally responsible for our ability to ambulate. A COS focusing on OLLFs will identify a more concise set of outcomes with greater specificity for measuring the patient experience of mobilising following OLLF compared to a COS developed for all open fractures. Although the BOAST guidance (187) and the NICE NG37 guideline (188) advocates for a minimum level of care for both upper and lower limb open fractures, clinically, they behave differently. It is well recognised that lower limb fractures typically take longer to reach clinical and radiological union compared to upper limb fractures. Lower limb fractures need to unite sufficiently to facilitate weight-bearing, while upper limb fractures do not. Also, OLLFs tend to have a higher risk of complications (principally infection leading to amputation in the most severe cases) compared to open upper limb fractures. It is theorised that this observation may be due to lower limb bones being

more superficial (the tibia) and having a poorer blood supply owing to an increased distance from the heart. It is likely that the BOAST guidelines for the management of open fractures were primarily aimed at OLLFs as they represent harder to treat pathologies and that the recommendations were extrapolated to include upper limb open fractures to ensure they also receive the best theoretical level of care.

1.6 Why is a COS needed for OLLF?

Currently, clinical trials evaluating new technologies to improve function and survival following OLLF fail to use standardised outcomes when measuring the effectiveness of interventions. Considerable outcome heterogeneity was identified in a recent systematic review conducted to determine how outcome is measured following adult tibial fractures (189). This review of a similar patient population highlighted not only outcome heterogeneity but also a lack of detail in the description of even the simplest outcomes and how they were measured, e.g. bone union, infection and reoperation, as well as poor and inconsistent use of PROMs (189). The issues with outcome-reporting are likely to be common to literature across all orthopaedic trauma; this increases the risk of outcome-reporting bias, makes it difficult to combine and compare results between studies, and hampers the development of clinical guidelines.

These problems can be addressed by developing a COS in partnership with patients. A COS will improve research design, efficiency, reduce research waste and ensure outcomes are meaningful to patients.

All MTCs are required to submit data to TARN. Currently, the outcomes reported are predominantly measures of process such as time to transfer, or gross measures such as mortality. OLLFs represent a key target for efforts to improve

clinical care. However, while we fail to measure appropriate outcomes, we cannot hope to improve the quality of care through clinical effectiveness trials, audit or service evaluation. TARN have begun collecting PROMs data (EuroQol 5-Dimensions (EQ-5D) and the Extend Glasgow Outcome Scale (GOSE)) on all major trauma patients, including those sustaining OLLFs but recognise that there is currently no evidence to guide the choice of OMIs in the OLLF population. This research will help meet TARN's aim to implement a meaningful set of OMIs to measure disability and patient experience of trauma. One of the key goals of this thesis will be the implementation of the COMIS within the TARN routinely collected national audit dataset; TARN has committed to supporting the incorporation of the COMIS once it is available.

Implementation of the COMIS by TARN will allow comprehensive measurement of core outcomes on patients presenting to MTCs following OLLF. This would facilitate investigation into the effect of regional variation in clinical practice on outcomes and open the door to future efficient embedded interventional studies.

1.7 Defining the scope of CO-OLLF project

Comprehensive literature and COMET database (69) searches (January 2017) identified no existing or planned COS for OLLF. This study was registered prospectively on the COMET database (http://www.comet-initiative.org/Studies/Details/688) see Appendix 5.

A Population, Comparison, Intervention and Outcome (PICO) approach in line with Cochrane guidance for defining project scope (39) was used to define the scope of the CO-OLLF study and describes the definition used for OLLF; detailed in Table 1.8

This study was guided by the COMET Handbook (70) and meets all currently available COMET guidelines and standards for COS development studies unless otherwise stated in the thesis discussion (68,70-73) (see Appendix 9 for a summary of key COMET guidance and standards).

PICO summary table to define the scope of CO-OLLF according to the criteria recommended by COMET (70)	
Population	Skeletally mature patients following open fracture of the lower limb treated by the NHS. Patients will be assumed to be skeletally mature at 16 years of age. An open fracture of the lower limb was defined as a break in any bone distal to the acetabulum of the hip joint where the bone is exposed to the outside environment—for example, an open fracture of the femur or below.
Types of Intervention/ Comparison	CO-OLLF will be suitable for all trials of interventions and for collecting important outcomes in routine clinical practice, e.g. local and national audits. Also, CO-OLLF should be feasible to embed within the TARN national open fracture audit. Health economic outcomes are considered out of scope for this project.
Outcome	n/a

Table 1.8. PICO approach to define the scope of CO-OLLF.

1.8 Thesis aims and objectives

1.8.1 Aims

The overarching aim of this DPhil project is to improve future research and clinical audit on patients following OLLF by unifying reporting of patient-centered outcomes, which is hoped will ultimately lead to better patient care. This project hopes to lay a foundation from which to create meaningful high-level evidence

synthesis for the care of patients following OLLF. This will be achieved by generating consensus for a set of core outcomes which will ensure the patient voice is heard in future study outcomes and reduce data heterogeneity and outcome-reporting bias. Specifically, this project aims to:

1. Identify important outcome priorities to adult patients following OLLFs and their stakeholders. Stakeholders will include healthcare professionals responsible for the care of patients recovering from OLLF, e.g. orthopaedic and plastic surgeons, physicians, general practitioners, nurses, physiotherapists, occupational therapists and trauma psychologists. Additionally, stakeholders will include study Patient and Public Involvement (PPI) members, key members of the TARN committee and medical academics, including academic clinicians and research methodologists with experience in measurement in medicine.
   This will inform a COS that will constitute the UK consensus for ***'what'*** outcomes should be measured.
2. Determine a COMIS for use with skeletally mature patients following treatment for OLLFs that will constitute the UK consensus for ***'how'*** outcomes should be measured.

1.8.2 Objectives and thesis overview

This DPhil project follows recommended guidance from the COMET and COSMIN initiatives as well as drawing on published experiences of other COS development groups, including OMERACT. Patient involvement has been a critical component of this project and will is described in Appendix 4. This thesis consists of five workstreams (WS):

WS1. What outcomes have been reported in the literature, and which OMIs have been used to measure them?

Chapter 2: a systematic review to identify outcomes reported on patients following OLLF from the published literature.

WS2. What outcomes are important to patients within their experience of recovery from OLLF?

Chapter 3: a secondary Thematic Analysis of interview transcripts exploring the lived experience of recovery from OLLF to identify outcomes important to patients.

WS3. Creation of an Inventory of Outcomes for OLLF.

Chapter 4: Structured discussion groups were used to refine outcomes identified in WS1 and WS2 to create an understandable and comprehensive list of candidate outcomes to present to stakeholders in the Delphi survey.

WS4. **What** is the COS that should be reported for patients sustaining OLLFs?

Chapter 5: Multiple stakeholder Delphi survey and consensus meeting to identify the COS for OLLF.

WS5. Do OMIs exist for outcomes identified in the COS?

What are their measurement properties? And…

How should core outcomes be measured?

Chapter 6: a systematic review to identify and assess the measurement properties of OMIs validated in the OLLF population. Development of novel criteria to select OMIs not validated in the OLLF population from those identified in WS1.

A final consensus meeting to identify the COMIS for OLLF.

See the thesis navigation road map below that schematically demonstrates WSs of the CO-OLLF study and how they relate to each other (Figure 1.6).

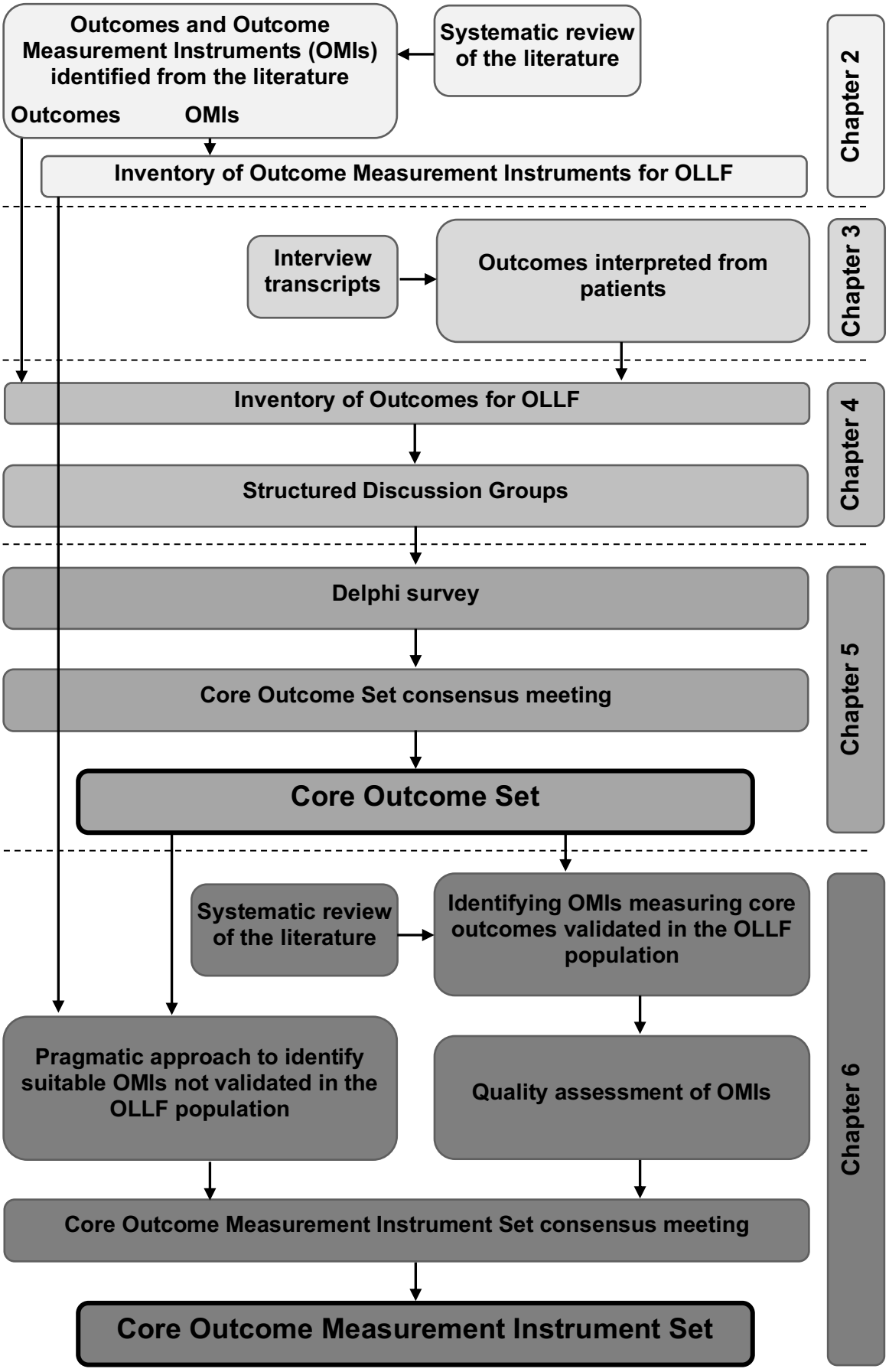


Figure 1.6. CO-OLLF study road map.

Chapter 2. A Systematic Review: What outcomes have been reported in the literature and how have they been measured?

2.1 Chapter summary

This Chapter lays the foundation for the CO-OLLF study by exploring 'what' and 'how' outcomes are currently reported across studies on OLLF. This Chapter reports a systematic review identifying all outcomes and Outcome Measurement Instruments (OMI) reported in the literature on OLLF from 2009 to 2019. A systematic review of the relevant literature is recognised by COMET as the first step in COS development (24,190).

Outcomes reported, and OMIs selected by clinical and non-clinical researchers when designing studies resulting in publication in the medical literature are likely to represent outcomes that are important to those stakeholders.

Research studies included in this systematic review, the outcomes they report and OMIs used are described and summarised in this Chapter. All outcomes identified were added to the Inventory of Outcomes and referred to in Chapter 4. All OMIs identified were added to the Inventory of Outcome Measurement Instruments and referred to in Chapter 6; when identifying how to measure core outcomes for OLLF.

The COMET Taxonomy of Outcomes is used throughout this thesis as a framework from which to categorise, organise and present outcomes.

See the Chapter 2 road map below that summarises key results and schematically illustrates the workflow of this Chapter (Figure 2.1).

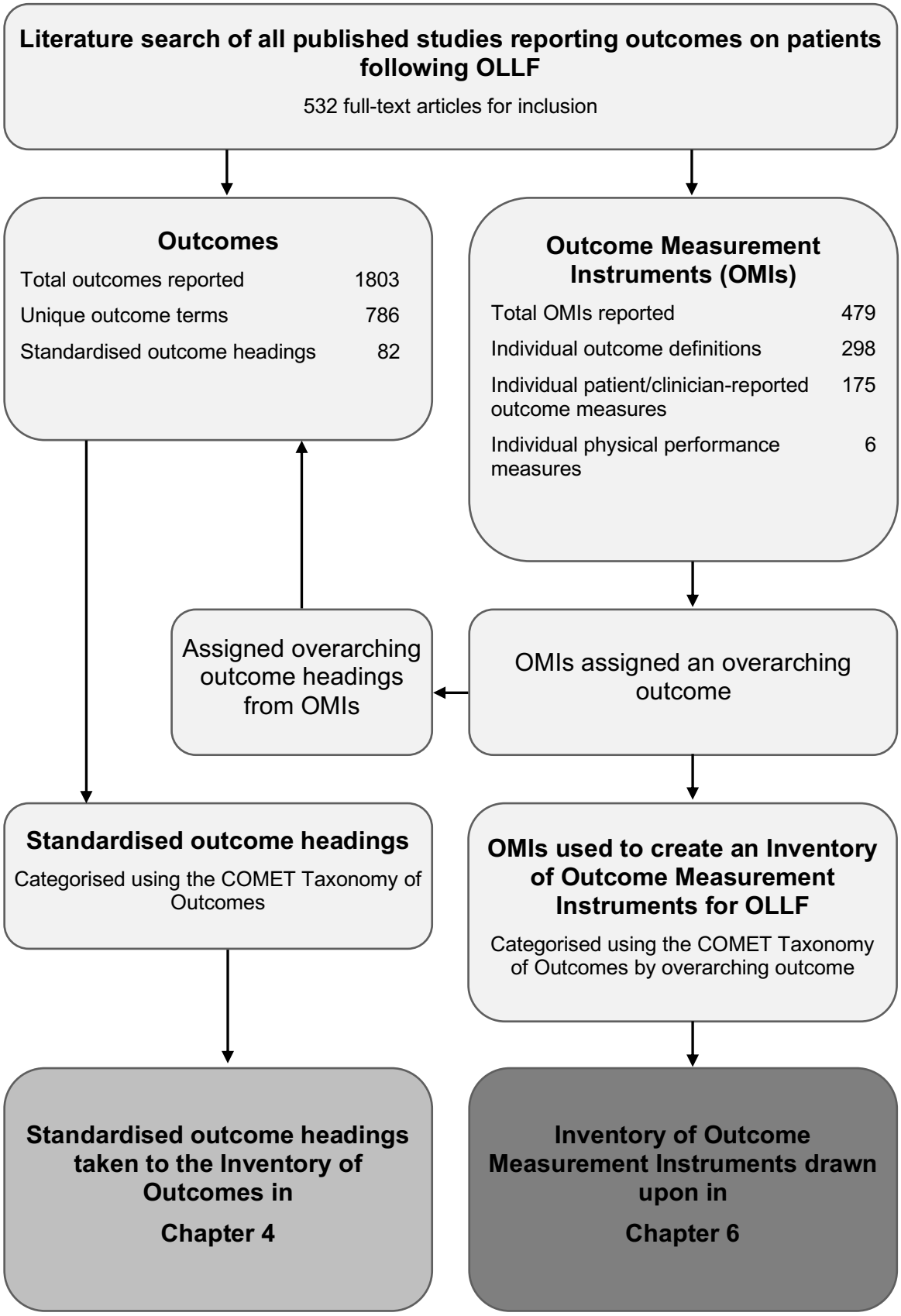


Figure 2.1. CO-OLLF study Chapter 2 road map.

2.2 Introduction

Advancements in medical and surgical practice have expanded the proportion of severely injured limbs that are now amenable to limb salvage and reconstruction (159,191,192). An ethos of patient-centered care is considered a guiding principle of modern medical practice, and as such the outcomes used in orthopaedic trauma research should reflect this, e.g. use of Patient-Reported Outcome Measures (PROMs). Consequently, measures of success need to shift from limb preservation to a more patient-focused approach (189). However, this does not appear to be reflected in the literature (133,189,193). Scoping searches of the literature undertaken in preparation for this project demonstrate that most studies reporting outcomes on patients recovering from OLLF tend to measure outcomes indicative of surgical success, e.g. objective clinical measures including bone union, alignment and infection status. These preliminary findings are supported by Morris *et al.* 2019, who demonstrates considerable outcome heterogeneity reported in studies on closed tibial fractures, as discussed in Chapter 1 (189).

The measurement of life impact outcomes such as function and quality of life using physical performance measures (PPMs) or PROMs appear to be largely neglected in the literature more generally (194) and particularly in the orthopaedic trauma literature in this area (189). Failure to measure outcomes important to patients will continue to propagate a discord between the surgeon and patient perceptions of successful treatment.

To develop a COS for OLLF, it is important to first determine what outcomes are reported and how they are reported (24,70).

This systematic review considered studies published after 2009. This point was chosen as a cut off due to the publication of BOA/BAPRAS Joint Standards for Open Fracture Management (130).

The introduction of the Joint Standards for Open Fracture Management in 2009 (130) was a defining milestone in the modern management of OLLF in the UK and was adopted throughout the world. The introduction of these guidelines is recognised as a point of change in the management of open fractures as they outlined for the first time a set of evidenced-based minimum treatment criteria to meet modern treatment standards. The uptake of these guidelines was high, and the treatment criteria they described became standards from which research studies, local and national audits used to report on successful processes of management of patients following open fractures. Efforts to meet the open fracture standards helped shape the UK trauma infrastructure, including the development of the Major Trauma Network and recognition of the importance of the orthoplastic unit. Only including papers published after 2009 allows the standards to be used as a guide for reporting outcomes in research and helps ensure that the outcomes identified in this review are representative of modern practice.

It is possible that some outcomes were reported prior to 2009 that may have been missed. However, the importance of these can be questioned if they have not been reported in the last 10-years.

2.2.1 Objectives

1. To identify, summarise and categorise outcomes reported in clinical studies on skeletally mature patients following OLLF.

2. To identify, summarise and categorise OMIs used in clinical studies on skeletally mature patients following OLLF.

2.3 Methods

The protocol for this systematic review was registered prospectively with the International prospective Register of Systematic Reviews (PROSPERO CRD42015024219, see Appendix 8). This systematic review was guided by the COMET Handbook (70) and reported by aid of the Preferred Reporting Items of Systematic Reviews and Meta-Analysis: The PRISMA Statement (195).

The scope of this systematic review is detailed in the PICO summary table detailed in Table 1.8, with the exception that the inclusion criteria will not be limited to studies on NHS patients.

2.3.1 Search strategy

The DPhil candidate (AA) consulted an Information Specialist at the Cairns Library, University of Oxford, when formulating search strategies.

Table 2.1 details the databases searched on the 20th of April 2017 and on the 12th of July 2019 using the Ovid advanced search function (Ovid Technologies, Inc 2020, Wolters Kluwer), CINAHL (EBSCO, Ipswich, MA, USA) and CENTRAL (Cochrane, London). The search strategy was principally derived for Ovid MEDLINE and adapted for other databases; a summary of the search strategy and search terms used is provided in Table 2.2 and detailed in full in Appendix 16. Searches were not limited by language or year of publication. Using the referencing software Endnote X9 (Thompson Reuters, New York, NY, USA), additional duplicates of full-text articles and conference abstracts that were later published in

full were removed. Following removal of duplicates, date filters were applied to identify studies published on or after the 1st of January 2009 in the primary search, and to identify studies published on or after the 1st of January 2017 in the search update. Duplicate articles identified between the 1st of January 2017 and the 20th of April 2017 were removed by hand.

Due to the significant period of time it took to complete workstreams presented in this thesis following the original literature search, a second updated literature search was necessary. In undertaking a near-identical literature search update two years after the primary search, it was possible to investigate whether any new standardised outcome headings were devised as a result of outcome extraction from later studies. This provided an opportunity to assess whether the primary literature search achieved data saturation on the identification of outcomes reported.

For full search strategies, see Appendix 16.

Databases searched and date ranges detailed	
Database	**Date range after addition of date filters (dd/mm/yyyy)**
Primary searches	
Ovid. **Medline** (Ovid MEDLINE® Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®) 1946 to the 20th of July 2017	01/01/2009 – 20/04/2017
Ovid. **Embase** 1974 to the 20th of April 2017	01/01/2009 – 20/04/2017
Ovid. **PsychINFO** 1806 to the 21st of April 2017	01/01/2009 – 21/04/2017
Cumulative Index to Nursing and Allied Health Literature (**CINAHL**) Database. EBSCO 1937 to the 21st of April 2017	01/01/2009 – 21.04.2017
Cochrane **CENTRAL** 1996 to the 11th of May 2017	01/01/2009 – 12/05/2017

Search updates	
Embase 1974 to present, **Medline** (Ovid MEDLINE® Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®) 1946 to the 12th of July 2019	01/01/2017 – 12/07/2019

Table 2.1. Databases searched and date ranges detailed.

Search strategy summary and terms used.		**Search type**
1	Open Fracture search component. Combined with Boolean terms: **'OR'**	
	Fractures, Open/ ((open or compound or severe* or mangle*) adj3 (fracture* or break*)).ti,ab.	MeSH Title and abstract search
2	Anatomical area search component. Combined with Boolean terms: **'OR'**	
	exp lower extremity/ or exp buttocks/ or exp foot/ or exp hip/ or exp knee/ or exp leg/ or exp thigh/ or Leg Bones/ or exp Foot Bones/ or exp Toes/ or Leg/ "lower extremit*".ti,ab or "lower limb*".ti,ab. or (leg or legs).ti,ab. or (foot or feet).ti,ab. or thigh*.ti,ab. or ankle*.ti,ab. or (hip or hips).ti,ab. or knee*.ti,ab. or femur*.ti,ab. or tibia*.ti,ab. or patella*.ti,ab. or talus*.ti,ab. or fibula*.ti,ab. or calcaneus*.ti,ab. or navicular*.ti,ab. or cuneiform*.ti,ab. or cuboid*.ti,ab. or metatarsal*.ti,ab. or phalan*.ti,ab. or (toe or toes).ti,ab. or pilon*.ti,ab.	MeSH Title and abstract search
3	1 **'AND'** 2	
MeSH- Medical Subject Heading (MeSH) exp – exploded MeSH heading * – Truncation/wildcard symbol ti – Title search (search for key word in article titles) ab – Abstract search (search for keywork in article abstracts) adj3 – Proximity search term (two words next to each other, in any order, up to 2 words in between		

Table 2.2. Search strategy summary and terms used.

2.3.2 Study eligibility

Inclusion criteria were designed to maximise data capture. The principal inclusion criteria were any clinical study reporting outcomes on skeletally mature patients, the majority of whom had sustained an OLLF. This systematic review defined the point where a mixed patient sample adequately reflects the inclusion criteria when considered studies had recruited 80% or more patients over the age of 16 years old following an OLLF. An arbitrary cut off of 80% was chosen to ensure that potentially relevant studies where the majority of participants recruited met the principal inclusion criteria were included. For example, any of the following clinical studies were included – RCTs, cohort studies, case-control studies, case series and cross-sectional studies. Systematic reviews were included as it is possible for the authors of a systematic review to specify novel outcomes (e.g. a new composite outcome that could be derived from individual outcomes reported in the existing literature). However, to avoid duplication, outcomes were not extracted from individual studies detailed in systematic reviews. Study protocols were included as outcomes were described and defined a priori. The inclusion of study protocols ensures the capture of outcomes to be reported in planned RCTs and systematic reviews. If an English-language abstract was available and gave details of the outcomes reported, the article was included even when the full text was non-English language. Where multiple papers were found reporting the same data, only the earliest article was included.

Case reports were excluded as outcomes were only reported on individual cases. Other studies excluded were paediatric studies, laboratory studies, animal studies, expert opinions where no pooled outcomes were presented and correspondence.

2.3.3 Title, abstract and full text screening

All titles and abstracts were screened independently by two researchers, AA and Dr Harry Claireaux (HC), using Rayyan (Qatar Computing Research Institute, Doha) against eligibility criteria. Disagreements were resolved by discussion between reviewers.

2.3.4 Full-text review and data-extraction

To increase efficiency, full-text review and data extraction were conducted simultaneously. The full-text screening was undertaken by AA, HC and Mr Christian Aquilina (CA). AA managed and undertook full-text screening and data-extraction on all shortlisted studies. HC undertook full-text screening and data-extraction on a random 15% sample of studies shortlisted from the primary search, and CA undertook full-text screening and data-extraction on a random 10% sample of studies from the search update. Each article identified for full-text review was assigned an article number, samples for duplicate full-text review and data extraction were identified using the random number generator function in Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA). Full-text review and data extraction undertaken by HC (15% sample in primary search) and CA (10% sample in search update) was compared with AA (100% of the sample in primary and updated searches) for consistency and suitability of studies included using the predefined inclusion criteria. The data extracted were reviewed for accuracy of data extraction and consistency of use of language when recording verbatim outcome terms. Study reviewers extracted data onto separate spreadsheets within the main online document, which allowed reviewers to check each other's work on

an ad-hoc basis and where differences occurred, they could be discussed and resolved in real-time.

A standardised data extraction sheet was created using Google Sheets (Google, Mountain View, California) and piloted before use to allow simultaneous data extraction by AA and HC/CA via 'the cloud' (see Table 2.3 for data fields collected).

All outcomes were extracted verbatim with any accompanying OMIs used, including outcome definitions and the time points of outcome measurement. All outcomes and OMIs were extracted whether or not they were specified in the methods or results section of each study. Outcomes were deemed to be defined where they were described in the study or referenced with a citation. Where an outcome was defined by a citation, the outcome definition was extracted verbatim from the cited article. Where studies reported PROMs or Physical Performance Measures (PPMs) without stating what outcomes they intended to measure, an overarching outcome was assigned as described below.

All verbatim outcomes extracted, including the frequency of reporting between 2009 and 2019, are detailed in Appendix 17.

In addition, all definitions of outcomes (objective clinical outcomes) were also extracted verbatim, as well as patient/clinician-reported OMIs and PPMs to create an Inventory of Outcome Measurement Instruments, which is presented in Appendix 18 and summarised in Figure 2.6. This was later used in Chapter 6 to identify suitable OMIs to measure core outcomes.

Data fields extracted	
Study demographics	**Study outcomes**
Publication date	Primary outcome identified/defined
Study title	**Extracted for each named outcome**
Journal	Primary or secondary outcome
Journal reference (volume, issue and page numbers)	Outcome wording (extracted verbatim)
Authors	Outcome definition
Language	OMI used to measure outcome
Location (country where research was conducted)	Time points measured
Abstract	**Extracted for each OMI**
Study design (e.g. RCT, cohort, case series etc)	OMI used
Study population (e.g. proportion of participants with open fracture)	Time points measured
Number of participants	Citation of OMI, where provided
Sex distribution of participants	
Age distribution of participants	
Study inclusion and exclusion criteria	

Table 2.3. Data fields collected in the data extraction sheet.

2.3.5 Assessment of bias

There was no data synthesis of study effect sizes in this systematic review; therefore, no assessment of the methodological quality of the studies was conducted.

2.3.6 Categorising outcomes and Outcome Measurement Instruments (OMIs)

2.3.6.1 Outcomes

As verbatim outcomes were extracted from the literature, they were reviewed in an iterative process to devise standardised outcome headings, which were then used to group verbatim outcomes. All similar outcomes were grouped under a standardised outcome heading, i.e. an outcome heading sufficiently representative of the outcomes in that group. For example, outcomes reported such as those

bullet-pointed below were assigned to the standardised outcome heading: ‘Bone union or healing’.

- Bone consolidation
- Bone healing
- Bone healing status
- Bone union
- Bony union
- Clinical bone union
- Clinical healing
- Clinical union
- Complete fracture healing
- Consolidation of fracture

Outcome headings were often representative of the most common outcome wording reported in the literature (see Appendix 17 for a full list of verbatim outcomes and the standardised outcome headings they were grouped under).

All standardised outcome headings were organised and categorised using the COMET Taxonomy of Outcomes as described below.

2.3.6.2 Outcome Measurement Instruments (OMIs)

OMIs included definitions of outcomes, patient or clinician-reported OMIs and PPMs. All OMIs identified were added to an Inventory of Outcome Measurement Instruments for OLLF, and categorised using the COMET Taxonomy of Outcomes as described below. This was achieved by establishing an overarching outcome for each OMI by either:

1. Using the outcome the OMI defined (e.g. in the case of an outcome definition) or was stated to measure in source literature (e.g. a PROM stated to measure quality of life such as the EQ-5D) in the source article.
2. Using an adapted method described by Macefield *et al.* 2014 and recommended by COMET (detailed in

3. Figure 2.2). This involved retrieving the source literature for the OMI and reviewing the individual items/scales of the instrument to assign an overarching outcome (70,196).

Overarching outcomes were then used to categorise each OMI to a COMET Taxonomy of Outcomes, outcome domain within the Inventory of Outcome Measurement instruments for OLLF.

Overarching outcomes devised from OMIs identified in the literature are also added along with standardised outcome heading to the Inventory of Outcomes described in Chapter 4.

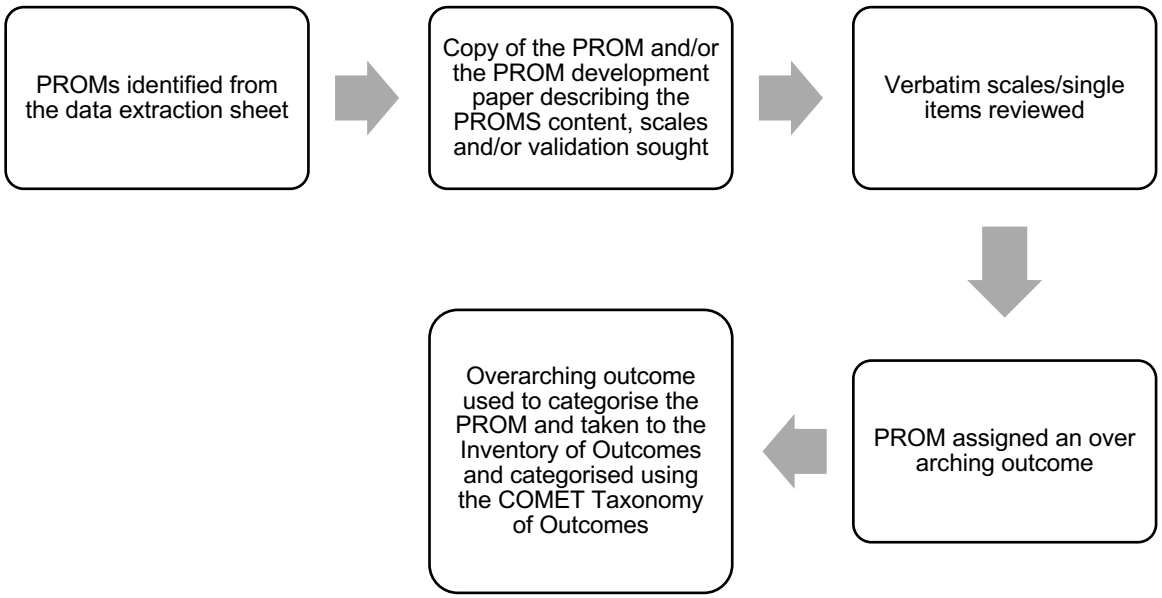


Figure 2.2. Schematic diagram of outcome extraction from PROMs.

2.3.6.3 Categorising and organising outcomes using the COMET Taxonomy of Outcomes

The workstream described in this Chapter used the COMET Taxonomy of Outcomes in two ways:

1. To categorise and organise standardised outcome headings into a hierarchical structure using the taxonomy's four core areas and 38 outcome domains (see Table 1.4 and Appendix 14) to give an organisational structure when presenting the systematic review findings on outcome-reporting (see Figure 2.5).
2. To categorise and organise OMIs identified in the literature when creating an Inventory of Outcome Measurement Instruments for OLLF that is later used in Chapter 6.

   The assigned overarching outcome for each instrument, as described above, was used to order OMIs by appropriate outcome domains, as demonstrated in Figure 2.6.

In addition, outcomes were categorised and organised using the COMET Taxonomy of outcomes to enable ease of integration with outcomes interpreted from the literature when creating the Inventory of Outcomes for OLLF described in Chapter 4.

2.4 Results

2.4.1 Studies identified

A total of 26,988 articles were identified from two electronic database searches: a primary and an updated search. After exclusion of duplicates and limiting of date

ranges, 4143 articles were shortlisted for title and abstract review. Article screening identified 606 articles for full-text review. Article screening conflict rate was less than 5%, and when conflict occurred, it was resolved by discussion between AA and HC or CA at face-to-face or virtual meetings.

At full-text review and data extraction, 74 articles were dropped, leaving the remaining 532 articles detailing outcomes reported on 429,076 participants for inclusion. Review of duplicate full-text review and data extraction by HC (15% of articles in primary search) and CA (10% of articles in search update) revealed no conflicts in studies included/excluded and no significant differences in data fields extracted. The PRISMA flowchart in Figure 2.3 details the study identification process in full giving reasons for article rejection at full-text review.

Study characteristics and demographics of included studies are detailed in Table 2.4. There was a relatively even spread in the number of studies published each year between 2009 and 2019; the lowest number of studies were published in 2009 (5%), and the highest was in the years 2015 and 2018 (11% respectively). Over 90% of studies had an observational design. Case series and cohort studies represented 53% and 29% of all included studies, respectively, and RCTs represented 5% or 29 individual studies (see Figure 2.4).

The majority of included studies reported outcomes on between 3 and 50 participants (52% of included studies). Studies were published in over 100 different scientific and medical journals; the most common journal of publication was Injury (11% of articles) (197). Studies were most commonly conducted in, or led by research groups based in the USA, UK and China (23%, 14% and 13% of articles, respectively).

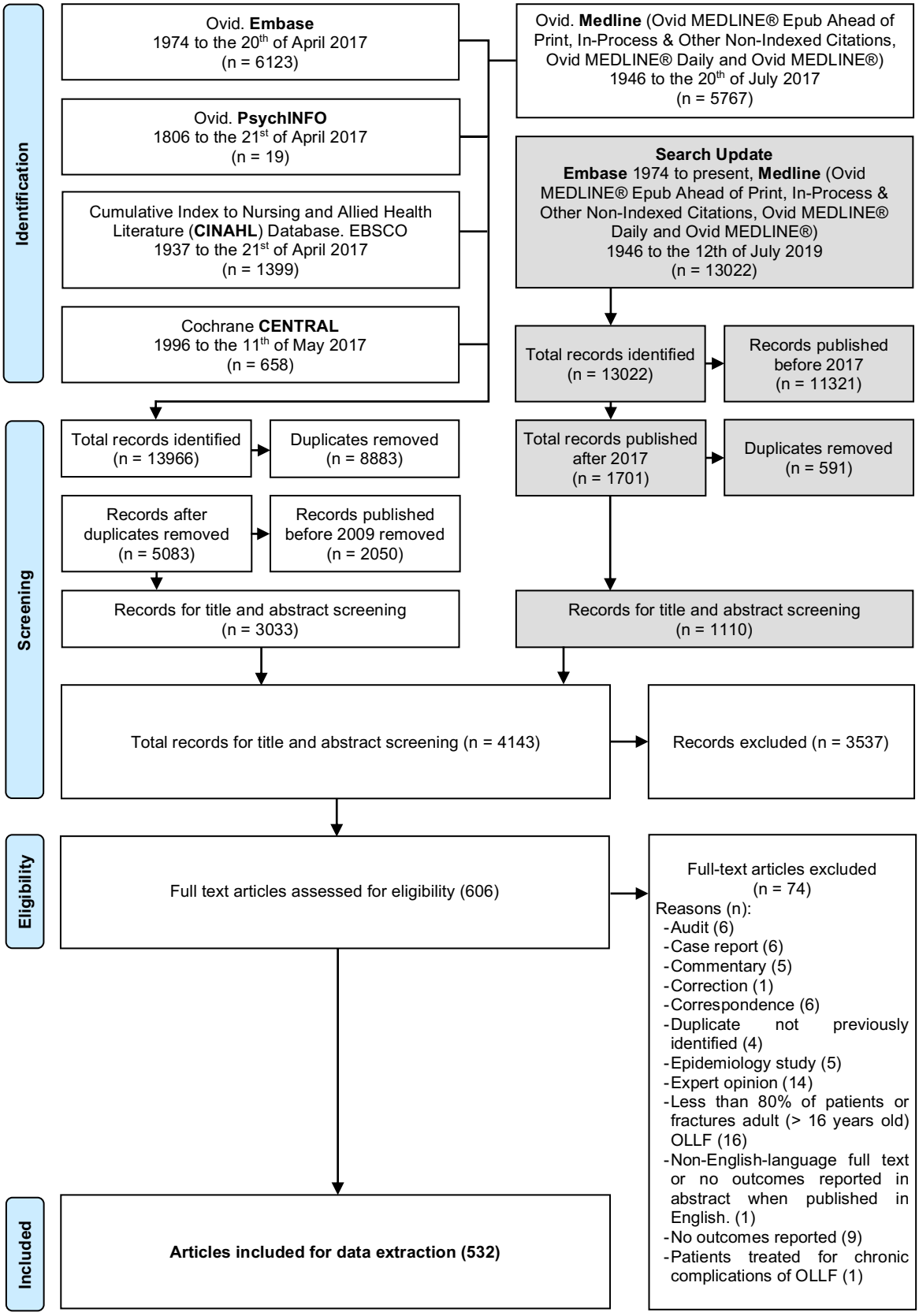


Figure 2.3. Chapter 2 PRISMA Flow diagram.

Characteristic (number of studies reported)	**Summary characteristics and demographics of included studies**										
Publication year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Number of studies (532)	27 (5%)	42 (8%)	51 (9%)	48 (9%)	47 (8%)	51 (9%)	58 (11%)	51 (9%)	53 (10%)	57 (11%)	47 (9%)
Study design	Case series	Retrospective cohort study	Prospective cohort study	Randomised controlled trial	Systematic review	Case control	Health economic	Qualitative	Cross-sectional	Protocol	Other
Number of studies (523)	275 (53%)	115 (22%)	38 (7%)	26 (5%)	23 (4%)	20 (4%)	8 (2%)	7 (1%)	4 (1%)	4 (1%)	3 (1%)
Number of participants (Total 429,076)	1 to 10	11 to 25	26 to 50	51 to 100	101 to 200	201 to 500	501 to 1000	Greater than 1000			
Number of studies (500)	35 (7%)	108 (22%)	117 (23%)	94 (19%)	60 (12%)	40 (8%)	16 (3%)	30 (6%)			
Top 10 journals of publication	Injury	Journal of Orthopaedic Trauma	International Orthopaedics	Bone and Joint Journal	China Journal of Orthopaedics and Traumatology	Journal of Reconstructive Microsurgery	Plastic and Reconstructive Surgery	Journal of Bone and Joint Surgery	Chinese Journal of Reparative and Reconstructive Surgery	Indian Journal of Orthopaedics	
Number of studies (532)	56 (11%)	52 (10%)	17 (3%)	16 (3%)	12 (2%)	11 (2%)	11 (2%)	11 (2%)	10 (2%)	9 (2%)	
Top 10 countries of origin	USA	UK	China	India	Turkey	Pakistan	Italy	Canada	Germany	Iran	
Number of studies (516)	117 (23%)	71 (14%)	68 (13%)	37 (7%)	22 (4%)	18 (3%)	17 (3%)	12 (2%)	10 (2%)	9 (2%)	

1. Where the study was conducted or if over multiple countries where lead author/institution was based.

Table 2.4. Summary characteristics and demographics of included studies.

A pie chart to illustrate study types identified in the literature

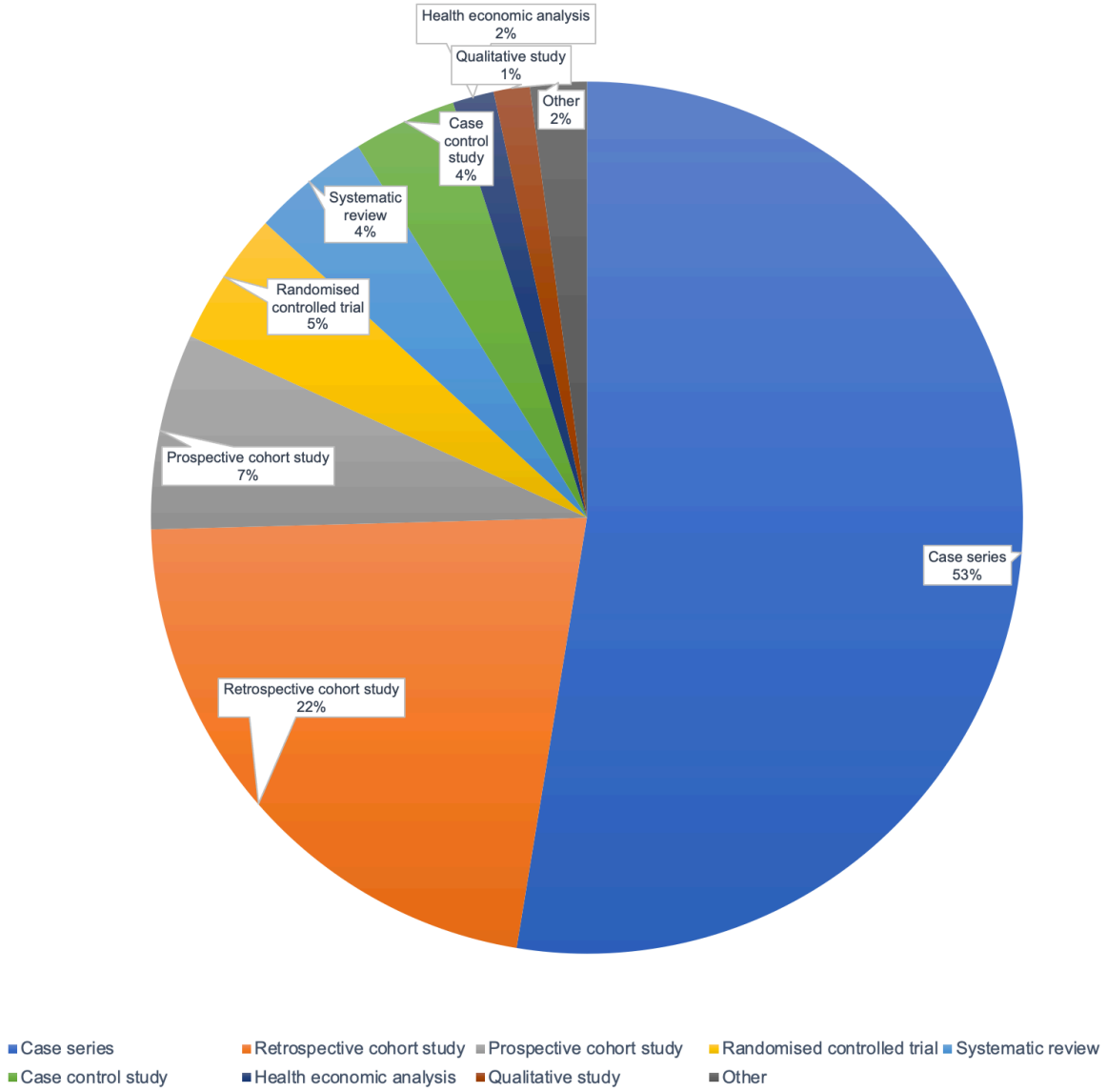


Figure 2.4. A pie chart to illustrate study types identified in the literature.

2.4.2 Outcomes reported

In total, 1803 individual outcomes were extracted verbatim from 532 included studies; after removing duplicate outcomes (outcome with identical wording), there were 786 unique outcome terms identified. The 786 unique outcome terms were grouped under 82 standardised outcome headings, which represented outcomes

with the same meaning but different wording. Standardised outcome headings were then categorised using the COMET Taxonomy of Outcomes.

Table 2.5 illustrates the number of times outcomes were reported in the literature categorised by the COMET Taxonomy of Outcomes, outcome domains. Reported outcomes are shown as: the number of all outcomes reported, outcomes reported with unique terminology and the number of standardised outcome headings created in each outcome domain. Figure 2.5 provides a conceptual schematic of all outcomes reported by standardised outcome headings detailing the number of times reported. Standardised outcome headings are colour-coded by the COMET Taxonomy of Outcomes core areas to facilitate ease of comparison of outcome-reporting differences between core areas (see Table 2.5, Figure 2.5 and Appendix 17 for a full list of unique outcome terms and the standardised outcome headings they were coded to).

All outcomes reported in the literature were categorised to 18 outcome domains detailed in Table 2.5 and Figure 2.5. The Musculoskeletal and connective tissue outcome domain was the most commonly reported with 1335 individual outcomes (74% of all outcomes reported) represented by 529 unique outcome terms, which were further collapsed to 41 standardised outcome headings (see Table 2.5 and Figure 2.7). The Musculoskeletal and connective tissue outcome domain consisted of outcomes representing objective clinical measures; the most commonly reported standardised outcome heading was ‘bone union or healing’ consisting of 265 individual outcomes (reported in 50% of included studies), which collapsed to 76 unique outcome terms. Besides ‘bone union or healing’, other ‘bone’ standardised outcome headings included ‘malunion or alignment’, ‘non-union’, ‘osteonecrosis’ and ‘’pseudoarthrosis’. Accumulatively the ‘bone’ outcomes were

reported 404 times representing 139 unique outcomes (see Appendix 17). After 'bone' outcomes, the next most commonly reported outcomes were around infection. Infection-related outcomes represented 371 outcomes and 85 unique outcome terms. Accumulatively, bone and infection outcomes represented 43% of all outcomes reported in the 532 included studies.

Outside the physiological/clinical core area, which was primarily dominated by outcome-reporting in the musculoskeletal and connective tissue outcome domain, 330 outcomes were reported in the life impact core area. Of the 330 outcomes, 258 were reported in the physical functioning domain represented by 149 unique outcome terms. The physical functioning domain mainly consisted of outcomes centered around lower limb function and ambulation. Global quality of life was only reported 32 times using 7 different unique outcome terms.

Of the 532 studies included, 129 (24%) stated a primary outcome. Infection was the most commonly reported primary outcome followed by bone union or healing in 27 (21%) and 15 (12%) studies where a primary outcome was stated, respectively.

Outcome domains identified how they were reported in 532 studies on adult OLLF.						
Outcome domain organised by the COMET Taxonomy of Outcomes, core areas and outcome domains	**Individual outcomes reported**	**Unique outcome terms reported**	**Standardised outcome headings created**	**Outcome Measurement Instruments (OMI)**		
				Definitions stated	**Individual patient/clinician-reported outcome measures or PPMs reported**	**Unique patient/clinician-reported outcome measures or PPMs reported**
Death						
Mortality/survival (1)	21	7	1	3	1	1
Physiological/ clinical						
Blood and lymphatic system outcomes (2)	10	8	1	0	0	0
General outcomes (9)	3	2	1	0	0	0
Musculoskeletal and connective tissue outcomes (15)	1335	529	41	239	9	3
Nervous system outcomes (17)	0	0	0	0	1	1
Renal and urinary outcomes (19)	5	5	2	2	1	1
Psychiatric outcomes (21)	0	0	0	0	3	3
Life Impact						
Physical functioning (25)	258	149	15	0	123	29
Social functioning (26)	4	4	2	0	0	0
Role functioning (27)	17	9	2	0	0	0
Emotional functioning/wellbeing (28)	11	9	5	0	2	2
Global quality of life (30)	32	7	1	0	39	8
Perceived health status (31)	2	1	1	0	0	0

Outcome domains identified how they were reported in 532 studies on adult OLLF.						
Outcome domain organised by the COMET Taxonomy of Outcomes, core areas and outcome domains	**Individual outcomes reported**	**Unique outcome terms reported**	**Standardised outcome headings created**	**Outcome Measurement Instruments (OMI)**		
				Definitions stated	**Individual patient/clinician-reported outcome measures or PPMs reported**	**Unique patient/clinician-reported outcome measures or PPMs reported**
Delivery of care (32)	6	5	2	1	2	2
Resource use						
Economic (34)	24	12	1	10	0	0
Hospital (35)	70	38	6	0	0	0
Need for intervention (36)	0	0	0	10	0	0
Adverse events						
Adverse events/effects (38)	5	1	1	33	0	0

Table 2.5. Outcome domains reported across 532 included studies.

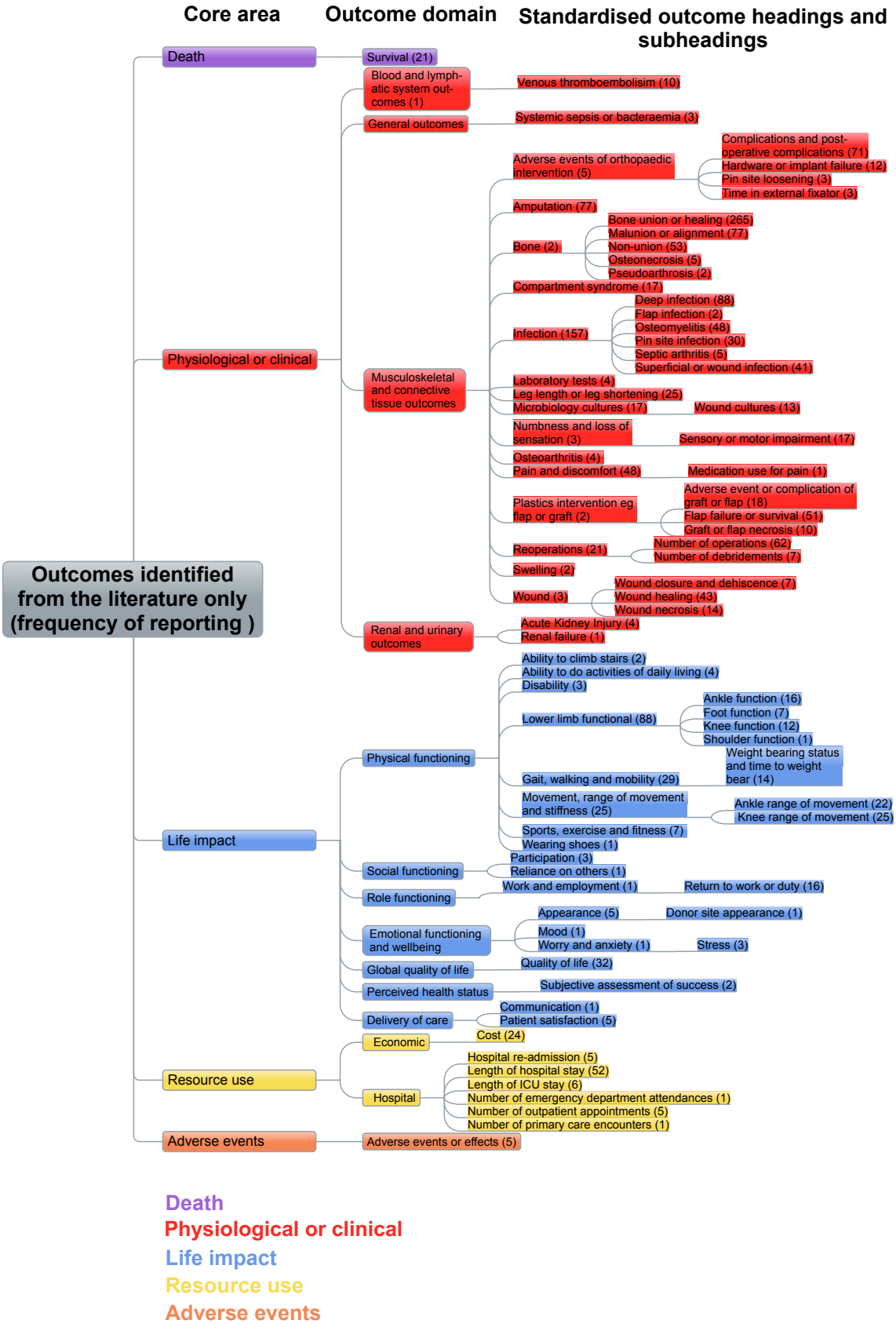


Figure 2.5. Standardised outcome headings identified from the literature and frequency of reporting.

2.4.3 Outcome Measurement Instruments reported

In total, 479 individual OMIs were identified across the 532 studies, which included 298 individual outcome definitions, 175 individual patient/clinician-reported outcome measures and six individual PPMs (see Table 2.5 and Appendix 18).

All OMIs extracted were categorised by their overarching outcome using the COMET Taxonomy of Outcomes and added to the Inventory of Outcome Measurement Instruments detailed in full in Appendix 18 and summarised in Figure 2.6 using a schematic diagram. Definitions were added verbatim, and source texts on composite OMIs, including clinician/patient-reported outcome measures and PPMs, were identified, cited, and used to summarise individual items or scales in each OMI detailed in Appendix 18.

Of the 1803 outcomes reported, 17% were defined (see Table 2.5 and Figure 2.7). The majority of outcome definitions were limited to outcomes categorised to the physiological/clinical core area and appeared to exclusively define objective clinical outcomes (see Figure 2.6). All individual outcome definitions were unique with respect to wording when describing the same outcomes. For example, ‘bone union or healing’ was the most commonly defined outcome. It was defined 50 times across all studies, with no two definitions being the same. No standardised definition texts were used across studies, with the caveat that several outcome definitions referred to the same citations when defining outcomes. For example, out of the 112 infection definitions, 20 studies either referred to, or cited the Center for Disease Control and Prevention (CDC) criteria for defining superficial or deep surgical site infection (149). However, despite referring to the same citations, definition texts differed in wording and often implied modification or variation of the

cited definition rather than stating that the citation definition was solely used to define and therefore measure the outcome of interest.

A total of 50 unique composite OMIs were used across included studies. The majority of composite OMIs were used to measure life impact, principally physical functioning and global quality of life outcomes (see Figure 2.6).

The physical functioning outcome domain was measured by 123 individual composite OMIs reduced to 29 unique OMIs. The most commonly used OMI for this domain was the Association for the Study and Application of the Methods of Ilizarov (ASAMI) criteria (198) used 24 times, followed by the American Orthopaedics Foot and Ankle Society (AOFAS) ankle-hindfoot scale (199) used 23 times (see Figure 2.6). A large proportion of the composite OMIs categorised to the physical functioning domain measured functioning of a specific anatomical area of the lower limb in combination with more general functioning such as ambulation. For example, on review of the individual scale items contained within the AOFAS ankle and hindfoot scale, it was demonstrated that the OMI measured ankle stability and hindfoot motion as well as more broad functional outcomes including walking on different surfaces, gait abnormality, functional limitations on activities and walking distance (see Appendix 18). For ease of presentation, OMIs measuring physical function specific to an anatomical area are categorised to the physical functioning domain only in the Inventory of Outcome Measurement Instruments summarised in Figure 2.6. However, the overarching outcome given where authors did not state what they intended the OMI to measure was assigned by the anatomical area of focus, e.g. the AOFAS ankle and hindfoot scale was assigned an overarching outcome of ‘ankle function’ which was taken forward to the Inventory of Outcomes in Chapter 4.

Across all included studies, quality of life was measured with composite OMIs 39 times using eight different instruments. The most commonly used instrument was the Short Form-36 (SF-36) (165), followed by the EQ-5D (200) used 17 and 8 times, respectively (EQ-5D-5L and EQ-5D-5L reported 6 and 2 times respectively).

Figure 2.6. Inventory of Outcome Measurement Instruments (OMI).

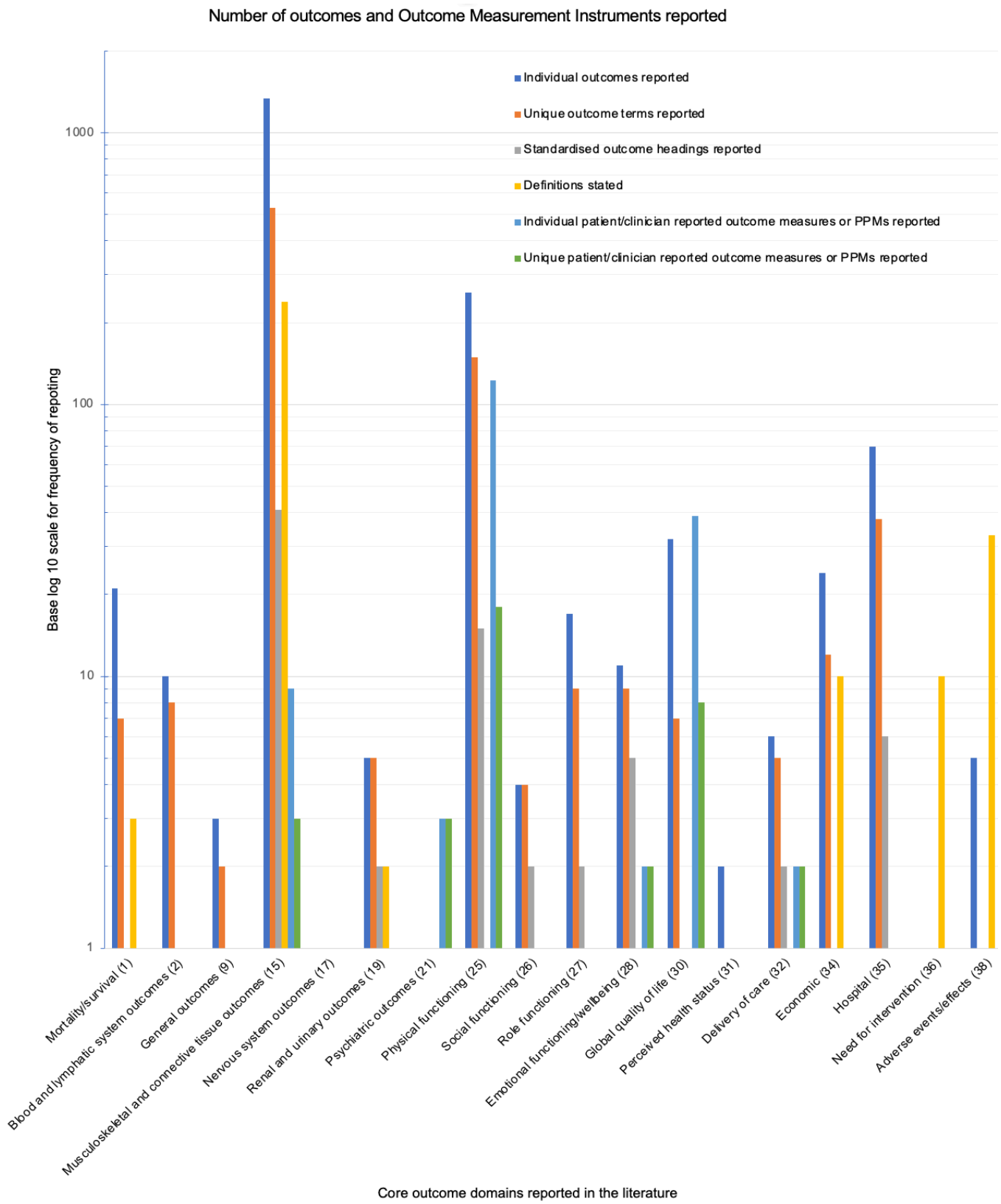


Figure 2.7. Logarithmic scale to show the number of individual and unique outcomes reported, the number of outcomes defined, and the number of individual and unique patient/clinician-reported outcome measures and physical performance measures identified in the literature.

2.5 Discussion

To the candidate's knowledge, this is the first systematic review of outcomes, and OMIs reported on patients following OLLF. This systematic review paints a picture demonstrating a lack of consistency in outcome-reporting and failure to use life impact measures across the literature on OLLF since 2009.

2.5.1 Heterogeneity of outcome-reporting

Widespread heterogeneity in the outcomes reported across all outcome domains is demonstrated in Figure 2.7, where the numbers of unique outcome terms used in each domain are shown to be around half the total number of individual outcomes reported. Also, large numbers of unique outcome definitions were used to define the same outcomes. This is illustrated in the musculoskeletal and connective tissue outcome domain, where the 1335 outcomes reported were reduced to 529 unique outcome terms represented by only 41 standardised outcomes. There were 239 unique outcomes definitions in the same domain with no standard texts used between studies when defining the same outcomes. Where studies cited outcome criteria such as the CDC surgical site infection criteria it was often modified in a way to fit the outcomes that had already been measured from a retrospective series case data. These findings illustrate widespread inconsistency in outcome-reporting, and little to no standardisation in outcome definitions. Widespread publication of low-quality retrospective studies demonstrating significant outcome heterogeneity creates a low level of evidence from which to inform best practice on the treatment of OLLF.

Such findings build evidence supporting the need to unify outcome collection and recognise the need for higher-quality studies in this research field. The creation of a COS for OLLF will provide an evidence base for collecting a homogeneous set of outcomes and outcome measures that may help address the current limitations identified in this field.

2.5.2 Reporting of life impact outcomes

Objective clinical outcome measures such as bone union, infection and flap failure represented the majority of outcomes identified in this literature review. This observation demonstrates an over-reliance on outcomes of surgical importance and is reflective of reporting outcomes of traditional importance to surgeons that are collected as part of routine practice due to their ease of measurement. This is despite recent guidance and research trends advocating for the increased measurement of life impact outcomes in the form of PROMs (130,201). Publication of the 'Standards for the Management of Open Fractures of the Lower Limb' in 2009 principally recommended the measurement of life impact outcomes in the form of the Enneking Score (180), which broadly assesses lower limb function in addition to the measurement of health-related quality of life suggesting the Short-Study Form-36 (SF-36) (165) or the Sickness Impact Profile (SIP) (202,203) as suitable tools (130). Despite these recommendations over 10 years ago, the 532 studies identified in this review reported using the Enneking score, SF-36 and SIP, 5, 17 and 5 times, respectively (see Figure 2.6).

There was a high degree of variation in the composite OMIs used to assess physical functioning (see Figure 2.7). Of the 18 different composite OMIs used, none were specific for measuring functioning following OLLF or traumatic injury.

The majority were designed to measure a specific functioning of an anatomical area in the context of elective orthopaedic surgery. OMIs measuring function also included five unique PPMs, including the 6-minute walk test (204), timed up and downstairs (205,206), timed up and go test (207) and the Hamlyn Mobility Score (HMS), which also consisted of a clinician and patient-reported component (208). The inclusion of PPMs in studies was encouraging as they provide an objective measure of functioning; however, despite their small number, there was still considerable variation in the types of PPMs used.

Quality of life was measured 39 times across all studies with little consistency in the OMIs used. A total of 8 different health-related quality of life (HRQoL) measures were identified (see Figure 2.6 and Appendix 18).

2.5.3 Systematic review strengths

This systematic review was ambitious in its data capture and included a large number of relevant studies over a 10-year period. As such, it is highly unlikely that any potentially important outcome term or OMI reported in the literature will not have been captured. Article title and abstract screening achieved a conflict rate between reviewers of less than 5%. Where conflicts did occur, this was predominately down to differences in interpretation over whether articles included a sample consisting of 80% or more patients following OLLF. This was difficult to ascertain from the study abstracts, and studies were given ‘the benefit of the doubt’ and included for full-text review to varying degrees by the reviewers. These differences were resolved before or during the full-text review. Full-text review and data extraction demonstrated rigour by checking two random samples of articles with independent reviewers for accuracy of applying the study eligibility criteria and

data extraction. Reviewers were in regular contact, and any queries over study eligibility or relevant data to extract were resolved by discussion. Also, by listing all outcome terms and definitions verbatim and summarising source literature for each composite OMI identified in this study (see Appendix 17 and Appendix 18), research transparency is demonstrated. This key detail allows reviewers to trace outcomes identified in the COS back to their source (70,209).

Due to the passage of time following the primary literature search, a search update was prudent. It is an accepted practice in COS development studies to conduct staged systematic reviews over different time periods and compare the outcome lists against each other to identify if data saturation has been achieved (70,209). When comparing outcomes identified from the primary search (January 2009 – April 2017) and the search update (January 2017 to July 2019), no new standardised outcome headings were created, suggesting data saturation was achieved in the primary search. Only the Medline and Embase databases were searched in the update; this decision was supported by the low yield of relevant articles identified from the PychINFO, CINHAL and Cochrane CENTRAL databases in the primary search.

2.5.4 Systematic review limitations

This systematic review limited inclusion of studies to those published after 2009. Limiting the systematic review to identify studies over a 10-year period was done to ensure the review remained focused on the relevant literature and manageable whilst avoiding unnecessary data extraction of potentially irrelevant literature. This decision is supported by COMET guidance (70). However, the addition of date limits can be viewed as a study limitation as outcomes important to stakeholders

may have been reported before 2009 and will have been missed. Although this is a possibility, it is unlikely, as the chances that outcomes, if important, would have been reported over the last decade. Also, as described above, a two-staged search was undertaken where no new standardised outcome headings were created following the updated search, suggesting data saturation was achieved.

Systematic reviews included in this review were only data extracted for composite outcomes they may have reported, i.e. outcomes reported in their included studies were not individually extracted, risking the possibility that potentially relevant outcomes were missed. However, where systematic reviews included eligible studies published elsewhere in the last 10-years, they will have been captured by this systematic review's broad and inclusive search strategy.

An additional constraint was that this systematic review was limited to the inclusion of studies published in the English language. Therefore, any outcomes reported exclusively in the non-English literature will have been omitted. However, this study's principal aim was to make a generalisable set of core outcomes for NHS patients recovering from OLLF. Data saturation was likely achieved as discussed above; therefore, it is likely that the outcomes identified are a comprehensive representation of those reported in the literature relevant to the UK OLLF population. Also, outcomes were extracted from non-English-language articles, where they reported an English-language abstract.

The categorisation of outcomes using the COMET Taxonomy of Outcomes is subjective, and as a result, there may be conflicting categorisation of outcomes between the outcome terms and the OMIs used to measure them, leading to inconsistencies (117). While the COMET Taxonomy of Outcomes provides an

excellent framework from which to categorise reported outcomes, it was not designed with the intention of categorising OMIs. Ultimately, the categorisation of outcomes and OMIs is a method to structure, organise and present data to stakeholders in the later parts of this project. Importantly each relevant outcome needs to be identified and presented in such a way that it can be traced to its source (70), which this systematic review achieves, as demonstrated in Appendix 17 and Appendix 18. Using an outcome framework such as the COMET Taxonomy of Outcomes, it is possible to see the spread of outcomes across core areas and the underlying outcome domains allowing COS developers to identify any apparent gaps in outcomes identified from the literature. Unexpected gaps, if present, may indicate that data saturation was not achieved. Figure 2.7 demonstrates that outcomes were spread across the outcome domains one would intuitively expect to have been reported in the literature on OLLF.

2.6 Conclusion

This systematic review highlights significant inadequacies in outcome-reporting in the current body of literature on OLLF. This is both in terms of outcome heterogeneity across the board and a failure to report on life impact outcomes measuring patient's functional recovery despite guidance published in 2009, advocating the use of PROMs. There was an over-reliance on objective clinical outcomes reported in the literature, which is a likely consequence of the significant proportion of included studies being retrospective and observational in design.

In the small number of composite outcomes identified, there was little consistency in their use between studies, including prospectively designed interventional studies. Combined with large variations in the reporting and definitions of the

objective clinical outcomes, the potential for any future attempts at conducting a meaningful meta-analysis of data in this field will be difficult at best.

Given the importance of delivering care to patients following OLLF, there appears to be a relative lack of well-powered RCTs in this area. This systematic review demonstrates the need to increase consistency of outcome-reporting, and promote the use of life impact outcomes, e.g. PROMs in this field.

Chapter 3. What outcomes are important to patients within their experience of recovery from OLLF?

3.1 Chapter summary

This Chapter answers the research question: what outcomes are important to patients in their experience of recovery from OLLF?

A Thematic Analysis of 25 interview transcripts exploring the lived experience of recovery from OLLF resulted in the development of 88 outcome themes and subthemes that were interpreted from the data and mapped to 19 outcome domains of the COMET Taxonomy of Outcomes (12).

Interviews were undertaken on a purposive sample of 25 patients to include a range of sex, age and grade of injury within the eligibility criteria of the WOLLF study (OLLFs that could not be closed at the primary surgery). Interviews were conducted by Drs Elizabeth Tutton (ET) and Sophie Rees (ET is a DPhil supervisor) as part of the WOLLF trial. Interviews were semi-structured using a topic guide to cover participant's thoughts, feelings, activities, function and work to direct an exploration of the lived experience of recovery following OLLF (1).

See the Chapter 3 road map below that summarises key results and schematically illustrates the workflow of this Chapter (Figure 3.1).

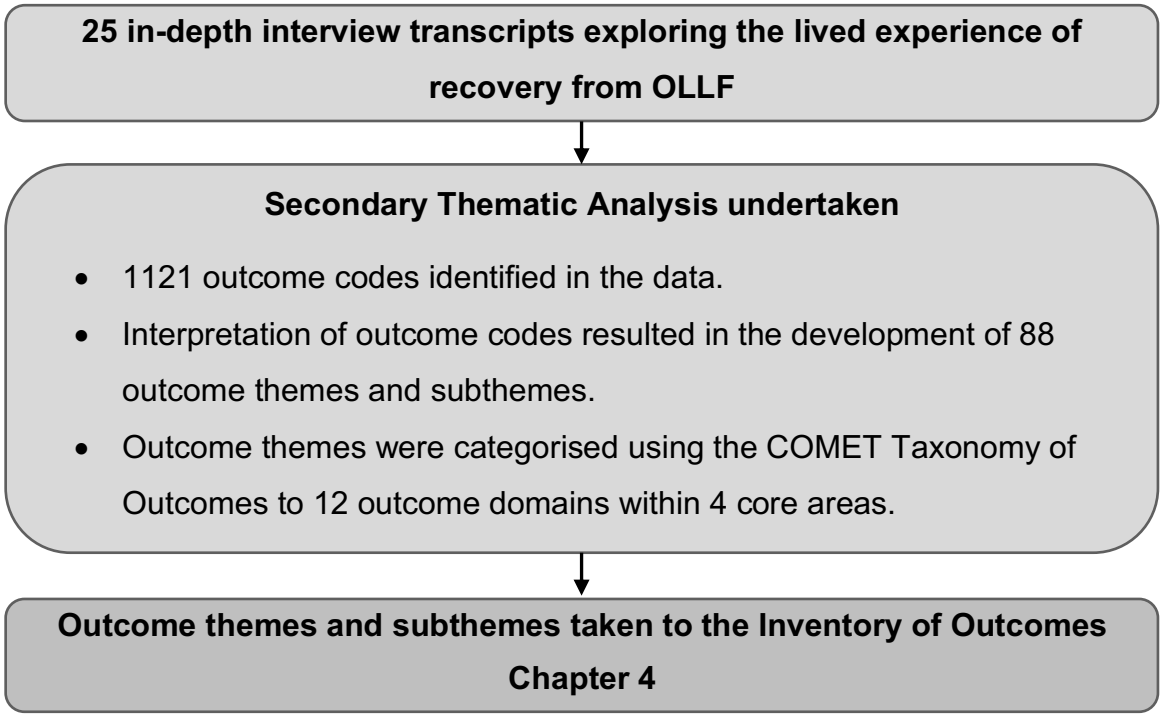


Figure 3.1. CO-OLLF Chapter 3 road map.

3.2 Introduction

3.2.1 Current understanding of the lived experience of recovery following OLLF

There is a small but expanding body of qualitative evidence exploring the patient experience of major trauma of the lower limb, and in particular, the lived experience of recovery from OLLF (1,101,210-216). The aims, methods and findings of these studies are summarised in Table 3.1.

The impact of OLLF was characterised by a core concept of embodied vulnerability in the acute phase of recovery, which extended in the longer term. Patients struggled to recover and accept a changed body, experienced cycles of progress and setbacks while learning to live with a new and uncertain future (1,101,215). This vulnerability is evident in the emotions expressed by patients (1,211,213,215),

loss of mobility (1,211,213,215), the uncertainty and fear of the future (1,211,213,215), pain (1,213,215), and having to adapt to changes in their body and how they live (1,212,213,215). The studies were methodologically sound but varied in their intent for understanding experience, decision making, satisfaction and outcome development. Timing of interviews post-injury varied from during hospitalisation up to 12 years post-injury.

Patient insights into the often-hidden world of recovery from OLLF sheds light on critical areas of their recovery; this starkly contrasts with the majority of outcomes currently reported in the medical literature identified in Chapter 2. This contrast suggests that when measuring outcomes following treatment of OLLF, researchers may be failing to measure outcomes that are most important to patients. Until this is addressed, we cannot hope to provide patient-centered care going into the future.

3.3 Objectives

1. To identify, thematise and categorise outcomes important to patients recovering from OLLF between two- and four-years following injury to the COMET Taxonomy of Outcomes framework.

Summary of qualitative studies on the patient experience recovering from OLLF			
Study (title and author)	**Aims and Participants**	**Methods**	**Findings**
A qualitative study of patient experience of an open fracture of the lower limb during acute care. Tutton *et al.* 2018 A (215)	Aim: To explore the early experience of patents who suffer major trauma. Participants: A purposive sample of 20 patients (male 16, female 4, mean age 40 years, range 20-82) sustaining GA II (4) and III (16) OLLF recruited to the WOLLF Trial (HTA 10/57/20) between July 2012 and July 2013 from two hospital sites. The mean time from first surgical intervention to interview was 12 days (range 5-35).	Patients underwent a semi-structured interview in the ward environment (mean interview length of 54 minutes) undertaken by a single researcher. Interviews sought to primarily explore what it is like to be injured. Prompts such as “tell me more about that” and “how did you feel?” were used to allow the interviewee to give a narrative with little intervention by the interviewer. The study draws on phenomenology and the work of Heidegger. Interview transcripts were analysed by coding a group of sentences or paragraphs based on the meaning within the text. Similar codes were then grouped to form a category, which were grouped to form themes. Data were organised using the computer software package NVIVO 10	An overall theme of vulnerability was identified. The impact of the injury was found to be far-reaching, affecting all aspects of an individuals’ sense of self. The extremely challenging early experience of OLLF was highlighted; it required a high-degree of personal resilience and reliance on others. Vulnerability was found to be expressed through three themes: ‘Being emotionally fragile’, ‘being injured’ and ‘living with injury’.

Summary of qualitative studies on the patient experience recovering from OLLF			
Study (title and author)	**Aims and Participants**	**Methods**	**Findings**
		(QRS International, Warrington, United Kingdom).	
Participation in a trial in the emergency situation: a qualitative study of patient experience in the UK WOLLF trial. Tutton *et al.* 2018 B (216)	Aim: To understand the patients' lived experience of taking part in a trial of wound dressings. The study also aimed to explore the reasons patients gave for taking part in a trauma trial and identify the benefits and challenges of participation in the context of a traumatic injury. Participants: As above	The study drew on phenomenology and used the same source data as described above. However, analysis focussed on exploring the patient experience of taking part in a trauma trial. Questions were asked at interview such as, "what is it like to take part in the trial?" followed up with prompts, such as "how did that feel?" and "what did you think?" Analysis identified codes derived from meanings inherent in the narrative to create categories and themes.	A theme of being compromised was identified, which was expressed through the categories of being dependent, being trusting, being grateful and being without experience. Patients found that being part of the trial closely aligned to their broader experience of injury.
Negative-pressure wound therapy versus standard dressings for adults with an open lower	This qualitative study was conducted as part of the WOLLF HTA Project, which was published separately above. Aims as per two studies above.	As per Tutton *et al.* 2018 A and B described above	As per Tutton *et al.* 2018 A with the addition of 'being compromised' as a fourth theme expressing vulnerability.

Summary of qualitative studies on the patient experience recovering from OLLF			
Study (title and author)	**Aims and Participants**	**Methods**	**Findings**
limb fracture: The WOLLF RCT. Costa *et al.* 2018 (101)			
Patient experience of long-term recovery after open fracture of the lower limb: a qualitative study using interviews in a community setting. Rees *et al.* 2019 (1)	Aim: To understand the patients' lived experience of OLLF at 2-4 years post-injury. Participants: A purposive sample of 25 patients (male 19, female 6, median age 51) recruited during follow up between October 2016 and April 2017 who were recruited to the WOLLF Trial. All patients sustained a GA grade 2 (4) or 3 (21) OLLF with a median number of months post-injury of 31 (range 24-49).	This study was informed by interpretive phenomenology and the work of Heidegger. Interviews were semi-structured and conducted face-to-face by two experienced researchers either in the participant's own home, a local hospital, or over the phone. Interviews had a mean length of 60 minutes (range 25-100). Interviewers used open questions such as "what has it been like for you since your injury?", with prompts such as "tell me more about that" and "how did that feel?" used to enable participants to share their experience.	The study identified an overarching theme of 'struggling to recover' where participants aim to make sense of their injury, balance striving to move forward with accepting how they are, finding meaningful ways of living while being uncertain of the future, and experiencing cycles of progress and setbacks. Three subthemes were identified including, 'being disempowered', 'being changed' and 'being myself'. The study also suggests that the theme of vulnerability identified in the acute phase of recovery (101,215) extends into the longer term.

Summary of qualitative studies on the patient experience recovering from OLLF			
Study (title and author)	**Aims and Participants**	**Methods**	**Findings**
		Analysis of interview transcripts was undertaken by two researchers in an iterative process where an initial code was generated highlighting sections of text for underlying meaning. Codes were then drawn together to generate categories and themes. NVIVO 11 (QRS International, Warrington, United Kingdom) was used to organise data. Findings were discussed with members of the WOLLF Trial PPI group.	
A qualitative approach to recovery after open tibial fracture: the road to a novel, patient-derived recovery scale.	Aim: To assess how patients perceive their recovery from open tibial fractures, adding to the understanding of the patient experience of OLLF and to define a list of categories to inform the development of an outcome measurement tool.	Two researchers conducted interviews in a non-clinical site on the hospital grounds each lasting approximately one hour. An interview guide was used to ensure key broad topics of recovery were not neglected. Open-ended questions were used with prompts to ensure the patient story was freely followed. Interviews were	The study identified 538 poignant items, the majority of which took the form of direct patient quotes. Items were then mapped to 17 categories: pain; mobility; flexibility; temperature (effects on symptoms); fear; appearance; sleep; diet/weight; employment; social; finance; impact on others; self-care; recovery (patient perceptions of recovery); frustration; goal-setting

Summary of qualitative studies on the patient experience recovering from OLLF			
Study (title and author)	**Aims and Participants**	**Methods**	**Findings**
Trickett *et al.* 2012 (213)	Participants: A purposive sample of 9 patients (9 male, 3 female mean age at injury 44.1 years, range 29.7-62.2 years) who had suffered an open tibia fracture were recruited from the Lower Extremity Fracture Database at Morriston Hospital, Swansea. All patients had been discharged from routine clinical follow-up and were considered to be 'clinically healed'. Mean time from injury to interview was 2.3 years. The patient group represented a broad range of injury severity and a spectrum of surgical treatments used.	audio-recorded, transcribed verbatim and content was confirmed by the patient. The study states that a conventional content analysis was used to develop codes and refine categories. Each researcher worked independently before working together to agree categories.	(by patients and healthcare providers); and adaptation (both physical and mental). Pain and mobility were felt to be centrally important to the recovery of all patients interviewed.
The development of a novel patient-derived recovery	Aim: To develop a PROM for patients recovering from open tibial fractures. This study builds	The study drew on the findings of Trickett *et al.* 2012, described above, which was used to generate a pool of items from	The study identified an outcome measurement instrument consisting of eight components and 10 response items using a 5-point Likert

Summary of qualitative studies on the patient experience recovering from OLLF			
Study (title and author)	**Aims and Participants**	**Methods**	**Findings**
scale for open tibial fractures. Trickett *et al.* 2020 (214)	on Trickett *et al.* 2012, described above. Participants: 35 participants identified from the Lower Extremity Fracture Database, Morriston Hospital, Swansea, that suffered an open tibial fracture completed the alpha scales. The beta scale was then developed and completed on 228 occasions by 204 participants from five orthoplastic units between October 2011 and December 2013. An additional second beta scale was completed by 21 patients from the John Radcliffe Hospital, Oxford.	which to create a 109-item alpha scale. The returned alpha scales were analysed for respondent redundancy, missing values, item redundancy, and interim correlation coefficients. Following refinements, the beta scale was developed consisting of 50 Likert and eight non-Likert items. The beta scale responses were analysed to determine reasonable interim correlations before multiple principal component analysis was undertaken. An Eigenvalue was calculated, which suggested retaining ten items.	response scale, the Wales Lower Limb Trauma Recovery (WaLLTR) scale. The WaLLTR scale is discussed later in this thesis.
A qualitative analysis of the decision-making process for	Aim: To investigate the decision-making process for patients and healthcare professionals for	Participants all underwent semi-structured interviews using a standardised interview guide with a single researcher. The	The study identified that patients were generally satisfied with their treatment and explored the feelings of patients who expressed decision

Summary of qualitative studies on the patient experience recovering from OLLF			
Study (title and author)	**Aims and Participants**	**Methods**	**Findings**
patients with severe lower leg trauma. Aravind *et al.* 2010 (210)	reconstruction vs amputation for OLLF. Participants: 20 participants (male 15, female 5, mean age 47 years, range 23-68 years) were selected from a medical record review identifying GA IIIB (17) and IIIC (6) open tibia fractures treated between 1997-2007 from a single US institution. A total of nine patients required amputation, four of which were primary. The mean time from injury to interview was 6.8 years (range 2.3-12). A 100 USD gift card was given for participation. Although the authors do not state a purposive sampling strategy, it appears patients were recruited from a diverse range of demographic backgrounds.	interviews were audio-recorded and transcribed verbatim. Visitors, including spouses were invited to join the interviews and add comments. A grounded theory methodology was used to analyse the data. Two researchers independently coded the data before a process of open coding and discussion to minimise bias from personal perspectives before a code-book was created. The authors did not describe or clarify what systematic procedures they used to develop their inductively derived theory around the phenomena. It is likely that their analysis was more in line with an inductive thematic approach than that of grounded theory.	regret. The authors suggested that the majority of patients interviewed who had a reconstruction were pleased to still have their leg and that the majority of patients that had amputations were happy to be alive. Patients who had reconstruction wanted to know if their physical function would have been improved with amputation and whether amputation would have resulted in a quicker, less painful recovery. While the second thoughts of patients who had secondary amputation were themed around whether further reconstructive surgeries would have ultimately resulted in them keeping their legs. The study suggests that younger more highly physically active patients are more likely to be dissatisfied with their treatment and recovery due to the significant impact the injury had on the levels of physical functioning.

Summary of qualitative studies on the patient experience recovering from OLLF			
Study (title and author)	**Aims and Participants**	**Methods**	**Findings**
A qualitative study of recovery from type III-B and III-C tibial fractures. Shauver *et al.* 2011 (212)	Aim: To explore the patient experience, including satisfaction after type III-B or III-C open fractures of the tibia. Participants: As per Aravind *et al.* 2010 described above with the addition of describing a purposive sampling strategy. It is likely that this study was undertaken as a secondary analysis of the data collected in Aravind *et al.* 2010.	As per Aravind *et al.* 2010 described above	The study identified three broad categories; 'effects on life', 'medical treatment' and 'medical decision making', which emerged from 23 codes. The study analysis focussed on the' effects on life' category. The authors detail the effects on life category consisted of 9 codes; physical functioning, pain, energy, work, impact on family, body image, social life, other's reaction to injury, overall life effects. Given that the authors state the study focus was on the 'effects on life' of an open tibial fracture they do not go beyond providing quotes to justify their codes, there is no discussion on how the codes emerged from the data. The brevity in this study is a likely consequence of a secondary analysis being conducted on the data collected by Aravind *et al.* 2010(210) which was collected primarily to explore the decision making process around reconstruction or amputation.

Summary of qualitative studies on the patient experience recovering from OLLF			
Study (title and author)	**Aims and Participants**	**Methods**	**Findings**
			The authors go on to explore a paradox they describe between poor functional outcomes following injury and generally good patient satisfaction. The authors hypothesise that satisfaction following injury is a likely result of adaptive coping strategies and go on to describe a cognitive framework demonstrating the relationship between stress, adaptive coping, self-efficacy and personal growth.
Meaning of living with external fixation for grade III open fracture of lower limbs: patient view. Lopez *et al.* 2013 (211)	Aim: To understand the meaning of living with an external fixator used in treating GA III OLLF, from a patient perspective. Participants: 6 participants (male 5, female 1, age-range 20-40 years) diagnosed with GA III OLLF identified from medical records at a single centre in Sao Paulo, Brazil, were invited to interview between June to August	This study was conducted as part of a Master's degree thesis and used principles of phenomenology. Participants underwent a semi-structured interview in a private location. Open questions were used to explore the patient experience which included; "tell me how it feels to live with a fastener attached to your body?" and "What are your feelings with regard to this situation?"	The study identified an overall theme of "seeking to live despite being trapped in a cage". This was expressed through three categories; "facing a sudden interruption in everyday life", "feeling trapped in a cage" and "seeking to restructure life despite the accident and the cage". Authors identified that patients struggle to deal with a new and changed body, altering their relationship and interaction with the world. Patients feared for the future and worried about the likely success of treatment. An additional

Summary of qualitative studies on the patient experience recovering from OLLF			
Study (title and author)	**Aims and Participants**	**Methods**	**Findings**
	2010. All patients were treated with an Ilizarov circular external fixator.	Interviews were transcribed verbatim, and the authors describe a four-step analysis process consisting of generating an overview of the narrative, dividing the report into ‘units of meaning’, transcribing units of meaning into a psychological understanding, and then the composition of general and specific synthesis to understand the structure of the patient experience.	need for emotional support was highlighted, and it was suggested that patients benefited where nursing staff participated in and encouraged the development of support networks.

Table 3.1. Summary of qualitative studies on the patient experience recovering from OLLF.

3.4 Methods

3.4.1 Secondary analysis

This DPhil project draws on primary data collected by Drs Elizabeth Tutton (ET) and Sophie Rees in a study funded by the WOLLF Trial HTA-10/57/20 Grant, the results of which are published separately (1) and summarised in Table 3.1. A purposive sample of 25 participants between 2- and 4-years post-injury was recruited from the WOLLF Trial participants between October 2016 and April 2017 during routine clinical follow-up. Purposive sampling included a range of sex, age, mechanism of injury, the severity of OLLF and time since injury (see

Patient number	Age (years)	Sex	Severity (assessed using the Gustilo and Anderson classification, see Table 1.5)
1	51	F	III A/B
2	69	F	II
3	78	F	III A/B
4	59	M	III A/B
5	48	M	III C
6	46	M	III A/B
7	27	M	III A/B
8	74	M	II
9	29	M	III A/B
10	70	M	III C
11	27	M	III A/B
12	57	M	III A/B
13	57	M	III A/B

14	26	F	III A/B
15	51	M	III A/B
16	44	M	III A/B
17	49	M	III A/B
18	48	M	III A/B
19	51	F	III A/B
20	42	M	II
21	44	M	III C
22	44	M	III A/B
23	80	M	II
24	64	M	III A/B
25	53	F	III A/B

Table 3.2). Participants were only recruited to the WOLLF Trial if, at the end of their first debridement surgery, wound closure was not possible, necessitating additional treatment with skin or muscle flaps. This eligibility criterion ensured that all patients recruited were at the higher end of the OLLF severity spectrum (excluded patients with GA type I OLLF, whose wounds could be closed in the primary surgery). Thus, interview data reflected the patient recovery journey following a GA II or-III OLLF. Ethical approval for the interviews was granted by the NHS Health Research Authority (12/WM/0001). See Table 3.1, Rees *et al.* (2019) for a description of interview methods.

Demographic information on the patient sample recruited to undertake the 25 qualitative interviews. Adapted from Rees *et al.* 2019 (1)	
Patient characteristics	**Number of participants**
Sex	
Male	19

Female	6
Age (years) median 51, range 26–80	
18–29	4
30–49	8
50–69	9
70–80	4
Time since injury (months) median 31, range 24–49	
24–35 months	14
36–49 months	11
Cause of injury	
Car collision	8
Motorbike collision	5
Pedestrian–vehicle collision	3
Fall from height/stairs	3
Crush injury at work	3
Low energy fall (from standing)	2
Bicycle–vehicle collision	1
Injury severity, Gustilo and Anderson classification	
II	4
III (inclusive of A/B)	18
III C	3

Demographic information by individual patient

Patient number	Age (years)	Sex	Severity (assessed using the Gustilo and Anderson classification, see Table 1.5)
1	51	F	III A/B
2	69	F	II
3	78	F	III A/B
4	59	M	III A/B
5	48	M	III C

6	46	M	III A/B
7	27	M	III A/B
8	74	M	II
9	29	M	III A/B
10	70	M	III C
11	27	M	III A/B
12	57	M	III A/B
13	57	M	III A/B
14	26	F	III A/B
15	51	M	III A/B
16	44	M	III A/B
17	49	M	III A/B
18	48	M	III A/B
19	51	F	III A/B
20	42	M	II
21	44	M	III C
22	44	M	III A/B
23	80	M	II
24	64	M	III A/B
25	53	F	III A/B

Table 3.2. Information on the patient sample providing the 25 interview transcripts for analyses in this Chapter. Adapted from Rees *et al.* 2019 (1).

3.4.2 Qualitative analysis

A theoretical Thematic Analysis approach was used informed by the work of Braun and Clarke 2006 (217).

3.4.2.1 Rationale for use of analysis method

The benefits of using Thematic Analysis are that it:

- Provides a way to identify, analyse and report patterns of meaning (themes) within a data set (217).
- Helps to organise and describe a data set in detail and can be further used to interpret various aspects of the research topic (218,219).
- Has few methodological constraints (217) and is widely used in the literature.
- Is utilised within many disciplines (220) and provides the researcher with core skills in qualitative analysis.
- Is strongly influenced by the work of Glaser and Straus in Grounded Theory (218,219) as they both seek to find patterns in the data. However, Thematic Analysis is a method rather than a methodology and does not intend to generate theory (217).
- Allows for a flexible and useful analysis that can provide a detailed and complex account of the qualitative data (217).

Thematic Analysis is an appropriate method of choice for this project as it is flexible and allows important patient outcomes to be grouped into themes by following straightforward methodological guidelines (217). This flexibility in approach facilitates mapping of outcome themes to a pre-existing framework of health rather than necessitating the development of a new framework. Thematic Analysis is a well-recognised method for exploring lived experiences (217,221), and is

commonly used in the context of trauma research (221-224). Thematic Analysis has been used to explore living with disability following trauma and how psychological distress may be improved through communication with healthcare professionals (222,225), to understand what factors influence physical activity participation following major trauma (222), and also to investigate the experiences of patients and their families receiving care following cervical spinal cord injury (223). Thematic Analysis has also been used as the qualitative analysis method of choice in the development of a COS for hip fracture (226,227) and for ongoing pain after knee replacement (228,229). Thematic Analysis also provides an excellent learning vehicle for the development of qualitative analytical skills. As a method, it can be found within methodologies such as grounded theory (218,219), discourse analysis and narrative analysis (217,230).

3.4.2.2 How Thematic Analysis was undertaken

Thematic Analysis of the 25 interview transcripts was undertaken in a two-step process: data management and data interpretation by the lead researcher (AA). The data management process involved immersion in the data by reading and re-reading the anonymised interview transcripts whilst making notes and annotating potential outcome concepts.

Open coding was used to identify text extracts representing meaningful outcome concepts, following which codes were grouped and organised under appropriate outcome domains in the COMET Taxonomy of Outcomes (12). Interpretation of the grouped outcome codes involved an iterative process of reading and re-reading the coded text extracts under each outcome domain of the COMET Taxonomy of Outcomes. This process helped generate an understanding of the

meaning behind the patient narrative to develop outcome themes and subthemes that best represent the patient sentiment in the underlying codes. See Figure 3.2 for a schematic of the Thematic Analysis process.

The Thematic Analysis process involved a combination of deductive and inductive approaches:

- A deductive approach was initially used to categorise and organise outcome codes using the COMET Taxonomy of Outcomes as a framework. This approach allowed for a more directed and detailed analysis of the data in relation to the specific research question.
- An inductive approach was used when interpreting the meaning behind outcome codes to develop outcome themes and subthemes grounded in the patient data.

This combined approach enabled the outcome themes to dynamically evolve throughout the analysis to represent the patient sentiment expressed in the underlying outcome codes, whilst maintaining the organisational structure of the COMET Taxonomy of Outcomes.

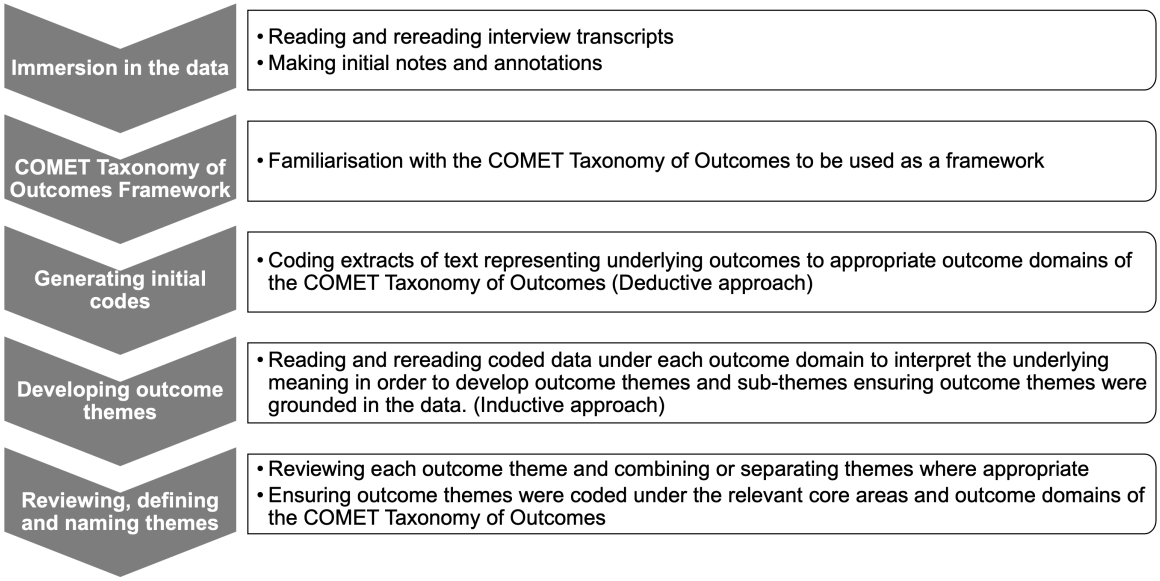


Figure 3.2. Schematic diagram of the phases of the Thematic Analysis undertaken in this project. Adapted from Braun and Clarke (2006) (217).

To facilitate reflection on the process of interpretation, a sample of 5 interview transcripts were coded in duplicate by AA and ET, before meeting to discuss and compare identified codes and interpretations. The coding followed a similar pattern, and any inconsistencies were discussed. The remaining analysis was conducted by AA. Rigour was demonstrated through trustworthiness (231,232). AA was engaged with the data and held regular meetings throughout the analysis with ET, who was well acquainted with the data allowing for reflection and discussion over the creation and categorisation of outcome themes and subthemes. Auditability was demonstrated through the use of quotes to illustrate outcome themes and categorisation of themes to the COMET Taxonomy of Outcomes (see Appendix 21 for examples). Data saturation in terms of generation of new outcome themes and subthemes was achieved; no further new outcome themes were identified following analysis of the first 15 interview transcripts. However, all 25 interview transcripts were analysed to ensure saturation. Outcome

themes were reviewed throughout the Thematic Analysis and evolved to best reflect the underlying codes.

All qualitative data were managed using the computer software package NVivo V.12 (QSR International, 2019).

Decisions directing the approach of the Thematic Analysis were guided by the research question:

What outcomes are important for patients within their experience of recovery from OLLF?

3.4.2.2.1 Defining a Theme

Outcome themes were identified where meaning in the data set was interpreted by AA to represent an important patient outcome. For example, pain and discomfort.

I sit down for an hour and I get up, oh the pain you can't describe it, but I mean for seconds, but it's enough to… it's really, really painful. P2

I feel the discomfort in that part of, in the upper, I don't know what the technical term is, in, in, in that sort of, in, in, in the bit between the foot and the ankle. P10

I know they have the Hippocratic oath to try and do the best they can but sometime saving it, so it looks like a foot is far less than the ramifications of the pain of it. The disability is not the problem, it's the pain. I could hobble for the rest of my life quite easily without pain. P13.

The meaning in the above narrative was interpreted as the experience of pain and discomfort, and the lack thereof is important to patients during their recovery. Therefore, an assumption was made that a lack of pain and discomfort is an important outcome to patients recovering from OLLF. Extracts of patient narratives from the 25-interview transcripts analysed where pain or discomfort was discussed were coded under the outcome theme of 'pain'. Codes were then reviewed over the whole data set, and the theme 'pain or discomfort' was created, which best

described the underlying outcome of importance in the coded patterns of patient narrative, i.e. inclusion of the outcomes pain and discomfort.

The creation of outcome themes was not limited to high prevalence codes such as ‘pain or discomfort’. Researcher judgement and discussion with the supervision team was also used to identify relevant and important outcome codes interpreted from the data when creating outcome themes, particularly for low prevalence codes. For example, sexual function.

We don’t have sex because every single time I move there’s something you know I can’t, yeah and plus you know, look at my legs you know it’s just like ‘no’. P19

The above text extract was the only datum coded as ‘sexual function’. Following discussion with the supervision team and later in discussion groups, it was felt that sexual function might be an important patient outcome following OLLF that warranted thematising. This decision was justified by researcher judgement and a hypothesis that the sentiment may have been underrepresented in the data due to its personal nature and likely omission from the additional narrative.

3.4.2.2.2 Decisions taken, coding and thematising the data

The data was coded by AA, whose background includes training in Trauma and Orthopaedic Surgery. It was recognised that coding of the data is not possible in an epistemological vacuum, and consequently, the data was interpreted through a medical lens. An analyst-driven approach was used to code the data with the aim of answering the specific research question, as stated above.

A semantic approach was broadly used to identify outcome themes represented by explicit or surface meanings in the data, which were described using the patient’s own words where possible. This is illustrated in the example given above,

demonstrating the creation of the 'pain or discomfort' outcome theme. A latent analytical approach was used where an important outcome theme was recognised in the patient narrative subtext and was interpreted as an outcome concept by attempting to theorise the patient ideas using a constructionist method. For example, this approach was required when attempting to interpret meanings around patients' emotional functioning and wellbeing illustrated below.

I'll never be able to wear a normal pair of shoes. P4

It broke my bike which I was quite… quite upset about… mmm… P5

My son's a bit older now, he's fourteen now, I mean it's not like I would take him to the park so I missed out on all that sort of stuff… mmm… P5

I think just before I had my accident, I was probably the fittest and the strongest that I've been, and I was 39 and now I feel that it's been taken away from me! P21

The above extracts were interpreted to represent feelings of lost opportunities, time and function, which were frequently identified within the subtext of the patient narratives. These extracts were coded to the COMET Taxonomy of Outcomes, outcome domain 'Emotional functioning and wellbeing' within the core area of 'life impact'. By reading and rereading these coded extracts, the theme 'feeling of loss' was interpreted to best represent the underlying meaning of the coded data. The data extracts were then coded under the outcome theme 'feeling of loss' within the COMET Taxonomy of Outcomes outcome domain of 'emotional functioning and wellbeing'. Where further patient narratives were interpreted to represent an underlying meaning of 'feeling of loss', the narrative extract was subsequently coded under that theme. This process was iterative, whereby the outcome themes evolved throughout the analysis to best represent the meaning of the outcome codes they thematised. Consequently, outcome themes were merged, split and

renamed throughout the analysis and during the structured discussion groups that followed.

Epistemologically the Thematic Analysis generally took an essentialist or realist approach. In this approach, meaning and experience in the patient narrative was theorised in an uncomplicated manner by assuming that a unidirectional relationship exists between experience and meaning and the language the patients used. This approach is recognised in the work of Potter and Wetherell (1987) and Widdicombe and Wooffitt (1995), where it is acknowledged that language reflects and enables us to articulate meaning and experience (233,234).

3.5 Results

3.5.1 Results overview

Thematic Analysis of 25 interview transcripts identified 1121 codes in the data representing an explicit or underlying outcome that may be important to measure in patients recovering from OLLF. Interpretation of the outcome codes resulted in the development of 88 outcome themes and sub-themes categorised using the COMET Taxonomy of Outcomes under 12 outcome domains within four core areas. The 88 outcome themes and subthemes categorised under outcome domains and core areas of the COMET Taxonomy of Outcomes are displayed in a schematic tree diagram in Figure 3.3 below. Appendix 21 provides example patient quotes supporting the creation and wording of each outcome theme devised in the Thematic Analysis.

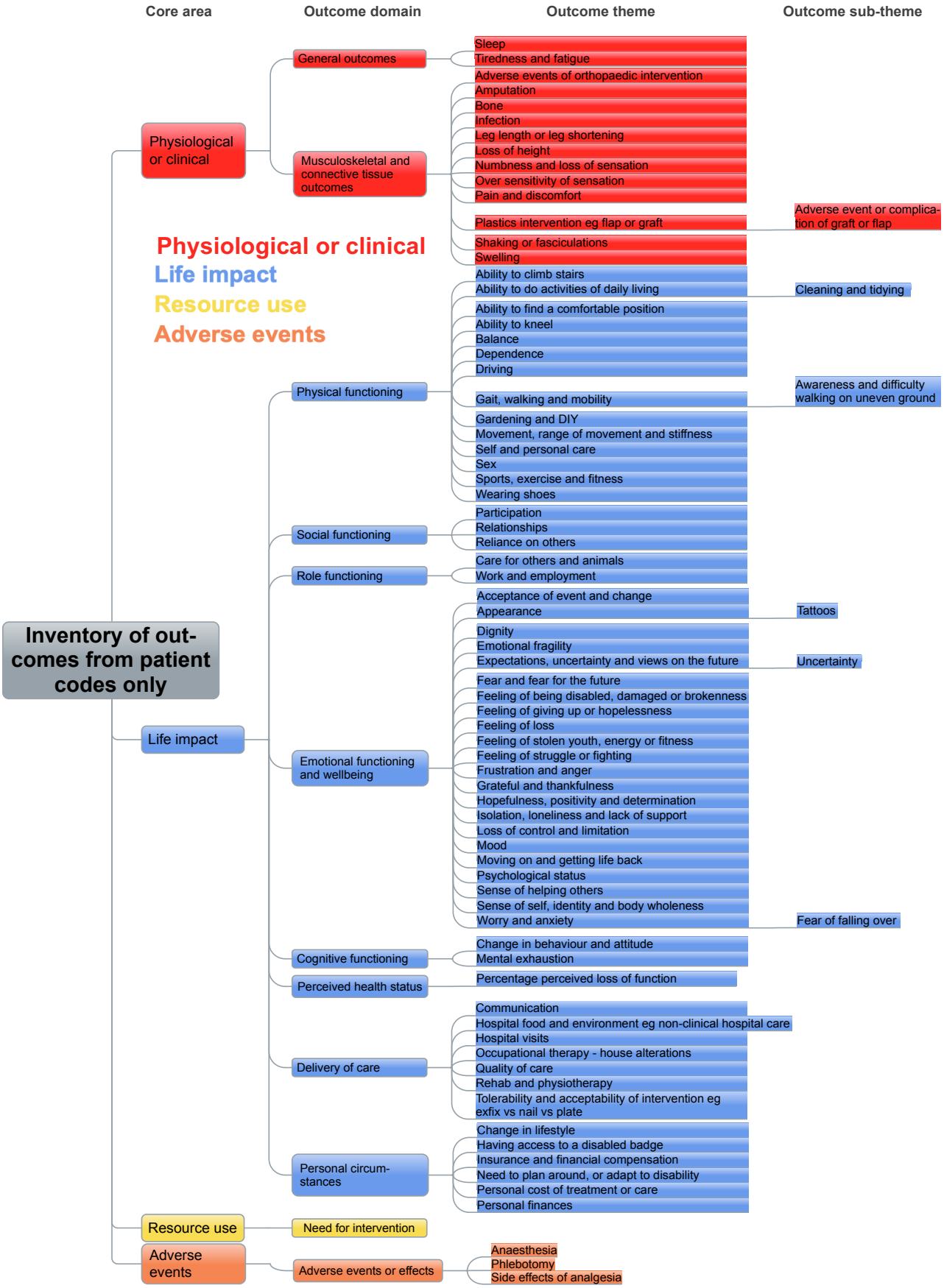


Figure 3.3. Outcome themes and subthemes categorised using the COMET Taxonomy of Outcomes.

3.5.2 Results of Thematic Analysis

Results organised using COMET Taxonomy of Outcomes core area and outcome domain headings:

3.5.2.1 Death

No text extracts were coded directly to the mortality/survival in the Thematic Analysis. Patients tended to refer to survival and the struggle to survive emotionally, physically and financially during their recovery journeys.

Yes, you do survive but you don't realise what you have to pay out, particularly for people with low incomes with bills to pay. P6

I couldn't see an end, I was worried about work, I thought if I can get back to work within three months you know we can survive. P21

One patient described dying as easier than struggling through their recovery:

I would just have died and that would have been so much easier, I wouldn't have had to go through a huge amount of pain and trauma and all sorts of things, I would just have died. P3

Some patients drew on the fact that they are alive despite such a traumatic event as a source of strength and positivity in their recovery journey.

I'm always positive you know I'm alive, I've got two feet it's fine you know whatever you can, you get one life you may as well live it. P19

3.5.2.2 Physiological or clinical

3.5.2.2.1 Musculoskeletal and connective disease outcomes

There were 12 outcome themes, and one subtheme within the musculoskeletal and connective tissue outcome domain, and two outcome themes under the general outcome domain interpreted in the Thematic Analysis (see Figure 3.3). Patients discussed their experiences of living through recovery, which included

accounts of dealing with episodes of infection, delays and complications in bone healing, adapting to a shortened leg, living with and coping with pain and discomfort, and encountering complications related to their plastic surgery.

I got a secondary infection in the groin and that nearly put me back into hospital again that was real bad actually. P15

I think it was about six or eight weeks I went for some x-rays and the bone actually hadn't started to heal yet…mmm… so then I had to wait a bit longer, I think another six to eight weeks… mmm… went for another check-up and it still hadn't started healing…so they offered the… mmm… solution of a bone graft so I ended up having that. P7

My leg's slightly shorter you stand slightly off balance anyway and then when you're looking at the table top they don't look quite as level as they should and then you just feel yourself starting to go. If I put insoles in my shoes, in the left one to lift me up that bit it doesn't happen nearly as much. P1

These accounts were descriptive narratives of complications and unexpected events during recovery. While they have been explicitly interpreted and coded to the physiological and clinical core area in this section of the Thematic Analysis, there was deeper meaning expressed in the subtext of the narrative. There was a feeling of exasperation, struggle, loss of patience, and wanting to give up purveyed through the narratives as the patients' recovery journeys continued to encounter unwanted complications.

I think I was just frustrated really… mmm… you know if it'd been something like my arm and you know I could still get around from day to day and it wasn't having too much of an impact on me I probably wouldn't have been bothered either way but I think that there were times where, you know, I almost wished they had just like amputated my leg because at least then I'd be up on my feet like even if it was with a prosthetic! P7

Deeper meanings of the lived experience of battling complications were better captured as outcome themes within the emotional functioning outcome domain in the life impact core area, such as the outcome theme 'feeling of struggle or fighting' and 'feeling of giving up or hopelessness' discussed below.

Concerning amputation and, to a certain extent, infection, patients described worry about the possibility of amputation or getting an infection in the earlier phases of recovery and later drew on the fact that they still had their foot/leg as a source of strength when encountering hardships including coping with pain later in recovery.

Very scary, yeah the thought of losing your legs I don't know how I would've dealt with that! P16

I never had any infection, touch wood! P2

One of the concerns I had with this was the possibility of infection, not from outside but from inside. P4

I was lucky not to have lost my leg really… Yes, I was happy I didn't lose my leg because I'd bought a brand-new pair of trousers before that. You have to laugh and joke sometimes. P6

Amputation was a complex issue for some patients dealing with extreme pain, intense emotions and coping with a 'mangled' limb which often resulted in wishing they had undergone a clean parting with their leg closer to the time of injury. This also fed into the complexities around compensation claims. One patient expressed feelings of anger and frustration that he was living in pain from a limb that, had it been removed, would have likely resulted in less pain and more financial compensation.

I said what would have made a difference was if I had lost my leg compared to my leg being a mangled mess now and he said it would have made a massive difference to the claim. P17

Pain and discomfort was a high prevalence outcome code categorised to the physiological or clinical core area. Experiences of living in pain, its penetrating effect on patient's lives, its treatments and coping strategies were discussed in all 25 patient transcripts analysed. Pain has far-reaching consequences affecting many aspects of recovery, including emotional functioning and wellbeing, cognitive

functioning, social functioning and physical functioning. The Thematic Analysis clearly demonstrates pain as a central theme to recovery from OLLF.

The pain is the biggest issue because it physically drags you down and will mentally wipe you out and I hate being mentally tired. I'd rather be physically tired than mentally tired. P13

3.5.2.2.2 General outcomes

Beyond the musculoskeletal and connective tissue outcome domains, more generally patients discussed problems with sleep, tiredness and fatigue. Patients described sleep as problematic; struggling to get comfortable, unwanted dreams and general disruption of sleep patterns. These issues may also relate to the effects of being in pain and the side effects of analgesia medication.

One of the problems I've had is not being able to sleep properly and that was a problem… I found that my sleep pattern was disrupted. P2

Sleeping, yeah just sleeping awkward I mean I haven't… I have to say I probably haven't had an un-interrupted night's sleep but it's just a case of rolling over and getting comfortable and going to sleep again. P5

There was quite period of time when I couldn't lay on my left side for very long when I slept. P20

Patients described difficulties dealing with and adapting to becoming easily fatigued. They found fatigue limiting, which led to feelings of grief over lost opportunities to participate in activities they would have otherwise been able to enjoy.

I could never sleep during the day and I know I must be getting more tired because if I sit down for any length of time I just go to sleep. P3

I never, I never used to stop, I've got, you know I've got whole cupboards full of crafty things I'm in theory 'arty' so I, but I was never, I would never stop I was always doing something and now I can't, I'll, I'll spend two hours sitting in front of the telly and I would never do that you know I'm just shattered all the time. P19

3.5.2.3 Life impact

There were 65 outcome themes, and subthemes interpreted from the outcome codes in the Thematic Analysis categorised under the life impact core area (see Figure 3.3). Outcome themes interpreted and coded to the life impact core area provide direct insight into some of the most important aspects of recovery from the patient point of view. The rich and detailed accounts of the patients' life experiences through recovery documented in the interview transcripts facilitated the thematisation and interpretation of a set of granular outcome themes. The resulting 65 outcome themes attempt to cover the complexity of these lived experiences with the hope of bringing the areas of recovery that patients are most concerned about into the COS.

3.5.2.3.1.1 Physical functioning

The outcome themes categorised to the physical functioning outcome domain provide an overview of the practical difficulties patients experienced during recovery. Patients described difficulties being able to move freely throughout space in their day-to-day lives where certain environments or activities became inaccessible or unappealing to them following injury. They felt held back and hindered by their recovering OLLFs which related to feelings of loss over activities they could do before that have subsequently become impractical, such as walking for enjoyment, going out to see friends or dancing etc.

Ideally, I'd love to be able to walk a mile, I'd love to be able to do that and I simply can't do that. P3

*I'd go out with ladies who lunch once a month and… mmm… and I'd go to the library a lot, I'd go to me friends… I can't do any of that now they all have to come here…*P2

I was a pretty good dancer… That's out of the question now. P12

Feelings of physical limitation are broadly represented in the outcome themes including 'walking, gait and mobility', 'ability to exercise', 'ability to balance' and 'lower limb function.' Patients described difficulties relearning to walk, balance and regaining a normal gait, with some describing themselves as walking like a duck or waddling like a penguin.

The biggest issue for me has been learning to walk again, that was really difficult. I found that constantly that my injured foot wanted to walk like a duck. P4

I think the mind's willing, but the body doesn't work so well. There are some things like just walking across a piece of uneven ground. P17

More specific physical limitations were described in the patient narratives, which were thematised to 'ability to climb stairs', 'ability to kneel' and 'ability to have intimate relationships'. Climbing stairs related more broadly to general mobility problems with patients experiencing difficulties due to a combination of lack of strength, balance, coordination, confidence and lower limb pain.

I still quite often have to do a step at a time, um, that's partly due to, I still have a little pain in my right leg. P22

Another thing that's scary, about forty-eight hours before you leave you have to manage the stairs… Going up was okay but coming down oh it is scary. P6

Whereas the ability to kneel, have sex and wear shoes more specifically related to pain caused when getting into certain positions or difficulty getting comfortable.

I can kneel down but it's awkward. P6

I can't kneel, I still can't kneel but I can on the other leg for a short time to a point but I can't kneel on the leg that I broke, my left leg, I can't kneel on it… I don't know if I will ever be able to kneel. P1

I can't get comfortable you know… we don't have sex because every single time I move there's something. P19

Yes, insoles so that it's comfortable otherwise I'm just in pain. P19

Physical functioning limitations were closely related to patients maintaining their independence and a feeling of dignity. Outcome themes in this area include 'ability to do activities of daily living', 'ability to be able to dress and do self and personal care', 'ability to drive' and an overarching theme of 'ability to be independent'. The ability to move freely without pain was clearly demonstrated to be integral to patient independence which allowed them to maintain a sense of dignity.

You can't just jump in the shower and things we take for granted, washing and dressing every day. I was having assistance. I've always considered myself quite an independent person and to come to terms with that and to have to ask for help I found hard. P18

I'm not having somebody wiping up after me and I wouldn't come out hospital until I could wipe my own bum either. P1

I think for me it has always just been about my independence. I found it hard at first when I just couldn't do anything for myself and so it's been building that up and I feel like I've got everything and the only thing I do struggle slightly with is independently driving. P14

Sports, exercise or fitness was discussed in every patient transcript analysed and is represented by the outcome theme 'ability to exercise'. The ability to exercise to previous levels appears to be a key recovery threshold that patients wanted to reach. For some patients interviewed, it was also linked to social participation through playing team sports. Patients often set their hearts on regaining their physical abilities in exercise, which led to a process of physical exploration, but unfortunately in many cases resulted in disappointment, and later compromise and acceptance after the establishment of new physical limits.

The only thing I miss really is the running, but I haven't written it off it's just that when I have tried it, it hasn't worked out very well. The first time I tried it I did feel a lot of pain. P20

I did try playing football… mmm… when I started running again but… mmm… sort of the sharp turning and that was just a bit painful on my ankle…and just kind of stopped doing that really. P7

Running's out of the question but every day I'm getting a little bit quicker at walking. P1

The ability to ambulate and exercise appear to be core components of the physical functioning outcome domain for patients recovering from OLLF, which are thematised by the 'walking, gait and mobility' and 'ability to exercise' outcomes.

3.5.2.3.1.2 Social functioning

The patient experiences around social functioning were thematised by 'ability to participate in social events' and 'ability to start, maintain and develop relationships'. Patients' ability or lack thereof to participate in social activities was often directly related to their level of mobility.

My walking was very slow and by that I mean my grandson who was 2 could walk faster than me, I couldn't keep up with him and that's why I couldn't go out walking with them which was another frustration I felt. P4

Patients often described stretched family relationships with spouses, sons and daughters, where relationship dynamics had changed, resulting in struggle to establish a new balance. Many patients also describe the existence of strong relationships with family and friends as being central to providing them with the emotional strength and support to get through their recovery.

Yes, you get very, very close to the edge and my wife and I a year or so ago we hit a rough patch. I said I can't do this anymore. P13

I have got a cracking bunch of friends, I've got to admit they're fantastic and so yes they've dragged me through along with my family. P17

3.5.2.3.1.3 Role functioning

The effect of sustaining an OLLF on a patient's life roles was thematised to 'being able to care for other people and/or animals' and 'return to life roles' (e.g. caring, work and military duty). To many patients their employment or roles looking after family and/or pets were integral to their sense of self and experiencing new limitations to life roles challenged their sense of identity.

It's been three and a half years now since it did happen so for the first six months I was off work so that was probably the hardest element of it. P11

I went back to work February time, I'm a lorry driver and I wasn't allowed to drive but they said I could do work in the office so I was doing paperwork and I hated that, I couldn't stand it in the office. P6

My son, you know, I couldn't have my son because I couldn't take him to school the next day… P5

My father's come to live with us for three or four months from January last year and I tried my damnedest to look after him but I couldn't do it and it was causing a strain between me and my wife through my fault and so we had to put him in a nursing home. P17

3.5.2.3.1.4 Emotion functioning and wellbeing

Outcome themes exploring patients' feelings, emotions and psychological experiences provide an intimate insight into the hardships of emotional recovery following OLLF. Patients experienced periods of profound emotional turmoil during their recovery journey, which penetrated into deep facets of their sense of self-worth and identity.

I mean, what do you do? You sit down and do nothing, and I'm not that kind of person, do you try and be the person you were before? And you can't be because you are 95% of what you used to be but it's just that 5% area that causes you 100% of the problems. P13

Coping with extreme, unwanted, and at times, unexpected emotional outbursts led to a state of emotional fragility where patients described being emotionally drained, 'close to the edge' and wanting to give up.

I was just in floods of tears, I could hardly recount the story, and you know similar to this, you know, and the doctor took me aside afterwards and said, "you know you should really talk to someone!" P22

I thought about topping myself because it's like I've been independent all my life, there wasn't a lot else I could do… I honestly thought about topping myself and what stopped me, my sister really, and she'd kill me. P6

Patients' lives throughout recovery can be characterised by a theme of evolving struggle where they try to re-explore living their lives only to encounter new and unexpected practical difficulties while often coping with ongoing pain. Previously relied upon coping strategies, including spending time outdoors, exercise and focus on work, were no longer available due to an acute loss of independence, often resulting in relationships being strained to breaking point.

Every day I struggle, and some days you just want to sit and cry your eyes out. P13

Before the accident my way to relax would be to come home from work and probably take my dogs for a good walk and all that was taken away from me… You've got to be totally focused on your own recovery but unfortunately that's at the detriment of other people around you. P18

Patients' previously taken for granted expectations for the future had been rocked and replaced with feelings of uncertainty, anxiety and disempowerment. This was in part compounded by vague prognostic predictions from clinicians, which prevented patients from starting to accept their new normal way of being.

I worry about what's in the future for me because everybody says your mobility is going to get worse. P13

It was just more about the uncertainty of the, mmm, the nature of will things heal properly, mmm, I am the sort of person who likes sort of to be in control of things and, and know, have answers for things and obviously there was a lot of this injury that I didn't understand and didn't know what sort of progression it was going to take. P16

See Appendix 21 for representative quotes for each outcome theme in this domain.

3.5.2.3.1.5 Cognitive functioning

Two outcome themes were categorised under the cognitive functioning domain; ‘change in behaviour and attitude’ and ‘mental exhaustion’. Patients described a fall in their mental agility and speed of thinking, resulting in shorter attention spans and mental tiredness when concentrating on tasks. They also looked back on their early recovery and recalled a loss in short term memory. The patients often related their cognitive decline to mental exhaustion caused by being tired and in pain for long periods, compounded by the side-effect of drowsiness caused by taking analgesia.

I had trouble concentrating on it (calculating personal finances) to work out what I needed to pay and what I didn’t because I was on about 15 tablets a day and that didn’t help. In fact, I weaned myself off them. P1

3.5.2.3.1.6 Global quality of life

No outcome codes were categorised under ‘global quality of life’. COMET suggest that the ‘global quality of life’ outcome domain should only be used to categorise composite OMIs for quality of life (12).

3.5.2.3.1.7 Perceived health status

When describing their recovery, patients often used semi-quantitative estimates of their functioning described as a percentage of normal function or the function they remember having before their injury.

The ankle is limited, it’ll flop forward more and I can’t actually raise it very far up and so the flexion is virtually 20% of what a normal person can do. P13

Know I'll never be 100%... Yes, but I've still got it (my leg), and I can use it, I've got a lot of use back in it, not all of it. I've lost about 30%. P1

I think I've got about 40-50% use back of the ankle and that's good enough to do the things I want to do. P18

Representation of function as a percentage of normal or remembered function is relatable and intuitive as a descriptor. Patients may have described their functioning in this way as it is easier than giving long and detailed accounts of their specific limitations, bothers and pains when engaging in polite conversation. This may be representative of the underlying complexities of living with reconstructed limbs, which are cumbersome and potentially upsetting to describe in detail.

3.5.2.3.1.8 Delivery of care

The 'delivery of care' outcome domain encompasses the patient experience of receiving NHS care following OLLF. This included outcome themes around communication between healthcare professionals and patients, living in the hospital environment, the experience of receiving physio and occupational therapy, hospital visits, as well as tolerability of the surgical intervention.

I did find there was definitely a communication breakdown between the, the bone people and the skin, skin, skin flap people… I was kind of the 'piggy in the middle'. P15

It (physiotherapy) was actually really limited with the NHS… mmm… they didn't really offer me any physio other than just kind of give me advice on, you know, what I should do to start walking again and just to build up a bit of muscle I actually ended up paying for some physio sessions myself… P7

3.5.2.3.1.9 Personal circumstances

The 'personal circumstances' outcome domain explores outcome themes around changes to patient's finances, home and environment. The financial strain resulting from sustaining an OLLF was a key component of the lived recovery experienced

by many patients. There were three themes around financial stressors which included loss of earnings/employment, cost burdens associated with living after an OLLF (e.g. new orthotics, clothes, funding private physiotherapy, increased travel expenses) and anxiety caused by going through lengthy litigation proceedings in order to receive financial compensation. Financial pressures patients experienced during their recovery represented significant sources of stress, anxiety and worry for the future.

My Mum and Dad had to start paying the mortgage! P21

I wasn't going to be fit enough to do the job I did before and basically, they said you either jump or we push you out of work… I went to no pay and so for the last year or more we've lived off our savings. P4

Where patients sought compensation following their injuries, they entered an often long and drawn-out litigation process which exposed them to additional feelings of uncertainty and frustration. Some patients marked the end of the compensation process as a line in the sand from which they were able to accept their new way of being and move on emotionally.

It's the worry, it's the uncertainty of what the future is going to hold for you. Somebody said what they should do is a study on pain pre-court date and post settlement to see what the difference is because I could imagine something like a 40% swing to say the pain had gone down dramatically now because its stress related. P13

The insurance came through… It's almost like there's, you know, like there's a little light at the end of the tunnel. P5

The final underlying closing of the, the chapter if you like was when I settled the private, mmm, case against the driver, err, and that was, I think the pay-out was about three months ago, mmm, and yeah since it's just been, life is like as usual. P16

3.5.2.4 Resource Use

The ‘resource use’ core area was devised by COMET to capture and categorise health economic outcomes such as cost, hospital-related outcomes, e.g. length of stay/admission to ICU and need for intervention, e.g. medication use. No outcome themes were categorised to this core area in the Thematic Analysis.

3.5.2.5 Adverse events

The Thematic Analysis interpreted three more general outcome themes categorised to the ‘adverse events’ core area and outcome domain; ‘poor experience during anaesthesia’, ‘discomfort from blood taking and cannula insertion’ and ‘side effects of analgesia’.

One patient described her memory of waking up during her surgery.

I woke up while I was being operated on… I woke up and I saw someone above me and then I looked down and just saw blood everywhere. P12

And another patient described his experience of undergoing multiple venepunctures.

The amount of needles I had in this arm was unreal… they kept putting the needle in the same hole all the time… my sister said “haven’t you had enough needles in you, look at the state of that arm!” because it was as black… it was terrible! P12

A number of patients described side effects of taking medication, including: not thinking straight, hallucinations, being depressed and getting headaches. This outcome theme is closely related to ‘lack of concentration and focus’ in the cognitive functioning outcome domain.

I was still on painkillers for the whole month I was in there so I don’t think I was really thinking straight… P2

I think it gives you nightmares. I was seeing things and every so often I had pain and that’s another weird thing, morphine is… I didn’t like morphine. P6

3.6 Discussion

3.6.1 Qualitative analysis

It was a strength of this research to have the opportunity to conduct a Thematic Analysis on primary data from patient interviews exploring the experience of recovery from OLLF gathered by expert researchers in this field as part of a HTA funded study. It became clear during the Thematic Analysis that the recovery journey in many cases proved to be lengthy, taking many years before patients felt able to emotionally move on. By undertaking an analysis of interview transcripts up to the four-year mark ensured a reasonable chance that the breadth of experience of the recovery process was captured in the data. This was highlighted by the recognition that in cases where patients were pursuing financial compensation claims, closure of the litigation process marked a significant time point from which patients described gaining a feeling of acceptance and ‘moving on’.

3.6.2 Strengths and limitations

A secondary Thematic Analysis undertaken by AA with a background in academic orthopaedic trauma surgery provides a clinical lens from which to distil the rich descriptive recovery experiences down to outcome themes that may be practically measured within the confines of the NHS and infrastructure of the Trauma, Audit and Research Network. AA was immersed in the data through reading and re-reading the transcripts and was, therefore, able to undertake a reflective interpretation of the data.

It was a strength that AA is passionate about the care of patients following orthopaedic trauma and has worked closely with patients recovering from OLLF at three Major Trauma Centers over several years as a junior doctor prior to starting this DPhil. As such, AA has seen patient recovery from OLLF first-hand in both outpatient and inpatient settings; this has allowed AA to talk to patients and gain a basic understanding and insight into their recovery experiences prior to starting the analysis. The resulting insights may have helped enhance the level of understanding when interpreting the patient narratives in this Thematic Analysis, particularly around developing outcome themes from the subtext of patient stories.

It can be argued that a limitation of AA not having undertaken the interviews was that adequate immersion in the data might not have been achieved. This was a recognised risk, and every effort was made to thoroughly read and re-read the interview transcripts before analysis, as well as repeating this process for the coded narrative extracts before the outcome themes were developed (see Figure 3.2). By undertaking a secondary qualitative analysis, AA was able to work closely with ET, who had conducted the interviews. Due to ET's familiarity with the data, in-depth discussions around the interpretation of outcome themes was possible throughout the analysis process, which provided opportunities for reflection and demonstration of trustworthiness over thematised outcomes.

3.6.3 Research findings in the context of existing literature

The outcome themes resulting from this Thematic Analysis are in congruence with the published work of Tutton *et al.* 2018 and Rees *et al.* 2019 (1,215). Outcome themes interpreted in this work add further detail to the picture that Tutton and Rees paint of embodied vulnerability extending to an overarching theme of struggle

in the longer term as patients adapt to new lives in a changed body. The rich detail depicted in the 'life impact' outcome themes demonstrates the complexity of emotional and physical hardships that patients are faced with and can be encompassed by the overarching theme of 'struggling to recover' (1).

Trickett *et al.* 2012 and 2020 (213,214) works to devise a novel Patient-Reported Outcome Measure (PROM) for people recovering from open tibia fractures. Trickett *et al.* 2012 undertakes interviews on nine patients, which identified 17 themes relating to recovery that were refined to ten components when devising the WaLTTR scale (213,214). These components were also identified within the initial 65 outcome themes resulting from the Thematic Analysis in this work. Findings from this Thematic Analysis support Trickett's findings that pain and mobility appear to be central tenets of recovery from OLLF (213).

In the context of existing work exploring the lived experiences and identification of important 'components' of recovery from OLLF, this Chapter provides additional detail, specifically around patient experiences that represent underlying aspects of recovery that are important to measure. The qualitative analysis goes further than that of Trickett *et al.* 2012 drawing on a larger data set of 25 in-depth interview transcripts (reaching data saturation at interview transcript 15) to produce a more comprehensive list of patient outcomes important when recovering from OLLF.

3.6.4 Conclusion

By drawing on patients' narratives over their lived experience of recovery from OLLF, a comprehensive longlist of important patient outcomes was developed. Ensuring the outcomes were grounded in the patient data, a strong foundation has

been set from which a refined shortlist of candidate outcomes meaningful to patients can be created in further work described in Chapter 4.

Chapter 4. Creating an Inventory of Outcomes for Open Lower Limb Fracture (OLLF)

4.1 Chapter summary

This Chapter brings together 82 standardised outcome headings identified in the published literature on OLLF (Chapter 2) and 88 outcome themes interpreted as important to patients from a Thematic Analysis of 25 interview transcripts exploring the lived experience of recovery (Chapter 3). Outcomes were categorised using the COMET Taxonomy of Outcomes to create the Inventory of Outcomes for OLLF.

Using an inductive approach, 150 outcome themes were reduced to 121 outcome statements which were presented at professional and patient Structured Discussion Groups (SDGs) before review by the Study Management Group resulting in a comprehensive and comprehendible set of 68 candidate outcomes that were taken to a Delphi survey detailed in Chapter 5.

See the Chapter 4 road map below that summarises key results and schematically illustrates the workflow of this Chapter (Figure 4.1).

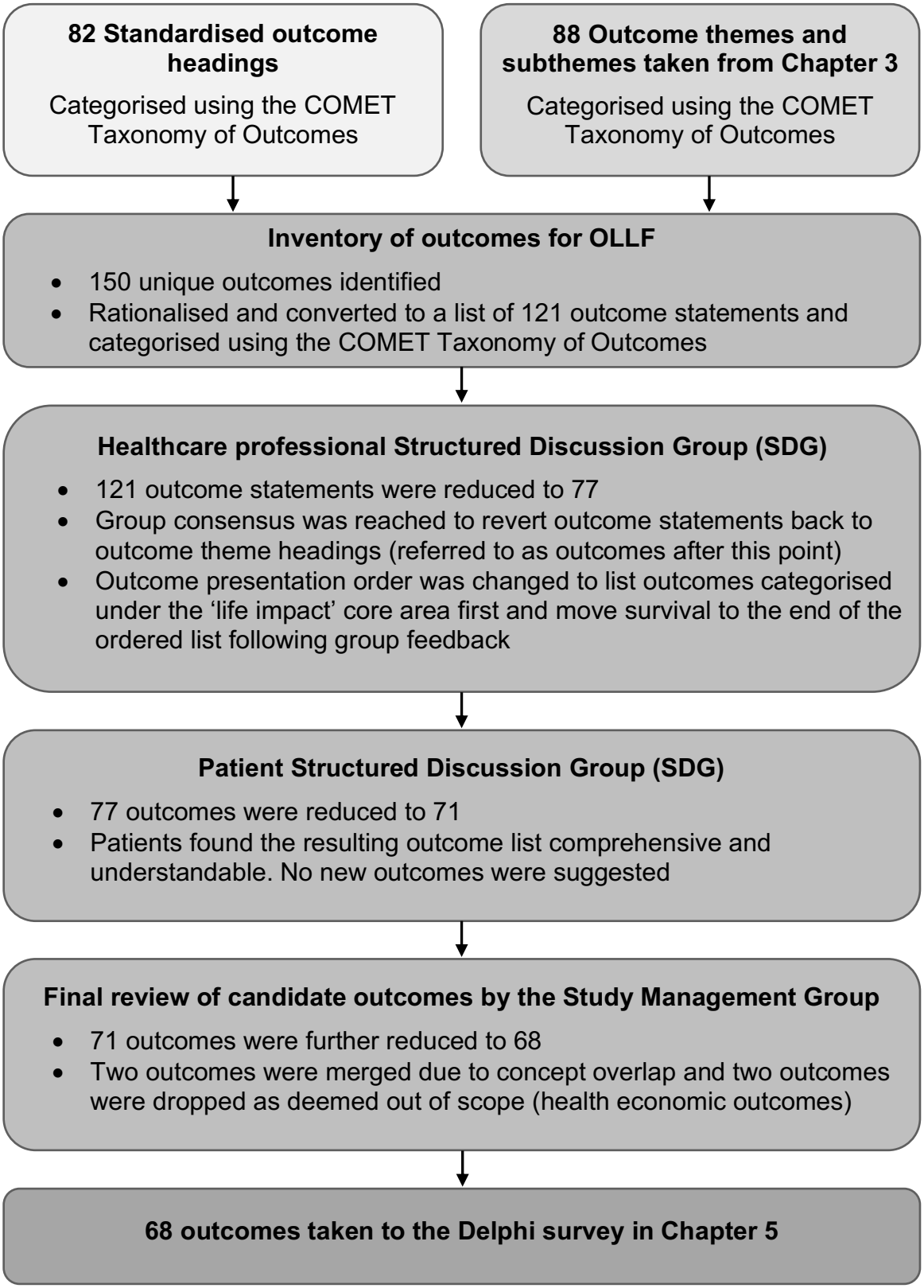


Figure 4.1. CO-OLLF Chapter 4 road map.

4.2 Introduction

In order to create a comprehensive list of candidate outcomes to rate for importance in a Delphi survey, outcomes identified from the literature and interpreted from patient interviews needed to be drawn together.

At this stage of a COS development project, it is important that outcomes gathered are considered in terms of structure, content and wording to avoid imbalance in the granularity of outcome selection, description and ambiguity of language (70). Ensuring that the list of outcomes is comprehensive and easily understandable for all stakeholder groups is essential to avoid revisions or multiple additions at the consensus stages of the project (Delphi survey and consensus meeting) (70).

Bringing together candidate outcomes from the literature and patients has the potential to create a long list of outcomes that risks overwhelming participants in a consensus process. Thus, this Chapter considers and describes a rationalisation and reduction in outcome numbers to make a manageable list of potential core outcomes with a view to reducing the risk of participant drop-out between rounds of the Delphi survey due to questionnaire fatigue.

Cognitive interviews are widely used in questionnaire development to refine instruments and ensure they are understandable to target groups (70,235,236). In this process, pilot questionnaire items are presented to patients and other stakeholders in an interview setting where stakeholders are invited to ‘think out loud’, allowing interviewers to gain insights into the understanding of the questionnaire from the respondent’s perspective (236). This process also facilitates an assessment of stakeholder interpretation of the question items as well

as gathering of feedback, all of which can be used to refine questionnaire items (235,236).

This Chapter explores the application of similar methods used in cognitive interviews to refine a list of candidate outcomes by conducting structured discussion groups with healthcare professionals and patients.

4.3 Objectives

1. To bring together:
    I. standardised outcome headings identified from outcomes reported in the published literature on OLLF (Chapter 2)
    II. Outcome themes interpreted from a secondary Thematic Analysis of interview transcripts exploring the lived experience of recovery from OLLF (Chapter 3)

    To create an Inventory of Outcomes for OLLF
2. To use healthcare professional and patient SDGs to refine a long list of outcomes and create a comprehensive and comprehendible set of candidate outcomes to be considered in the initial round of the Delphi survey in Chapter 5.

4.4 Methods

4.4.1 Inventory of outcomes

An Inventory of Outcomes for OLLF was created by combining outcomes identified from the medical literature in Chapter 2 and those interpreted from patients in Chapter 3. The inventory was presented to patients and healthcare professionals

at two separate SDGs to review for duplication of outcomes, outcomes missed or outcomes outside the scope of this COS project (see Table 1.8) and understandability, including the use of language. Following structured discussions, a finalised list of candidate outcomes was reviewed by the Study Management Group before it was taken forward to a Delphi survey, detailed in Chapter 5.

The Inventory of Outcomes was devised to group and organise outcomes identified from the medical literature and from patients using the core areas and outcome domains of the COMET Taxonomy of Outcomes. This was with a view toward the creation of a coherent and structured list of outcomes to facilitate ease of review at structured discussion groups and at the Delphi survey. See Figure 4.2 for a schematic diagram of how the Inventory of Outcomes for OLLF was created.

Grouping similar outcomes by outcome domain also helped facilitate identification of missing outcomes by participants in SDGs and at the Delphi survey (i.e. it may be more obvious that an outcome is missing when reviewing similar outcomes when grouped together), thus promoting the development of a more comprehensive list.

All standardised outcome headings and overarching outcomes from OMIs identified from the medical literature were imported to the NVivo project file and grouped under outcome themes and subthemes generated from the Thematic Analysis described in Chapter 3. Where outcome themes did not exist for standardised outcome headings imported from the literature, a new outcome theme or subtheme was created. For example, the standardised outcome heading ‘laboratory tests’ was identified from the review of the literature and was not interpreted as an outcome theme in the Thematic Analysis, as such a new outcome

theme heading was created within the physiological or clinical outcome domain: ‘laboratory tests’.

This approach enabled full use of the NVivo software package functionality, which facilitated ease of comparison of outcomes expressed as important by patients to those reported in the literature.

An inductive approach was used to rationalise the long list of outcomes brought together in the Inventory of Outcomes. Where similar outcome themes or subthemes were identified, they were combined. Every effort was taken to ensure the meaning grounded in the patient data was not lost when combining outcome themes to create a single unifying outcome.

The rationalised list of outcomes was then converted into a series of outcome statements. For example, the outcome theme ‘feeling of loss’ was translated to ‘feeling of loss is an important outcome to measure when recovering from open lower limb fracture’. This was undertaken with the aim of increasing the interpretability of the outcomes by providing the context of why they may be important to measure. However, following feedback from healthcare professionals in the first SDG, outcomes statements were converted back to outcome theme headings, which are referred to as ‘outcomes’ from this point forward.

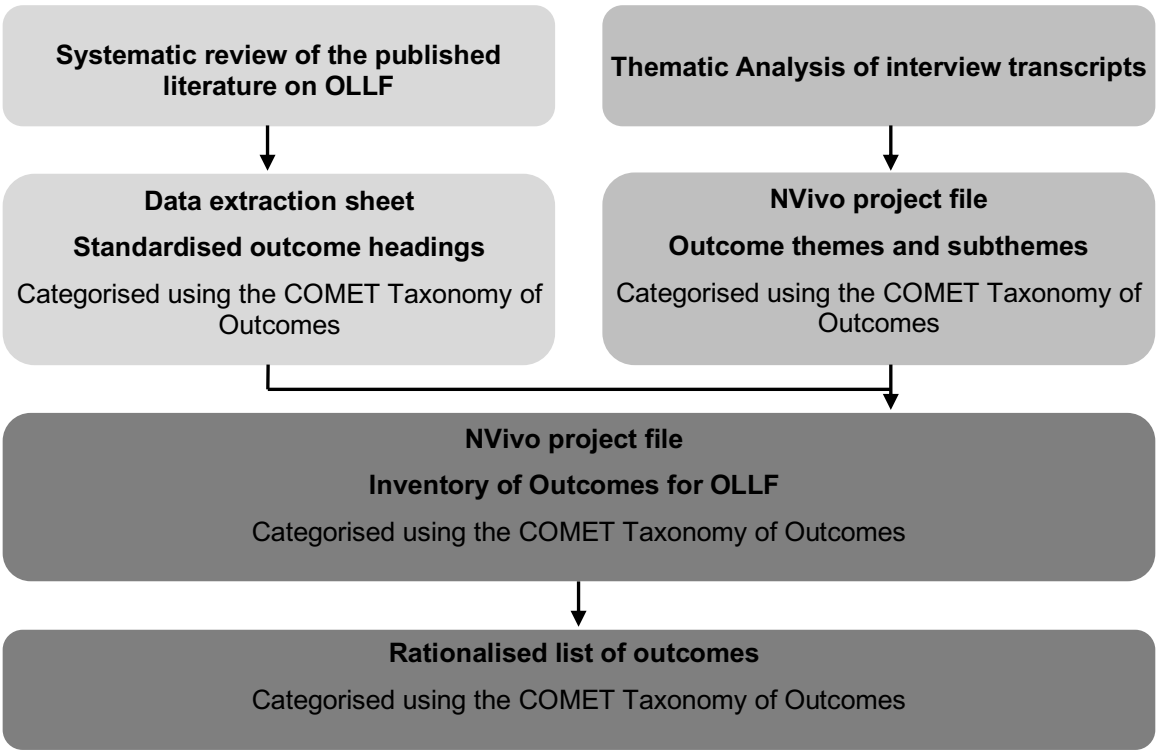


Figure 4.2. Schematic flow diagram detailing the process of creating the Inventory of Outcomes for OLLF and subsequent list of outcomes for review at structured discussion groups.

4.4.2 Structured discussion groups (SDG)

Two SDGs were conducted, the first with healthcare professionals and the second with patients recovering from OLLF (see Table 4.2 for participant demographics and meeting information). SDGs provided a key quality control step to ensure validity and accountability to the interpretation of outcomes identified from the qualitative analysis and from the systematic review of the literature.

4.4.2.1 Aims of SDGs

1. To ensure outcomes were representative of patient and healthcare professional views on what is important to measure.

2. To identify any missed outcomes. On review of outcomes, patients and healthcare professionals were invited to identify and discuss any potentially important outcomes they felt may have been missed.
3. To review outcomes for duplication, e.g. where outcomes had significant overlap, this was identified, discussed and a new encompassing outcome theme was devised and agreed.
4. To identify outcomes out of scope for this project. For example, outcomes used in economic analysis were considered out of scope.
5. To review each outcome theme for the correct use of language and understandability for the Delphi survey.

4.4.2.2 Participant recruitment

4.4.2.2.1 Patient recruitment

CO-OLLF was adopted by the National Institute of Health Research (NIHR) Clinical Research Network (Protocol number: 13257), which facilitated multi-site recruitment. Patients were recruited from four UK MTCs (Hull and East Yorkshire Hospitals NHS Trust, North Bristol NHS Trust, Oxford University Hospitals NHS Foundation Trust and University Hospitals Coventry and Warwickshire NHS Trust) from March 2018 to March 2019. At each study site, patients were recruited either directly from the trauma wards or the major trauma follow-up clinics. Suitable patients were identified either in the morning trauma meeting by the research nursing team or by outpatient coordinators using eligibility criteria detailed in Table 4.1. Treating clinicians were notified of a patient's eligibility, and following their consultation, a summary of the project was given before asking the patient if they would be interested in participating. If interested, a research nurse would attend

the patient, give a more detailed description of the study and provide a patient information leaflet. A patient response sheet was then completed detailing the patient's name, date of birth, contact information, occupation, a brief description of their injury, months since their injury and indicating whether the patient would like to participate in, either or all; structured discussion group (SDG), online-Delphi survey or consensus meetings (see Appendix 6). Participant response sheets were scanned, encrypted and emailed securely via NHS email to AA. Hardcopies were filed (locked filing cabinet in an access-controlled room) at each participating site.

In addition to recruitment by the site research teams, the CO-OLLF study advertisement poster was made available to display at recruiting study sites enabling patients to contact AA directly (see Appendix 6).

AA anonymised each patient participant by assigning a study identification number before adding participant details to the CO-OLLF patient recruitment database.

A spreadsheet matching patients' study identification number to name and contact information was encrypted and stored separately on a secure server.

CO-OLLF participant inclusion and exclusion criteria

Inclusion criteria for three stakeholder groups:

Patients

1. Recovering from an OLLF (any open fracture distal to the pelvis) at any time point since the injury.
2. The participant is willing and able to give informed consent for participation in the study.
3. Aged 18 years or above.

Healthcare Professionals

1. Any healthcare professionals who are involved in the care of patients recovering from OLLF. 2. This may include medically qualified professionals such as surgeons, physicians and general practitioners and non-medically qualified professionals including psychologists, nurses, physiotherapists and occupational therapists.
Researchers
1. Any researchers who have experience working in musculoskeletal clinical research. 2. This may include statisticians, health economists, research managers, research associates and research nurses.
Exclusion Criteria
For all stakeholder groups 1. Lack of capacity to provide informed consent at any point during the study. 2. Unable to speak, read and write proficiently in the English language.

Table 4.1 CO-OLLF participant eligibility criteria.

A purposive sample of patients was identified from patients that indicated they were interested in attending the SDG. These patients were then contacted by email or telephone to invite them to the patient SDG.

4.4.2.2.2 Healthcare professional recruitment

Healthcare professionals working at the John Radcliffe Hospital, Oxford, involved in the care of patients following OLLF were emailed or approached in person to ask if they were interested in participating in this study. If interested, they were screened against the participant eligibility criteria (see Table 4.1) and emailed a professional information leaflet (see Appendix 6). A purposive sample of interested healthcare professionals was devised to ensure variation in training background, sex and experience. Identified healthcare professionals were then contacted by email to ask if they could attend the SDG.

4.4.2.3 Structured Discussion Group (SDG) methods

The SDGs were organised similarly to traditional focus groups described by Powell and Single (1996) (237); each SDG was made up of a purposive sample of individuals with shared key characteristics, e.g. having sustained an OLLF or active involvement in treating patients following OLLF. The SDGs were more structured than focus groups to address the research aims while also drawing on participants' experiences when discussing outcomes. Using a structured approach centered on review and discussion of outcomes, the SDGs utilised methodological elements of traditional focus groups and the Nominal Group Technique (237). This allowed participants to share a full range of perspectives and develop and expand on each other's contributions. Structured facilitation of discussion around the research aims, inviting all participants in turn to contribute an opinion on each outcome theme fostered an atmosphere of controlled interaction between participants allowing all views to be shared. Where participants recommended changing, merging or rejecting of outcomes, amendments were discussed and not accepted until all group members were in agreement. Any group consensus gained over addition, rejection, rewording or merging of outcome themes was noted by AA.

The SDGs were organised and facilitated by AA with supervision, support and encouragement from ET when required. All participants were provided with information leaflets and gave signed consent before commencing the meeting (see Appendix 6 for ethical approval, information leaflets and consent forms). Following introductions using an ‘icebreaker’ to familiarise the group with one another AA introduced the project, the outcomes and explained the SDG aims in a short presentation. Each participant received a printed copy listing the candidate

outcomes categorised using the COMET Taxonomy of Outcomes as outcome statements in the healthcare professional SDG (see Appendix 19) and as both outcome statements and themes in the patient SDG (see Appendix 20). Printed outcome lists and stationery were provided to aid discussion, review the use of language, understandability, and allow notetaking. Audio recordings were made of each SDG and transcribed verbatim. Notes were taken by AA, as well as documentation of discussions and amendments to outcome themes/statements by ET using a flipchart. This information was then used to inform revisions to the outcomes after each meeting, to ensure auditability and rigour in generating the final list of outcomes and to inform the results and discussion in this Chapter and Thesis.

The professional SDG was held first and attended by 8 participants, the patient meeting was held one month later and attended by 5 participants. Each meeting was also attended by AA, ET and Elizabeth Baird (EB). EB acted as the study Patient and Public Involvement (PPI) partner (see the PPI summary in Appendix 4 for EBs role throughout the project). The meetings were both held in private meeting rooms in the John Radcliffe Hospital, Oxford.

In response to feedback at the professional SDG, outcome statements were converted back to the wording used for the original outcome themes. Outcomes were amended and refined as per the changes agreed before presentation later at the patient SDG.

The professional SDG was organised first to provide a more concise list of outcomes for the patient SDG, and to allow the patients to undertake the final review of the outcomes before discussion at the Study Management Group

meeting (see Appendix 3 for members of the Study Management Group). It was decided not to conduct mixed professional and patient SDGs to ensure the patient view was not overpowered, and to allow the patients to make the final approval of the outcome list before presentation to the Study Management Group.

Healthcare Professional Structured Discussion Group (SDG)		
Length of meeting: 2 hours and 20 minutes Meeting date: 9th of July 2018		
Participant number	**Sex**	**Professional Background**
Participant 1	Female	Plastic surgeon
Participant 2	Female	Senior Research Nurse
Participant 3	Male	Research Physiotherapist
Participant 4	Female	Research Nurse
Participant 5	Male	Academic Trauma and Orthopaedic Surgeon
Participant 6	Female	Trauma Psychologist
Participant 7	Female	Consultant Nurse
Participant 8	Male	Trauma and Orthopaedic Surgeon

Patient Structured Discussion Group (SDG)					
Length of meeting: 2 hours and 30 minutes Meeting date: 3rd of August 2018					
Participant number	**Sex**	**Age range (years)**	**Description of injury**	**Months since injury**	**Back-ground**
Participant 1	Male	50-60	GA III (inclusive of a/b) tibial fracture	9	Self-employed

Participant 2	Male	50-60	GA III (inclusive of a/b) tibial fracture, delayed amputation	17	Unemployed
Participant 3	Male	20-30	GA III (inclusive of a/b) tibial fracture	3	Estate agent
Participant 4	Male	50-60	GA III (inclusive of a/b) tibial fracture	2	Clerical worker
Participant 5	Male	30-40	GA III (inclusive of a/b) tibial fracture	1	Heavy plant mechanic

Table 4.2. Structured Discussion Group participant demographics and meeting information.

4.4.3 Study Management Group meeting

As a final quality control check, amended candidate outcomes were presented in the order recommended by the professional and patient SDGs (see Appendix 21). Each outcome was presented, and its progression from the Inventory of Outcomes to its final form was discussed and reviewed for being ‘in scope’ using the project scope criteria (see Table 1.8 for CO-OLLF project scope).

4.5 Results

4.5.1 Results overview, creation of the Inventory of Outcomes for OLLF and final list of outcomes for the Delphi Survey

The systematic review of the literature undertaken in Chapter 2 identified 82 standardised outcome headings, which were combined with the 88 outcome themes and subthemes interpreted from patients in the Thematic Analysis in Chapter 3 (see Figure 4.5). Combining outcomes resulted in an Inventory of Outcomes for OLLF consisting of 150 outcome themes and subthemes (see Figure

4.4). The Inventory of Outcomes lists all outcomes identified from the literature and patients categorised using the COMET Taxonomy of Outcomes.

The 150 outcome themes and subthemes contained within the Inventory of Outcomes were rationalised and converted to 121 outcome statements. For example, the outcome themes ‘microbiology cultures’ and ‘wound cultures’ were rationalised to an overarching outcome statement of ‘Microbiological culture results are an important outcome to measure when recovering from open lower limb fracture’. Some outcome themes were dropped due to significant overlap with other themes or considered irrelevant or out of scope. For example, ‘loss of height’ was dropped due to overlap with ‘leg length or leg shortening’. More general outcome themes were divided into multiple, more specific outcome statements to ensure granularity in the outcome statements presented at SDGs. For example, the outcome theme ‘pain or discomfort’ was divided into four outcome statements (subthemes):

1. Pain is an important outcome to measure when recovering from open lower limb fracture.
2. Ache is an important outcome to measure when recovering from open lower limb fracture.
3. Post-operative pain is an important outcome to measure when recovering from open lower limb fracture.
4. Pain on walking is an important outcome to measure when recovering from open lower limb fracture.

The resulting 121 outcome statements (see Appendix 19) were then presented to healthcare professionals at the first SDG, where the outcome statements were

further rationalised to 77 outcomes. Following feedback, the outcome statements were reverted to outcome theme headings which were then presented and discussed at the patient SDG (see Appendix 20). The outcome themes were reduced again to 71, which were then taken to the Study Management Group for review. Participants at the professional SDG recommended the presentation order of the outcomes be changed for the Delphi survey. It was advised by a Trauma Psychologist participant to move the life impact outcomes (the functioning outcome domains) to the beginning of the survey to reduce exposure to the risk of survey fatigue when being scored for importance. Study Management review resulted in the reduction of the 71 outcomes to a final list of 68 to be taken forward to the Delphi Survey (see Table 4.3).

The progression of candidate outcomes to the final list taken to the Delphi survey is schematically presented below in Figure 4.3.

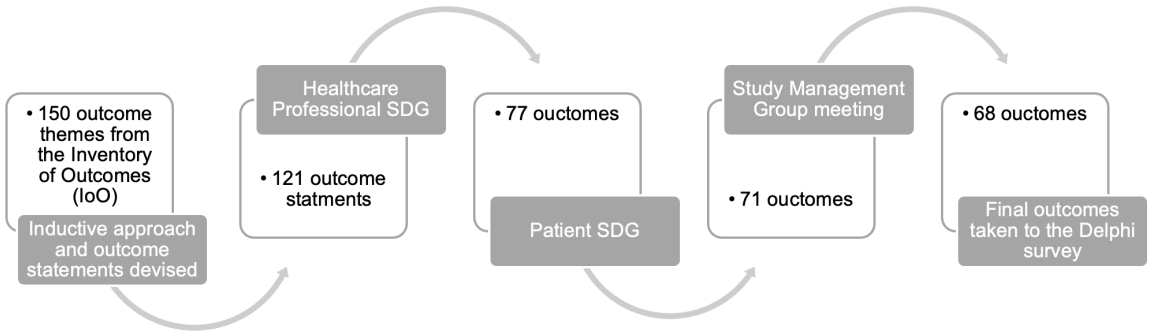


Figure 4.3. Schematic diagram of progression outcome themes to final list of outcome statements taken to the Delphi Survey.

Appendix 22 details the stepwise rationalisation and progression of each of the 150 outcomes refined to the final 68 taken forward to the Delphi. The rationale is provided for each outcome where changes were made.

Final list of 68 outcomes taken to round 1 of the Delphi survey	
COMET Taxonomy of Outcomes category, core area and outcome domain (outcome domain number)	**Outcomes taken to Delphi survey**
Life impact Physical functioning (25)	1. Ability to do activities of daily living 2. Ability to kneel 3. Ability to balance 4. Ability to be independent 5. Ability to drive 6. Walking, gait and mobility 7. Ability to be able to dress and do self and personal care 8. Ability to have intimate relationships 9. Ability to exercise 10. Ability to comfortably wear shoes and clothes of your choice 11. Lower limb function 12. Range of movement
Social functioning (26)	13. Ability to participate in social events 14. Ability to start, maintain and develop relationships
Role functioning (27)	15. Being able to care for other people and/or animals 16. Being able to return to life roles (e.g. caring, work, military duty)
Emotional functioning and wellbeing (28)	17. Appearance of lower limb e.g. scars, flaps and swelling 18. Change in body shape or weight 19. Feelings of self-identity and body wholeness 20. Feelings of disablement, being damaged or broken 21. Feelings of giving up and hopelessness 22. Feeling of loss 23. Feelings of frustration and anger 24. Feelings of hopefulness, positivity and determination 25. Isolation, loneliness and lack of emotional support 26. Low mood 27. Ability to move on and feeling of getting life back 28. Having clear expectations and views on the future with lack of uncertainty 29. Tolerance of uncertainty and living in fear e.g. fear of falling or going outside and fear for the future 30. Being anxious or stressed 31. Loss of confidence or control and feeling of limitation 32. Experience of flashbacks to the traumatic event 33. Emotional vulnerability, volatility and fragility. 34. Ability to accept the event and life change 35. Feelings of struggle or fighting against the body 36. Maintaining a feeling of dignity
Cognitive functioning (29)	37. Lack of concentration and focus

Physiological or clinical Blood and lymphatic system outcomes (2)	38. Venous thromboembolism (blood clot in legs or lungs)
General outcomes (9)	39. Sleep and fatigue 40. Number of unplanned hospital re-admissions 41. Length of hospital stay 42. Number of outpatient appointments 43. Number of Primary Care visits
Musculoskeletal and connective tissue outcomes (15)	44. Metalwork failure 45. Complications resulting from soft tissue (muscle flaps or grafts) 46. Amputation 47. Bone healing 48. Malunion, alignment and rotational deformity 49. Deep infection 50. Surface infection 51. Leg or bone shortening 52. Change in sensation 53. Muscle weakness 54. Pain or discomfort 55. Unplanned return to the operating theatre
Life impact Global quality of life (30)	56. Quality of life
Perceived health status (31)	57. Degree of perceived loss of general health and wellbeing
Delivery of care (32)	58. Quality of communication of healthcare professionals to patients 59. Satisfaction with care 60. Tolerability and acceptability of surgical intervention e.g. external fixator
Personal circumstances (33)	61. Change in lifestyle 62. Being compensated financially for injury 63. Personal cost of treatment and care following injury 64. Effect of injury on personal finances
Adverse events Adverse events and side effects (38)	65. Number of adverse events 66. Side effects of medication 67. Poor experience during anaesthesia
Mortality or survival Mortality (1)	68. Survival

Table 4.3. Final list of outcomes taken to round 1 of the Delphi survey, categorised using the COMET Taxonomy of Outcomes and in the order they were presented.

Figure 4.4. CO-OLLF Inventory of Outcomes.

4.5.1.1 Differences on outcomes identified from the literature and interpreted from patients

There were differences in the types of outcomes reported in the literature compared to those interpreted from the Thematic Analysis. Outcomes reported in the literature tended to be more clinician orientated, i.e. objective clinical outcomes categorised to the physiological or clinical core area of the COMET Taxonomy of Outcomes. The reverse was true for outcomes interpreted in the Thematic Analysis, which tended to be more patient-orientated, i.e. functioning outcomes categorised to the life impact core area (see Figure 4.5). The systematic review identified 45 and 28 standardised outcome headings categorised to the physiological or clinical and life impact core areas, respectively. In contrast, outcomes interpreted as important from the Thematic Analysis identified 15 and 65 outcome themes categorised to physiological or clinical and life impact core areas, respectively. Figure 4.5 demonstrates a clear discord in clinician and patient-focused outcomes identified in the literature compared to those interpreted from patient recovery narratives.

A. **B.**

Figure 4.5. CO-OLLF Outcome themes and sub-themes categorised by the COMET Taxonomy of Outcomes core domains.

A. Outcome themes and subthemes interpreted from the Thematic Analysis of patient interviews only.

B. Outcome headings and sub-headings (number of times they were reported) identified from the systematic review only.

4.5.2 Progression of outcomes from the Inventory of Outcomes for OLLF

4.5.2.1 Death

A professional SDG participant with a background in Trauma Psychology suggested that ‘death’ was not ‘a helpful place to start the Delphi survey’ from the point of view of patient psychology. It was recommended to add it as a footnote or drop it. A compromise was reached to change the outcome wording to ‘survival’ which uses more positive language, and to move it to the end of the outcome list (see Table 4.3).

4.5.2.2 Physiological or clinical

The 50 outcome themes and subthemes comprising the physiological/clinical core area of the Inventory of Outcomes were reduced in a stepwise process to 18 outcome themes (see Appendix 22 for detail of progression of each outcome with reasons for changes).

Participants at the professional SDG decided that the four subdivided pain outcomes and ‘medication use for pain’ should be merged back under the original outcome ‘pain or discomfort’. Using the term ‘discomfort’ in the outcome theme was thought to cover the sensation of ache and pain adequately. It was felt that pain is an important outcome, and combining the pain subthemes back to one overarching outcome would give the ‘pain or discomfort’ outcome a better chance of progressing into the COS.

4.5.2.3 Life impact

The 79 outcomes compromising the life impact core area of the Inventory of Outcomes were reduced in a stepwise process to 46 outcome themes (see Appendix 22 for detail of progression of each outcome with reasons for changes).

A significant area of discussion at the professional SDG was over the 20 emotional functioning and wellbeing outcomes. A Trauma Psychologist suggested that the outcomes in this domain were representative of elements of the following six well-recognised psychological constructs:

1. Body image/appearance outcomes
2. Depression/mood outcomes
3. Stress and anxiety outcomes
4. Post-traumatic stress disorder related outcomes
5. Resilience and acceptance outcomes
6. Satisfaction related outcomes

It was recommended that using the above overarching constructs may prove beneficial in terms of later selection of OMIs. However, distilling the 20 outcome themes (see Appendix 22) down to the six psychological constructs would only represent the tip of the iceberg in terms of the rich and granular emotional experience the patients shared at interview. Given the complexity and detail of the patient experience explored and summarised in the outcome themes, further reduction to six blunt psychological constructs may deliver a disservice to future patients. Instead, the 20 emotional functioning and wellbeing outcomes were grouped using the six psychological constructs (see Appendix 22). This grouping was subsequently used to reorder the emotional functioning and wellbeing

outcome themes for the patient SDG (see Appendix 20) to allow the patients to express their views on the matter. At the patient SDG, participants strongly related to many of the outcomes in ways that were reminiscent of their own recovery narratives. The consensus was to retain the granularity of the emotional functioning and wellbeing outcomes but retain the grouping for the Delphi survey (see Table 4.3).

4.5.2.4 Resource Use

A total of seven outcomes were created to categorise resource use outcomes reported in the literature, which were reduced to five at the patient SDG (see Appendix 22). A decision was made during review by the Study Management Group to drop the outcome 'cost to healthcare provider' and re-categorise the four remaining outcomes to the general outcome domain. This was because the resource use core area was considered out of scope for this COS project. However, the four remaining outcomes demonstrate a patient impact:

1. Number of unplanned hospital re-admissions
2. Length of hospital stay
3. Number of outpatient appointments
4. Number of Primary Care visits

The outcome theme 'hospital re-admission' was re-worded to 'number of unplanned hospital re-admissions', which better reflects hospital admissions relating to unplanned events rather than being part of the treatment plan.

4.5.2.5 Adverse events

Of the four adverse events outcome themes, three were taken forward to the Delphi survey (see Table 4.3). ‘Blood taking and cannula insertion’ was dropped at professional SDG as participants agreed it was representative of routine medical practice and should not be considered for the COS. The outcome ‘side effects of analgesia’ was re-worded to ‘side effects of medication’ at the professional SDG to be more general for all types of medicines.

4.5.3 Structured Discussion Groups (SDG): an overview of discussions

SDGs provided a way of reviewing and discussing all outcomes against the meeting aims, and changes were made where a whole group consensus was reached. Participants were fully engaged with the process, and an open atmosphere was fostered based on a non-judgmental approach. Participants in both SDGs understood the concept of a COS and how it may benefit future research and patients. SDG participants enthusiastically identified outcome themes that they believed were not relevant or important enough to be considered as core outcomes and suggested dropping them at the SDG stage. Several outcome themes were dropped (see Appendix 22). There was a tendency to pre-empt the Delphi survey and reduce items further. In terms of progressing the outcomes to a suitable set for the Delphi survey, the SDG process proved to be an excellent step for refining the language used when describing the outcomes and merging outcomes where significant overlap occurred (see Appendix 22).

Besides discussing each outcome, SDG participants shared personal accounts of treating patients with OLLF or stories of recovery. Where a patient described an experience, other patients added details from their own experience that illuminated

certain aspects of recovery and the patient experience of going through the hospital process. A collaborative learning experience was fostered among the facilitators and patients in the second SDG. For example, when discussing the outcome 'amputation' a detailed and insightful conversation around the decision-making process of lower limb amputation ensued. This was fuelled by one of the participants having recently undergone a delayed amputation who had a wealth of lived experience that he shared. Participants started with the view that amputation is an important outcome to measure, but following the subsequent conversation, they came to the understanding that the outcome 'amputation' is broad and non-specific in terms of timing of amputation and the level at which it may take place; all of which have significant effects on the expected subsequent function. This allowed some of the participants who had a more straightforward recovery journey to learn from and appreciate the experiences of others where limb salvage had not gone to plan. This fed into detailed discussions around pain and decisions to electively amputate a limb.

Personally, I'm bound to say that its extremely important because the level of amputation is also more important than the fact that you're having the amputation because it makes so much difference. Say for instance below knee you need 35% extra effort to walk, through the knee it's 50%, above knee it's 85% extra effort to walk. Patient SDG

Some have just said I wish I'd had an amputation and got it over and done with... I did, I said that myself. Patient SDG

Conversation around the participants' lived experience of recovery, and the facilitators' experience of treating people with OLLF cultivated a therapeutic process of sharing stories which further enhanced the discussions around which outcomes were important, and how the wording could be changed to be more representative of the patient experience.

Drawing on their experience, patients aptly identified outcome themes they believed were key candidates for the COS, for example, ‘walking, gait and mobility’, ‘pain or discomfort’ and ‘tolerance of uncertainty and living in fear’.

The SDG process provided reassurance that the Inventory of Outcomes and the subsequent outcomes presented were comprehensive as no new outcomes were suggested for inclusion.

The attendance of the study PPI lead, EB, at each SDG provided an independent voice, echoing the opinions and decisions made at professional SDG into discussions at the patient SDG. EB helped create a bridge between the two SDG meetings where indecisions or areas of conflicting opinions from the professional SDG could be presented for discussion at the patient SDG. Where discussion around dropping or adapting an outcome became difficult in the professional SDG, there was often agreement that the issue may be best resolved at the patient SDG, allowing the patient group to have a deciding say. Patients found no issue expressing their opinions, and matters of indecision rolling over from the professional SDG were quickly resolved. For example, participants at the professional SDG felt that ‘DIY and gardening’ could be covered by ‘activities of daily living’ and considered dropping it, however, agreement was not met, and it was agreed that the final decision should be left for the patient group to decide. The matter was discussed in the patient SDG, and it was concluded that the outcome represented more of a hobby than an essential component of daily living, and so was dropped.

AA *Ability to do gardening and DIY, we felt like maybe we should get rid of this one at the last discussion group….*

Participant *That just covers being able to do hobbies*

Yes I think that's very hobby orientated as that's your hobby isn't it. Also I've never been able to do any gardening or DIY.

AA *So we all thought that was probably to do with activities of daily living that broad concept and so I'll put can go and so I'm glad you guys all agree with what the professionals thought as well.* Patient SDG

The patient SDG shed further insight around the importance of certain outcomes and how they related to each other in previously unexpected ways. One such example came from a discussion that ensued about whether kneeling was an important outcome to measure.

AA *Ability to kneel. Do you feel that's important?*

Participant *Massively…*

I would say mechanic straightaway climbing through and over things, kneeling on everything let alone having a kid at home. Patient SDG

Later in the meeting a participant related pain on kneeling to difficulties having sex when discussing the outcome 'ability to have intimate relationships'.

It ties in with the kneeling as well for some people… kneeling and the intimate …. I can't, it's as a simple as that, I can't kneel and so I can't do a lot of things and I do feel, I don't know about the rest of you feel, but I feel really inadequate at times. Professional SDG

In discussions around the outcomes within the emotional functioning and wellbeing outcome domain, several participants in the patient SDG hypothesised that achieving a good emotional functioning and wellbeing outcome may be dependent on making a good recovery in terms of musculoskeletal and physical functioning outcomes. These opinions were formed when participants compared their own experience around emotional recovery to others in the group who had either a more or less complex physical or clinical recovery journey. Participants made the link that those of them in the group that were back walking pain-free and hadn't suffered any major complications such as infection or amputation appeared to

have also made a more positive emotional recovery. One participant suggested not measuring the emotional functioning and wellbeing domains at all.

Participant *I know the psychological side of it is important but is it really relevant to having your leg fixed and how you're going to judge if your leg has been fixed successfully or not?*

It seems to me that it's a separate thing, if you're aiming to get five questions (outcomes) – has this treatment been successful then the psychological feature can't come into it…

Participant *I feel it's about judging and finding an objective way of judging the success of the treatment. Now if you're going to include things like that, I know it's sort of related to it but it's related to any other injury you might have.*

AA *You're saying all these things are secondary to the original treatment.*

Participant *Yes, you want to say these are the things and walking is obviously important and that's the way you want to judge it but if you get into the psychological thing of it which again is the issue of the clothes it's related to it but it's an annex to it and it's no more related to a leg injury than it is to hiccups.* Patient SDG

Upon further discussion around emotional function and wellbeing outcomes later in the meeting and after more of the participants had time to discuss their own psychosocial struggles, there was an agreement that emotional function and wellbeing outcome themes were important. However, the point was made that in choosing the most important 5-7 outcomes, it is unlikely that an emotional function and wellbeing outcome will make the list. This was representative of the group opinion that a successful overall recovery is significantly dependent on being able to walk, being pain-free and getting back to work/normal activities.

The SDG meetings provided a rigorous process through which the 121 original outcomes were rationalised to 71 outcomes before review by the Study Management Group. The resulting outcomes had been checked for understandability and were deemed to be comprehensive going forward to the

Delphi survey. The patient SDG also provided additional valuable insights into the patient experience of recovery from OLLF and their experience of healthcare services.

The Delphi survey protocol was also discussed with participants at SDGs, and a number of recommendations were made, which included using information dropdowns, providing patient quotes from interviews that were representative of the outcomes being scored (quotes used are provided in Appendix 21).

4.5.4 Final review of outcomes by the Study Management Group

The list of 71 outcomes as they would appear in the Delphi survey were presented to the Study Management Group. Outcome themes were discussed in the proposed order they would be scored when completing the Delphi survey. Where applicable outcomes were presented with accompanying quotes from the patient interviews to demonstrate trustworthiness and auditability, or the number of times they were reported in the literature (see Appendix 21). Each outcome theme was checked for understandability, relevance and whether it was ‘in scope’ for the project.

The Study Management Group recommended merging the two perceived health status outcomes due to overlap and dropping the ‘complications’ and ‘cost to healthcare provider’ outcomes because of overlap with ‘adverse events’ and being out of scope, respectively. In addition, the Study Management Group also suggested a small number of outcome wording changes (see Appendix 22). Following the recommended changes, a list of 68 outcomes for the Delphi survey was finalised (see Table 4.3).

4.6 Discussion

4.6.1 Structured Discussion Groups (SDG)

The inclusion of two SDG meetings in this project provided a key quality control step to ensure the outcomes added to the Inventory of Outcomes for OLLF were representative of patient and healthcare professional views over what is important to measure when recovering from or treating patients with an OLLF. This process assured that any key areas of importance had not been neglected in the Thematic Analysis or failed to be identified in the systematic review. SDGs were also used to ensure the wording of the outcomes were understandable to patients and healthcare professionals. The SDGs played a crucial role in demonstrating rigour rationalising the 121 outcomes down to 71 for final review by the Study Management Group.

The patient SDG was challenging to recruit to, and on the day of the meeting, some patients could no longer attend. A total of six male patients could attend who represented a variety of age groups and injury severity (see Table 4.2). Unfortunately, there were no female participants other than EB and ET. Although the patient SDG was not representative in terms of sex, EB, in her capacity as PPI representative in the study, advocated for potential female interests over outcome themes of importance. Notably, this was around physical appearance outcomes. EB's attendance at both outcome meetings helped voice discussion points from the professional to patient SDG, which aided final decisions over inclusion, exclusion, or outcomes modification.

4.6.2 Inventory of Outcomes, outcome themes and rationalisation

The work in this Chapter supports an increasing acknowledgement that the outcomes currently measured and reported in the literature on OLLF fail to fully recognise outcomes that are most important to patients in their recovery. This is demonstrated by the juxtaposition of heavy reporting of physiological/clinical outcomes in the literature compared to the emphasis of importance placed on life impact outcomes around functioning by patients at interviews and in the patient SDG (see Figure 4.5). This observation supports an increasing opinion that a majority of studies investigating orthopaedic trauma interventions are currently failing to measure outcomes important to patients, e.g. PROMs. This further justifies the importance of this study's aims to recognise and promote the use of patient-centered outcomes in future research on OLLF.

Representing the richness in the qualitative data around patient experience, the Thematic Analysis produced a series of comprehensive granular outcomes categorised to the life impact core area. As discussed, there was a suggestion at the healthcare professional SDG from a clinical psychologist that the 20 outcome themes in the emotional functioning and wellbeing outcome domain could be reduced to six well-recognised psychological constructs (see Appendix 22). Both the healthcare professionals and patient SDG participants could see the merit of using broad psychological constructs, e.g. depression or anxiety. There was a recognition that the broader the construct, the more likely it would be that the outcome theme would make it into the COS. However, it was also argued that the voice of patient experience present in the existing outcomes would be lost by distilling outcomes down to overarching psychological constructs.

This represented a dilemma in terms of whether to simplify the emotional functioning and wellbeing outcomes or retain their granularity. There was a concern that by simplifying the outcomes, patients would be served an injustice as their voices coming through from the narratives would become smothered by medical labels. Ultimately the decision was made to retain the existing granular outcomes, which was supported by the patients who found the outcome themes intuitive and relatable, and also expressed apprehension over problems associated with medical labelling.

Another interesting discussion point that resulted from the patient SDG came after a participant questioned why we should include any psychosocial outcome themes at all going forward into the Delphi survey. The participant felt that the most important outcomes were around mobility, lower limb function, pain and return to work, and if a good outcome can be achieved in these areas, then it is likely that a good psychosocial recovery will also be made. An additional supporting point was made that if the aim is for COS to contain only 5-7 core outcomes, it is unlikely that any of the psychosocial outcome themes would make it in as the physiological/clinical and physical function outcomes are so important. It was acknowledged that it might indeed be the case that no psychosocial outcome themes are included in the COS, but they are an essential component of recovery, and as such, they should go through the consensus processes of the Delphi survey and consensus meeting.

4.6.3 Conclusion

The work scheme described in this Chapter has resulted in the creation of a comprehensive Inventory of Outcomes for OLLF. The subsequent refinement of

the inventory using professional and patient SDGs has created a shortlist of outcomes important to both patients and healthcare professionals that are comprehensive and comprehendible. Using professional and patient SDGs to undertake a cognitive review of the candidate outcomes demonstrates content validity in the outcomes taken to the Delphi survey and ensured the outcomes remained grounded in the patient experience of recovery.

The body of work in this Chapter lays the grounding to undertake a consensus process to identify the most important outcomes for inclusion in the COS for OLLF in Chapter 5.

Chapter 5. What is the COS that should be reported for patients sustaining OLLF?

5.1 Chapter summary

This Chapter draws on the findings of Chapters 2, 3 and 4 to present a list of 68 candidate outcomes to key stakeholders in order to generate consensus for the most important outcomes to measure in research and routine clinical practice on OLLF.

Two consensus gathering methods are described, an online-Delphi Survey consisting of two survey rounds and a multi-stakeholder consensus meeting using a modified Nominal Group Technique (NGT) to decide the COS for OLLF.

Two additional candidate outcomes were added in the Delphi survey's initial round, and 11 outcomes met the 'consensus in' criteria in the final round. The consensus meeting resulted in an agreement for a four outcome COS consisting of:

1. Walking, gait and mobility
2. Being able to return to life roles (e.g. caring, work and military duty)
3. Pain or discomfort
4. Quality of life

A Chapter 5 schematic diagram detailing the workflow elements of the consensus meeting is provided on page 214 (Figure 5.4), and a schematic detailing all workflows and results in this Chapter is provided on page 222 (Figure 5.8).

5.2 Introduction

A review of the OLLF literature undertaken in this thesis demonstrates significant outcome heterogeneity, over-reliance on outcomes important to surgeons and a disproportionate number of low-quality studies. Optimising treatment for patients following OLLF is a crucial target for the NHS and other healthcare systems worldwide. However, this injury's relative importance appears to be at odds with the current research quality in this field.

The development of a COS can address these issues; ‘an agreed, standardised set of outcomes to be measured and reported, as a minimum, in all trials in a particular health area’ (70). COS development has been endorsed to reduce outcome heterogeneity and increase the relevance of research through key stakeholders' involvement, including healthcare professionals, researchers, and patients using robust consensus science methods (24). A COS for OLLF will also provide trial designers justification for their choice of trial outcomes when approaching funding bodies, supporting the case for successful future funding applications (238).

An example of where research quality and quantity has improved due to COS development in orthopaedic trauma is in fragility hip fracture following the publication of a COS in 2014 (227). The COS informed outcome-reporting in the World Hip Trauma Evaluation (WHiTE) cohort study (239), WHiTE embedded RCTs and has been adopted by the National Institute for Health and Care Excellence in Hip Fracture Guidelines (240).

Following work described in Chapters 2, 3 and 4 to create a list of candidate core outcomes, the level of importance of each outcome was assessed. The

assessment was conducted using methods that built consensus with methodological rigour and used strategies to ensure a diverse range of opinions are heard (70). Methods used in previous COS studies and recommended by COMET include Delphi survey and consensus meetings (often using NGT methods) (68,70). The majority of COS studies registered on the COMET database in 2018 used a multi-methods approach to develop consensus (83%), with studies increasingly using Delphi methodology (31% in 2013 to 77% in 2018) (68).

5.3 Objectives

To gain consensus among three key stakeholder groups:

1. Patients
2. Healthcare professionals
3. Researchers

For a clinically relevant set of core outcomes to standardise outcome reporting in future research and clinical practice for patients following OLLF by conducting:

1. A multiple stakeholder Delphi survey
2. A consensus meeting

5.4 Methods

This study was prospectively registered with the COMET initiative, registration number 688 (see Appendix 5) and ethical approval was granted (see Appendix 6).

All methodological decisions were guided by the COMET handbook (70), discussed with the Study Management Group and followed consultation with patients and members of the Public as detailed in Appendix 4.

5.4.1 Scope

The scope of CO-OLLF is detailed in Table 1.8, which is defined according to the criteria recommended by COMET (70).

Outcomes identified from the literature and a Thematic Analysis of 25 interview transcripts exploring the lived experience of recovery from OLLF were combined to create a comprehensive Inventory of Outcomes for OLLF detailed in Chapter 4. A healthcare professional, and patient Structured Discussion Group (SDG) was used to refine the Inventory of Outcomes to a shortlist of candidate core outcomes deemed comprehensive and understandable. Also, SDGs determined the ordering of outcomes and recommended the addition of patient quotes to describe outcomes derived from the Thematic Analysis to appear in dropdown boxes to aid understandability in the Delphi Survey. The shortlist of candidate core outcomes was assessed as being in scope and approved by the Study Management Group, resulting in 68 outcomes being taken to the Delphi survey (see Appendix 27 for ordered outcomes and descriptor quotes).

5.4.1.1 Recruitment

Participants were invited to undertake the CO-OLLF Delphi survey by two standardised emails, one for healthcare professionals and researchers (see Appendix 24), and the other tailored for patients, the wording of which followed PPI feedback (see Appendix 23). Emails were managed using MailChimp (The Rocket Science Group, LLC, Atlanta, USA) a bulk email service that facilitates personalisation of email content, embedding of documents, and linking to websites. MailChimp is used by the Health Research Authority (241), and is TRUSTe verified: privacy programs, policies and practices meet the requirements

of the EU-U.S. Privacy Shield (https://trustarc.com). Invitation emails contained links to the Delphi survey website and the professionals and patient study information leaflets, respectively.

Eligibility criteria and recruitment of patients are described in Table 4.1 and on page 172, respectively. All 83 recruited patients were invited to participate in the Delphi survey.

Standardised emails for healthcare professionals and researchers were sent to professional organisations and cascaded to their membership. Table 5.1 lists the professional organisations whose memberships were contacted.

Also, relevant professional contacts of AA and the CO-OLLF Study Management Group were contacted. These contacts included:

1. Academic staff interested in musculoskeletal research at the Universities of Oxford, Warwick and Bristol.
2. UK Trauma and Orthopaedic, and Plastic Surgery trainee surgeons.
3. Study site Principal Investigators (PI) were asked to forward the invitation email and contact relevant clinical and research teams at their institutions to encourage participation.

Professional organisation memberships invited to participate in the CO-OLLF Delphi Survey

1. The Orthopaedic Trauma Society (OTS).

   The OTS consists of over 300 members and associate members, most of whom are consultant trauma and orthopaedic surgeons across the

	British Isles (242). Members were also asked to cascade the study invitation email to colleagues at their home institutions.
2.	The British Association of Plastic Reconstructive and Aesthetic Surgeons (BAPRAS) (243).
3.	Attendees of the annual National Open Fracture Summit (Newcaste-Upon-Tyne, October 2018). Also, AA publicised the CO-OLLF study in an oral presentation at the summit, inviting participation (see Appendix 2).
4.	The Association of Trauma and Orthopaedic Chartered Physiotherapists (244).

Table 5.1. Professional organisation memberships invited to participate in the CO-OLLF study.

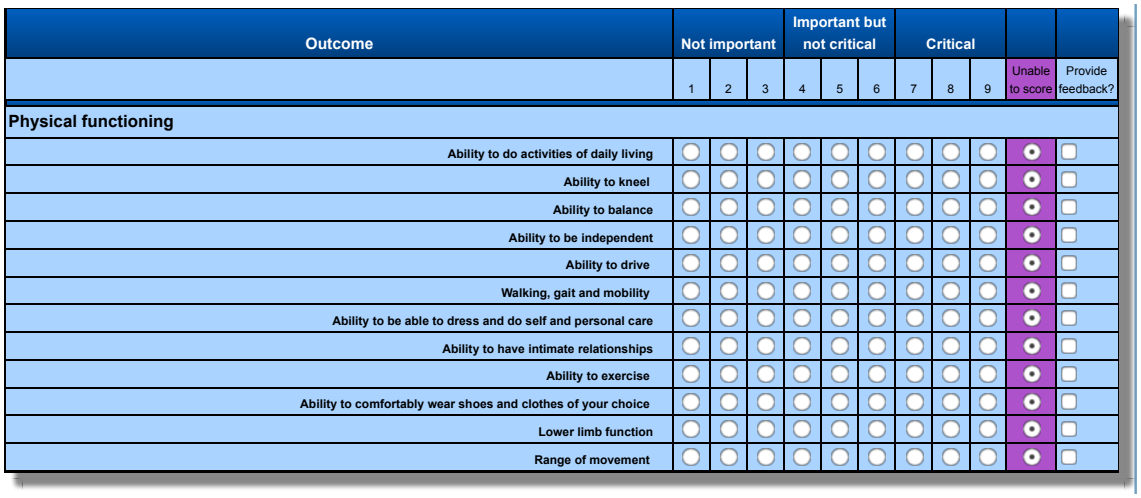
5.4.2 Delphi Survey

The Delphi Technique was developed by Dalkey and Helmer (1963) to achieve convergence of opinion from experts (stakeholders) on the importance of different outcomes using sequential questionnaires (rounds) (245). Participants are able to consider the views of others before re-rating each outcome enabling them to change their initial responses based on feedback from the previous rounds. This method avoids the influencing effect of dominant personalities encountered at face-to-face meetings and can be circulated to large numbers of individuals over wide geographical areas (70,245).

5.4.2.1 Scoring outcomes

Participants were asked to score each outcome for importance using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) 1 to 9 Likert scale (246). The scale was displayed as 1 to 3 labelled ‘not important’, 4 to 6 labelled ‘important but not critical’, and 7 to 9 labelled ‘critical’ (see Figure 5.1.).

The GRADE Working group originally developed the scale for assessing the level of importance of research evidence and has been shown to work effectively in previous COS projects (68,70,235).



Outcome	Not important			Important but not critical			Critical				
	1	2	3	4	5	6	7	8	9	Unable to score	Provide feedback?
Physical functioning											
Ability to do activities of daily living	○	○	○	○	○	○	○	○	○	⊙	☐
Ability to kneel	○	○	○	○	○	○	○	○	○	⊙	☐
Ability to balance	○	○	○	○	○	○	○	○	○	⊙	☐
Ability to be independent	○	○	○	○	○	○	○	○	○	⊙	☐
Ability to drive	○	○	○	○	○	○	○	○	○	⊙	☐
Walking, gait and mobility	○	○	○	○	○	○	○	○	○	⊙	☐
Ability to be able to dress and do self and personal care	○	○	○	○	○	○	○	○	○	⊙	☐
Ability to have intimate relationships	○	○	○	○	○	○	○	○	○	⊙	☐
Ability to exercise	○	○	○	○	○	○	○	○	○	⊙	☐
Ability to comfortably wear shoes and clothes of your choice	○	○	○	○	○	○	○	○	○	⊙	☐
Lower limb function	○	○	○	○	○	○	○	○	○	⊙	☐
Range of movement	○	○	○	○	○	○	○	○	○	⊙	☐

Figure 5.1. Screenshot of scoring system for outcomes as they appeared in the Delphi survey.

5.4.2.2 Consensus criteria

At each consensus generating element of this project, the consensus criteria detailed in Table 5.2 was used to define consensus. There are numerous criteria for defining consensus, commonly relating to each outcome's mean or median scoring. This study uses the percentage of participants scoring an outcome as either 'crucial' or 'not important' (70). The criteria chosen for this project uses the "70/15%" scoring system recommended by COMET and has been successfully

used in other COS projects (247-249). The rationale is that for an outcome to be included in a COS, the majority (greater than 70%) should consider it 'crucial' limited to only a small minority regarding it as 'not important' (less than 15%) (70).

CO-OLLF consensus criteria	
'Consensus in'	Over 70% of participants in each stakeholder group score the outcome 'critical' (7-9) or 'in', AND less than 15% of participants score outcome 'not important' (1-3) or 'out'.
'Consensus out'	Over 70% of participants in each stakeholder group score the outcome 'not important' (1-3) or 'out', AND less than 15% of participants score outcome 'critical' (7-9) or 'in'.
'No consensus'	Anything else.

Table 5.2. CO-OLLF consensus criteria.

5.4.2.3 Delivery of the Delphi survey

This project used the Delphi technique in a two-round survey as a consensus-seeking process. Participants self-allocated to a stakeholder group (healthcare professional, researcher or patient) and were allowed to change their scores on the importance of outcomes in round 2 after seeing their previous score and an anonymised summary of round 1 responses, displayed graphically as overall scores and by stakeholder group.

Delivery of the Delphi survey was achieved using DelphiManager (University of Liverpool, UK), a bespoke online platform for delivering and managing Delphi surveys for COS projects developed in conjunction with the COMET initiative. Round 1 of the survey was piloted in full by the Study Management Group and PPI

lead EB. Feedback was sought regarding the survey instructions, ease of completion, understandability and time taken to complete the survey. The survey was modified in response to feedback. Amendments included changes to the wording of survey introduction and instructions text and a more accurate estimate of the time required to complete the survey.

Upon clicking on the embedded email link, participants were directed to the Delphi registration page (see Appendix 25). The registration page contained a plain language study summary and a description of the Delphi process, making it explicit that full participation involved completing both survey rounds. It was also made clear that participation implied consent for data use.

Selecting the register icon took participants to the Delphi registration form, which collected demographic information (see Appendix 26 for information collected). On completion of registration, participants were taken to the survey round 1 start page and assigned a unique identifier code, ensuring responses between rounds were linked and anonymised.

All recruited patients were contacted by email to ask if they could complete the survey, which was followed up by telephone call in cases of no response. Where patients had difficulty using the DelphiManager platform or did not have internet access, the survey was undertaken over the telephone and scores were entered manually into DelphiManager by AA. This process was repeated for rounds 1 and 2. Healthcare professionals and researchers were assumed to have access to the internet and the Information Technology skills necessary to complete the survey.

5.4.2.4 Delphi survey round 1

Round 1 was conducted over 22 days, from the 9th of February 2019 to the 3rd of March 2019. Participants were asked to score each of the 68 candidate core outcomes for importance and were given the option to provide feedback on individual outcomes. Participants were able to select an 'unable to score' category if they did not feel they had sufficient expertise or experience to score an outcome (see Figure 5.2). Outcomes were ordered as per Appendix 27 and presented over 14 webpages, one for each outcome domain grouping (see Figure 5.2 for physical functioning page). Participants could see patient quote descriptors in textboxes when hovering the cursor over outcomes derived from the Thematic Analysis. After scoring all outcomes, participants were invited to make any comments on the survey, outcomes or study in a textbox. On the final page of the survey, participants could review their scores before being given the option of adding and scoring any additional outcomes.

After round 1 had closed, all information gathered, including individual scores listed by patient identifier, were downloaded. The percentage of participants scoring each outcome from one to nine was calculated for each stakeholder group and participants as a whole and transposed to 68 bar charts using Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA). Bar charts were uploaded to DelphiManager for display in round 2. The Study Management Group reviewed suggested additional outcomes; unique and in-scope outcomes were entered into round 2.

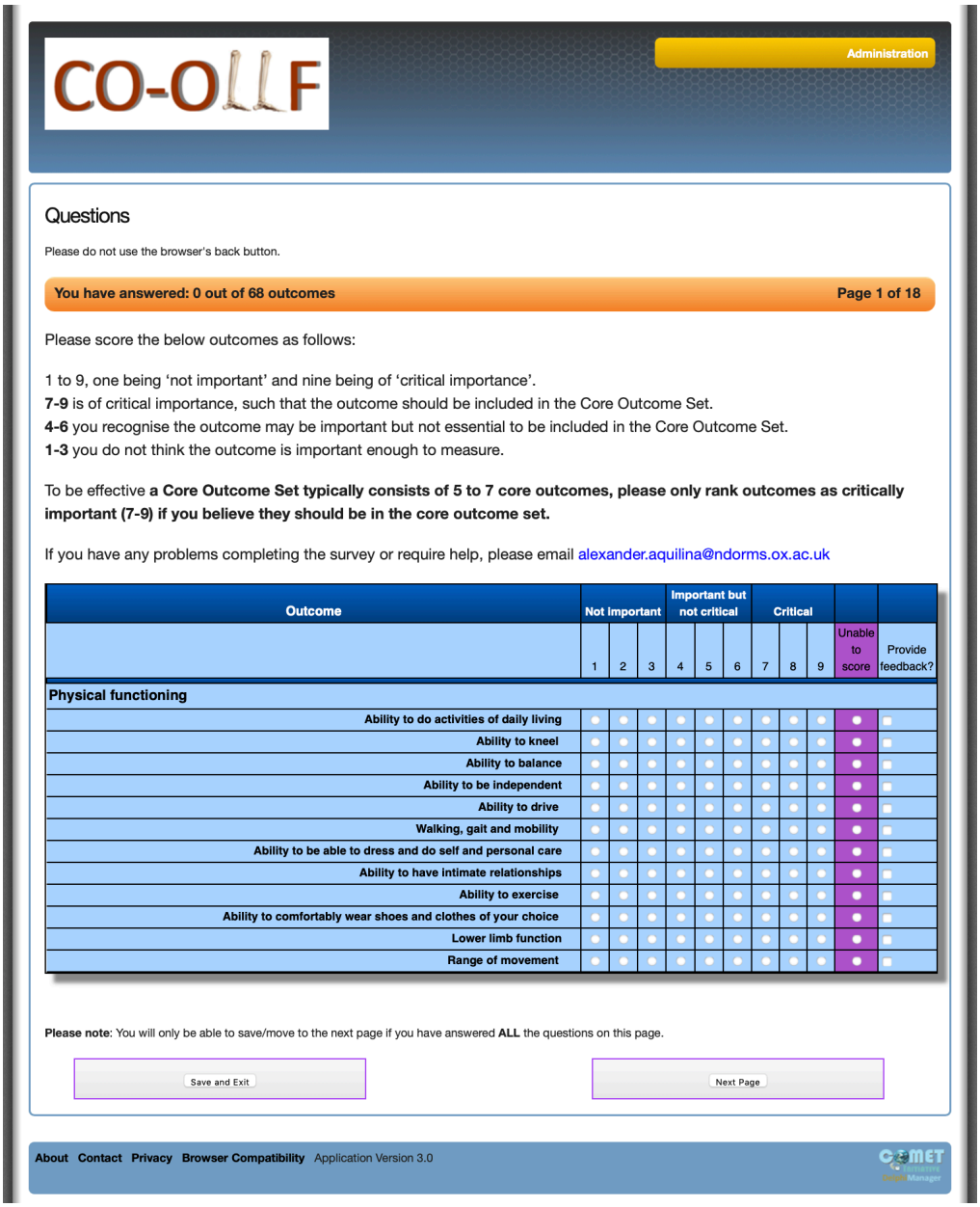


Figure 5.2. Screenshot of page one, round 1 of the Delphi survey using DelphiManager.

5.4.2.5 Delphi survey round 2

Round 2 was conducted over 16 days, from the 3rd of March 2019 to the 19th of March 2019. No outcomes were dropped between rounds; two additional outcomes were added from round 1 (70 outcomes in total). For each outcome, participants were shown their previous score and a bar chart displaying the scores

of each stakeholder group and all participants as a percentage (see Figure 5.3). Participants were asked to review the scores of other stakeholder groups before re-scoring the outcomes, where outcomes were re-scored, the reason for the change was requested using a textbox pop up. Each outcome was displayed on an individual page. Before completing the survey, participants scored additional outcomes suggested by participants in the round 1 survey.

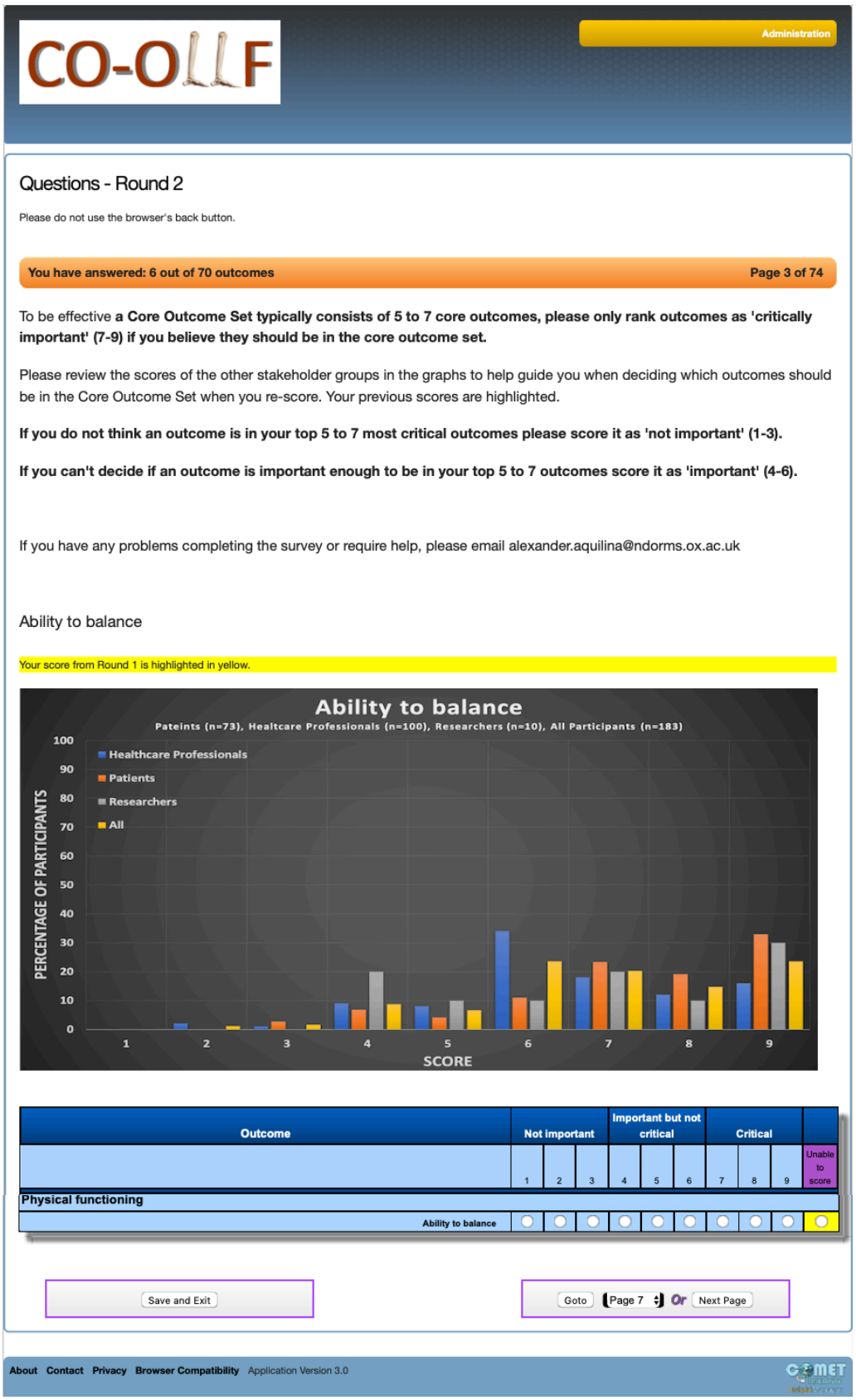


Figure 5.3. Screenshot of page six, round 2 of the Delphi survey using DelphiManager.

5.4.3 COS Consensus meeting

Results of the Delphi survey were presented at a face-to-face consensus meeting held at 'The Studio', a purpose-built events center near Birmingham New Street railway station (https://studiovenues.co.uk/venues/birmingham/), from 10 am to 4 pm on Tuesday the 26th of March 2019.

Participants were eligible to attend where they had completed both rounds of the Delphi survey. Participants were sampled purposively using a sampling matrix to ensure a balanced representation of patients in terms of age, gender, injury severity and time since injury and healthcare professionals and researchers in terms of achieving a mixed sample of professional backgrounds. Patients were identified from the patient recruitment database and contacted by email or telephone to invite them to the consensus meeting. Healthcare professionals and researchers were invited by email. All participants were sent a detailed pre-meeting reading pack written in plain language summarising the project and results of the Delphi survey, as well as a meeting agenda and a detailed description of what to expect on the day.

The meeting structure and methods were guided by the COMET handbook (70) and adapted from the James Lind Alliance (JLA) Priority Setting Partnerships (PSP) methods for a final priority setting meeting described in the JLA guidebook (87). The meeting consisted of three separate sessions (see Figure 5.4) and was chaired by Professor Matt Costa (MC), a member of the Study Management Group who has experience in consensus meeting methods through involvement in previous JLA PSPs (88,89). Throughout the day, MC ensured that contrasting views were actively sought, and all participants had equal opportunity to contribute

to the discussion. In addition to MC, ET and Ms Julie Wright (Trauma Nurse Consultant) (JW) acted as group facilitators for two breakout sessions. All group facilitators were sent a meeting protocol, a copy of the JLA guidebook for familiarisation and asked to facilitate breakout groups in line with JLA workshop best practice guidance (87).

The JLA recommends using breakout sessions to reduce the group size allowing each participant in turn to give their views on the importance of outcomes. Smaller group sizes can promote detailed discussion and allow the group facilitator to ensure the equal sharing of views. Participants were allocated to three breakout groups at registration: each containing a mixed sample of healthcare professionals, researchers and patients. Mixed groups were chosen to encourage stakeholder group integration throughout the day, which promoted a greater understanding of each other's views before the whole group electronic-voting session at the end of the day.

A modified Nominal Group Technique (NGT) was used throughout the meeting to reach consensus (consensus criteria described on page 205). NGT is a well-established and well-documented consensus method that can be used by face-to-face groups to make decisions efficiently whilst taking everyone's views into account (70,87,250). Facilitators encouraged each participant to share their views on an outcome before a group voting or ranking exercise was undertaken. NGT eliminates duplicate ideas and allows all individual opinions to be considered, which influences the group with the aim of converging opinions to achieve a consensus (70,250).

The meeting was introduced with a presentation to 'set the scene', and faculty members were introduced. The COS concept was defined and explained. The study aims, the justification for the project, and research completed to date were all described before outlining the plan for the day. See Figure 5.4 for the consensus meeting process.

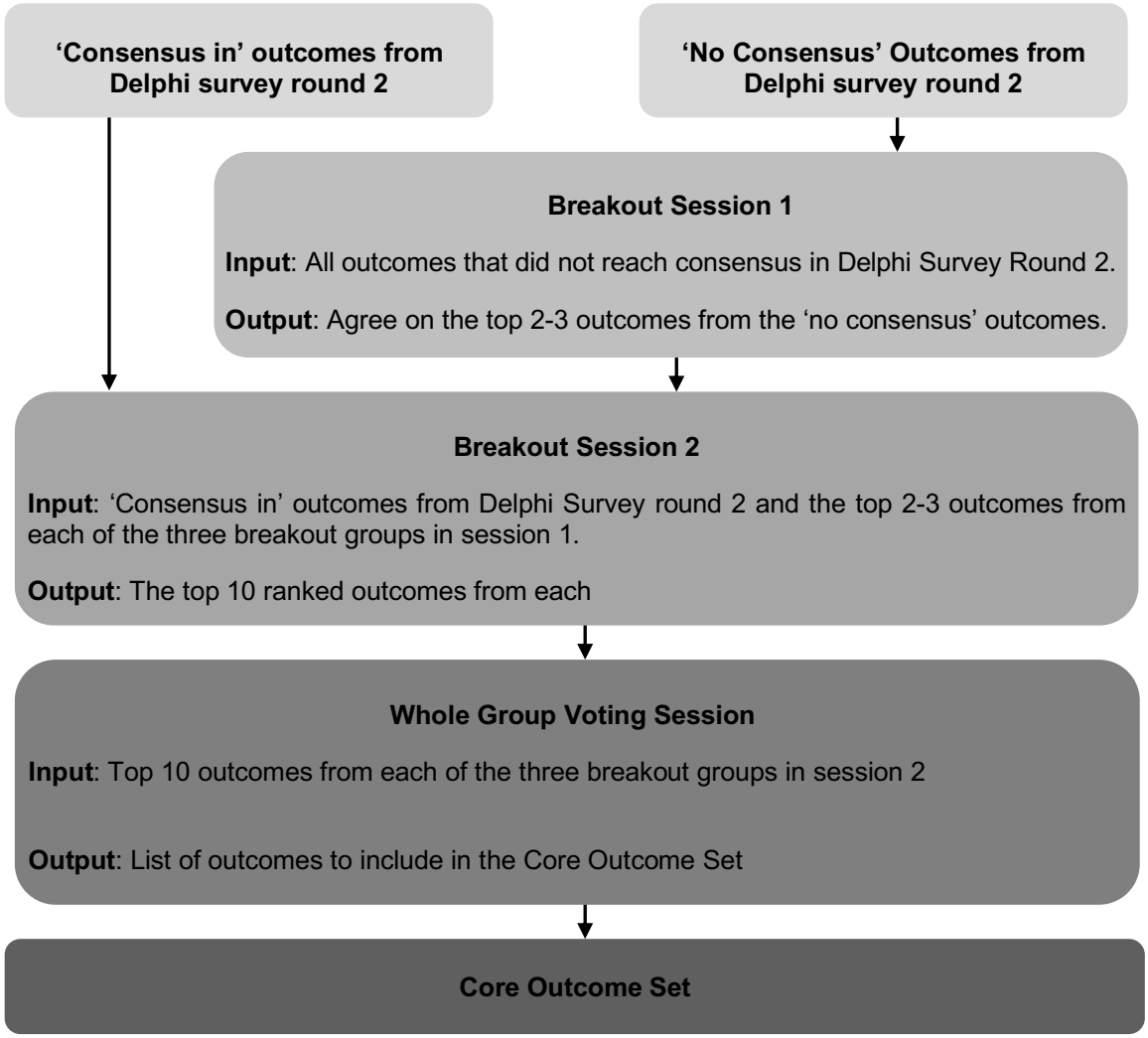


Figure 5.4. COS consensus meeting schematic flow diagram.

5.4.3.1 Breakout session 1

Participants were split into approximately three equal-sized groups of 10-15 people, each hosted in a separate workspace (see Figure 5.6 for the layout of workspaces). Each group were provided with a set of 70 A4 outcome cards; outcome headings printed on one side, and the results of round 2 of the Delphi survey on the other (see Appendix 29). Outcome cards were used as props to aid discussion and decision making using NGT (see Figure 5.7). All outcomes that failed to reach ‘consensus in’ or ‘consensus out’ from round 2 of the Delphi survey were reviewed in turn. Participants were also invited to add any additional outcomes. Additional outcomes were written on blank cards and added for discussion. Participants in each of the three groups voted to select their top 2-3 outcomes to take to breakout session 2. Voting was undertaken by counting a show of hands.

Breakout session 1 provided a safety check to ensure that any potentially important ‘no consensus’ outcomes from the Delphi survey were identified and provided the last opportunity for participants to add additional outcomes for further consideration.

5.4.3.2 Breakout session 2

Each group was asked to produce a ranked top-10 list of outcomes from most to least important. Outcomes considered included:

1. Outcomes selected in session 1
2. Outcomes identified from Delphi round 2 as ‘consensus in’.

This was achieved by the group facilitators laying the outcome cards on the floor before asking participants, in turn, to discuss the ordering of the cards (see Figure 5.7). Participants were also asked to consider the Delphi survey results printed on the back of each card when making ranking decisions. The top-10 outcomes from each group were taken forward to session 3.

A process of ranking by importance using NGT is a consensus method supported by the JLA, the justification of which is provided in Table 5.3.

The James Lind Alliance (JLA) justification for gaining consensus by ranking based on importance (87)**.** Ranking can be a helpful technique in consensus groups to account for the following commonly encountered problems when working with a mixed group of professionals and patients:
1. Some group members are much more vocal than others.
2. Some group members think better in silence.
3. There is concern about some members not participating.
4. The group does not easily generate many ideas.
5. Participants are not used to working together.
6. The issue is controversial, or there is heated conflict.

Table 5.3. The James Lind Alliance (JLA) justification for gaining consensus by ranking based on importance. Justification points adapted from the JLA guidebook (87).

5.4.3.3 Whole group electronic-voting session 3

Ranked top-10 outcomes from each group in session 2 were collated and added to a preprepared Microsoft PowerPoint (Microsoft Corporation, Redmond, Washington, USA) presentation template. The presentation template was set up using TurningPoint© software (Turning Technologies LLC, Youngstown, USA) to facilitate anonymous electronic voting.

All participants were brought back to the large meeting room (see Figure 5.6) and given one TurningPoint© handset each. AA delivered a presentation outlining the plan for the final session of the day and conducted a trial round of electronic voting to ensure TurningPoint© software and handsets worked. Electronic voting used the same format as the Delphi survey but with three response options rather than 9 for each outcome:

1. Not important
2. Important but not critical
3. Critical

The ‘unable to score’ option was not made available to ensure active involvement by all participants (see Figure 5.5 for slide appearance). The previously described consensus criteria on page 205 were used to approve core outcomes.

MC chaired the discussion on each candidate core outcome before voting was opened. This process was conducted over two rounds with MC encouraging participants to ‘come off the fence’ and vote outcomes as either: 1. Not important, or 3. Critical. Voting on each outcome was concluded when the outcome consensus status did not change between rounds of discussion and voting. Or when an outcome reached consensus ‘in or ‘out’ after the first round of voting. All outcomes reaching the ‘consensus in’ criteria were selected for the COS.

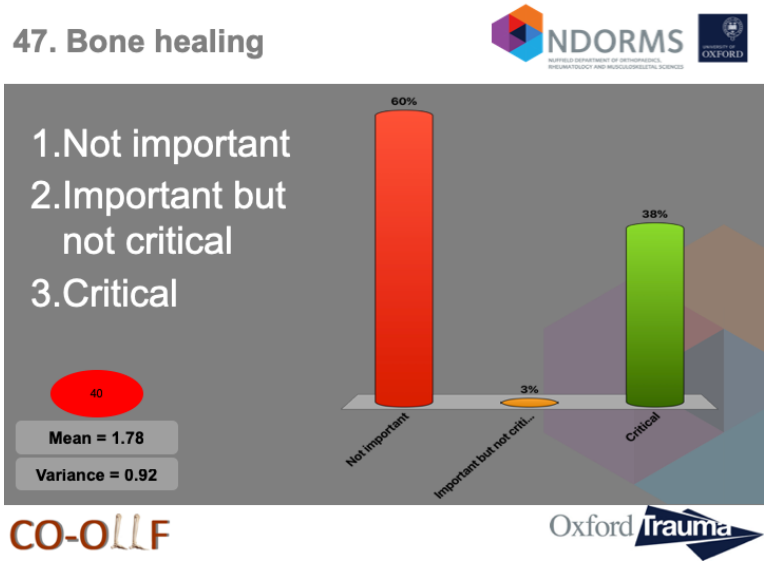


Figure 5.5. Appearance of slides used for electronic voting. Red oval indicates the number of votes recorded.

Figure 5.6. Set up of three workspaces used in COS consensus meeting. Whole group space on top row and smaller breakout rooms on bottom row.

ET breakout session 1

MC breakout session 1

JW breakout session 1

ET breakout session 2

MC breakout session 2

JW breakout session 2

Figure 5.7. Pictures taken of breakout sessions.

5.4.4 Statistical considerations

There is currently no recommended minimum number of participants to include in a Delphi survey, and no requirement to demonstrate a statistically representative sample (251-254). Gargon *et al.* (2019) demonstrate that in 19 COS studies registered on the COMET database in 2018 reporting Delphi survey results, the number of Delphi participants ranged from 26 to 670 and 26 to 586 in rounds 1 and 2, respectively (68). From the information provided by Gargon *et al. (*2019), the mean number of Delphi survey participants was calculated at 160 and 141 participants in rounds 1 and 2, respectively, giving an overall participant attrition rate of 12% (68). In previous studies, a number of between 10 and 15 participants per stakeholder group has been demonstrated to yield satisfactory results (251-254). This study aimed to recruit a minimum of 30 participants per stakeholder group to increase generalisability, and to allow for an attrition rate between Delphi rounds of 20%.

The use of NGT does not depend on statistical power, and there is no robust or commonly used method for calculating the required number of participants (70,254). Gargon *et al.* (2019) identify seven COS studies registered on the COMET database in 2018 reporting results from mixed stakeholder consensus meetings. Consensus meeting participant numbers ranged from 19 to 54 with a mean calculated participant number of 29. This study aimed to recruit a minimum of 15 participants to the COS consensus meeting as this number has been demonstrated to be valid in other settings (246,253,255). However, given the demographic and injury severity range of patients sustaining OLLFs and the diverse number of healthcare professionals involved in their care, a consensus

meeting sample of 30 would be more appropriate in providing a representative sample.

Median and standard deviation were calculated for each outcome scored in the COS consensus meeting electronic voting session using TurningPoint© software.

5.5 Results

See Figure 5.8 for a schematic overview of results in this Chapter.

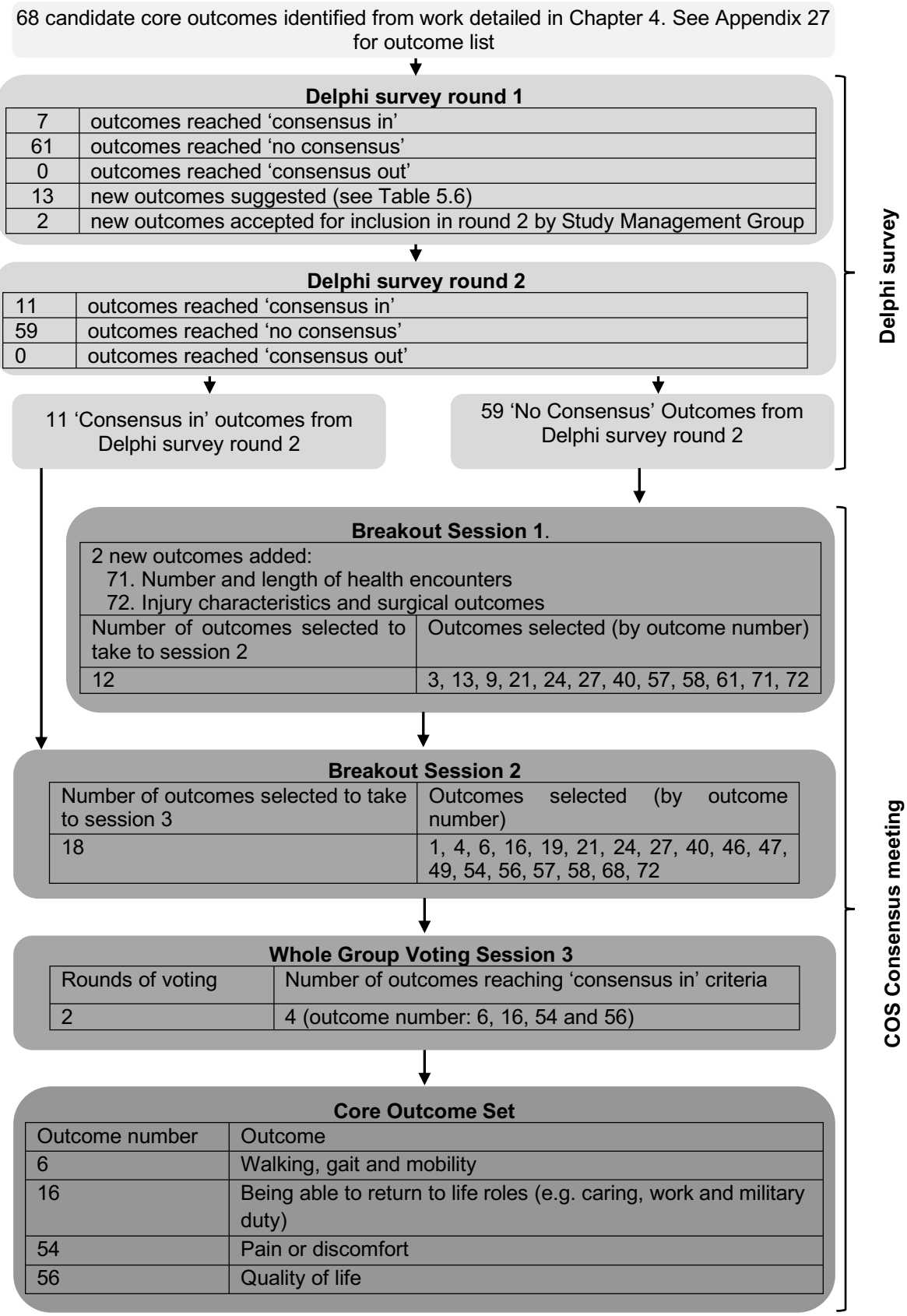


Figure 5.8. Schematic flow diagram of the Delphi survey and COS consensus meeting consensus results.

5.5.1 Delphi survey

5.5.1.1 Round 1

Round 1 of the Delphi survey was completed by 187 participants from the UK, of which 74 (40%), 102 (55%) and 11 (5%) self-allocated to the patient, healthcare professional and researcher stakeholder groups, respectively. The patient response rate for completing Delphi survey round 1 was 89% from 83 patients recruited to the study (35 Oxford University Hospitals NHS Foundation Trust, 27 University Hospitals Coventry and Warwickshire NHS Trust, 20 North Bristol NHS Trust and 1 Hull and East Yorkshire Hospitals NHS Trust). The majority of patients completing round 1 had sustained an open fracture of the tibia/fibula (85%), requiring cover with a skin graft or muscle flap (72%). Trauma and Orthopaedic (50%) and Plastic and Reconstructive (21%) Surgeons represented most healthcare professionals completing round 1. Research students (29%) and research nurses/associates (21%) represented most researchers completing round 1. See Table 5.4 for participant demographics.

Delphi survey round 1 resulted in 7 outcomes reaching ‘consensus in’, 61 outcomes reaching ‘no consensus’ and no outcomes reaching ‘consensus out’ (see Table 5.5 for outcomes reaching ‘consensus in’). Participants in Round 1 suggested 13 additional outcomes, of which 11 were rejected, and two were accepted for inclusion in Delphi survey round 2 with justifications provided in Table 5.6.

5.5.1.2 Round 2

Round 2 was completed by 136 participants, of which 55 (40%), 73 (54%) and 8 6%) were patients, healthcare professionals and researchers, respectively. There were 11 outcomes reaching consensus ‘in’, no outcomes reaching ‘consensus out’ and the remaining 59 outcomes reaching ‘no consensus’ (see Table 5.5).

The overall attrition rate between survey rounds 1 and 2 was 27%, with attrition spread relatively evenly across the three stakeholder groups (26% patients, 28% healthcare professionals and 27% for researchers).

Over the 136 participants who completed both rounds of the survey, there were 273 score changes made by 35 participants to the 68 outcomes presented in round 1. Participants increased their score 128 (47%) times, decreased their scores 134 (49%) times, changed from ‘unable to score’ to give a score 9 (3%) times and vice-versa on 2 (1%) occasions. The mean overall score change between rounds was 0.21 (Standard Deviation 2.22).

Delphi survey and COS consensus meeting participant demographics table.	**Delphi Survey**		**COS Consensus meeting**
	Round 1 n=187	**Round 2 n=136**	**n=41**
Stakeholder group, n (%)			
Patients	74 (40)	55 (40)	15 (37)
Anatomical area of open fracture[1]			
Open fracture of the thigh (femur)	1 (1)	1 (1)	-
Open fracture of the leg including ankle (tibia/fibula)	61 (85)	43 (81)	14 (93)
Open fracture of the foot (all bones of the foot including phalanges)	5 (7)	5 (9)	1 (7)
Open fracture of the thigh and leg	1 (1)	1 (1)	-
Open fracture of the leg and foot	3 (5)	2 (4)	-
Open fracture of the thigh, leg and foot	1 (1)	1 (1)	-
Indication of severity of open fracture[2]			
Open fracture closed primarily	16 (22)	11 (20)	6 (40)
Open fracture required a skin graft or muscle flap.	52 (72)	40 (74)	9 (60)
Open fracture resulting in an amputation.	4 (6)	3 (6)	-
Patient carers	-	-	1 (2)
Healthcare professionals[3]	102 (55)	73 (54)	14 (34)
Anaesthetist or Intensive Care Physician	1 (1)	1 (2)	-
General Practitioner	3 (3)	3 (4)	-
Nurse (including advanced nurse practitioners)	9 (8)	7 (10)	3 (21)
Physician (e.g. Orthogeriatrician)	3 (3)	3 (4)	1 (7)
Physiotherapist	11 (10)	8 (11)	1 (7)
Plastic and Reconstructive Surgeon	23 (21)	14 (20)	3 (21)
Psychologist (e.g. Trauma psychologist)	1 (1)	1 (2)	1 (7)
Trauma and Orthopaedic Surgeon	55 (50)	35 (45)	3 (21)
Other	3 (3)	0	2 (16)
Researchers[4]	11 (5)	8 (6)	11 (27)
Post-Doctoral researcher	3 (11)	1 (14)	2 (18)
Professor or Associate Professor	4 (14)	0	5 (46)
Research Nurse/Associate	6 (21)	3 (43)	2 (18)
Student (MSc or PhD)	8 (29)	0	1 (9)
Trial manager	2 (7)	2 (29)	1 (9)
Other	5 (18)	1 (14)	-
Gender, n (%)			
Male	123 (66)	85 (62)	23 (57)
Female	64 (34)	51 (38)	17 (43)
Patients: Male	43 (58)	31 (56)	9 (60)
Female	31 (42)	24 (44)	6 (40)
Age, n (%)			
Patients: 20-29	13 (17)	9 (16)	1 (6)
30-39	10 (14)	8 (15)	3 (20)
40-49	11 (15)	7 (13)	1 (6)
50-59	22 (30)	17 (31)	6 (40)
60-69	6 (8)	3 (5)	1 (6)
Over 70	12 (16)	11 (20)	3 (20)
Mean (years)	49	51	53

Delphi survey and COS consensus meeting participant demographics table.	**Delphi Survey**		**COS Consensus meeting**
	Round 1 n=187	**Round 2 n=136**	**n=41**
Mean Male (years)	44	44	48
Mean Female (years)	58	59	60
Professionals: 20-29 (Healthcare professionals and researchers)[5]	8 (7)	8 (10)	-
30-39	51 (46)	36 (45)	-
40-49	36 (32)	23 (29)	-
50-59	13 (11)	10 (13)	-
60-69	3 (3)	2 (2)	-
Over 70	1 (1)	1 (1)	-
Mean (years)	41	41	-
Patients sustained OLLF on military duty, n (%)	3 (4)	2 (4)	-
Professionals employed by the military, n (%)	9 (9)	6 (8)	-
Plastic and Reconstructive Surgeon	6 (66.7)	5	-
Trauma and Orthopaedic Surgeon	3 (33.3)	1	-

1. 2 Patients did not state the anatomical area of open fracture.
2. 2 Patients did not indicate the severity of their open fracture.
3. 7 Healthcare professionals self-identified as researchers when selecting stakeholder group.
4. 17 Researchers self-identified as Healthcare Professionals when selecting stakeholder group.
5. 1 healthcare professional entered an incorrect date of birth

Table 5.4. Delphi survey and COS consensus meeting participant demographics table.

Percentage of stakeholder groups scoring 7-9 (critical) for an outcome in rounds 1 and 2.								
Outcomes	**Delphi Round 1**				**Delphi Round 2**			
Outcomes reaching 'consensus in' at Delphi survey round 1	**Patients**	**Healthcare Professionals**	**Researchers**	**All**	**Patients**	**Healthcare Professionals**	**Researchers**	**All**
Outcomes reaching 'consensus in' at Delphi survey round 2	**n=74**	**n=102**	**n=11**	**n=187**	**n=55**	**n=73**	**n=8**	**n=136**
Physical functioning								
1. Ability to do activities of daily living	88	95	100	92	91	99	100	96
2. Ability to kneel	55	14	30	31	41	4	13	19
3. Ability to balance	75	46	60	58	96	26	38	44
4. Ability to be independent	85	87	86	86	89	92	100	91
5. Ability to drive	63	31	20	44	57	14	25	32
6. Walking, gait and mobility	86	80	80	83	91	79	63	83
7. Ability to be able to dress and do self and personal care	88	75	100	82	91	83	88	87
8. Ability to have intimate relationships	51	46	40	47	37	18	0	25
9. Ability to exercise	71	31	50	48	63	14	13	34
10. Ability to comfortably wear shoes and clothes of your choice	56	24	40	38	44	8	25	24
11. Lower limb function	84	53	80	67	83	54	88	68
12. Range of movement	71	33	50	49	57	14	25	32
Social functioning								
13. Ability to participate in social events	59	49	70	54	48	29	38	37
14. Ability to start, maintain and develop relationships	59	52	70	56	46	33	50	40
Role functioning								
15. Being able to care for other people and/or animals	52	24	50	36	49	7	13	24
16. Being able to return to life roles (e.g. caring, work, military duty)	74	69	70	71	75	72	75	74
Emotional functioning and wellbeing								
17. Appearance of lower limb e.g. scars, flaps and swelling	38	23	40	30	26	6	13	14
18. Change in body shape or weight	35	18	30	25	24	3	0	11

Percentage of stakeholder groups scoring 7-9 (critical) for an outcome in rounds 1 and 2.								
Outcomes	**Delphi Round 1**				**Delphi Round 2**			
	Patients	**Healthcare Professionals**	**Researchers**	**All**	**Patients**	**Healthcare Professionals**	**Researchers**	**All**
Outcomes reaching 'consensus in' at Delphi survey round 1								
Outcomes reaching 'consensus in' at Delphi survey round 2	**n=74**	**n=102**	**n=11**	**n=187**	**n=55**	**n=73**	**n=8**	**n=136**
19. Feelings of self-identity and body wholeness	38	30	30	34	30	14	13	20
20. Feelings of disablement, being damaged or broken	36	36	30	35	26	14	13	19
21. Feelings of giving up and hopelessness	47	52	60	50	38	31	38	34
22. Feeling of loss	40	32	40	36	28	11	13	18
23. Feelings of frustration and anger	49	34	40	40	30	8	13	17
24. Feelings of hopefulness, positivity and determination	68	44	50	54	63	24	38	41
25. Isolation, loneliness and lack of emotional support	49	45	40	46	45	30	13	35
26. Low mood	43	43	60	44	35	21	38	27
27. Ability to move on and feeling of getting life back	78	51	78	63	81	44	63	60
28. Having clear expectations and views on the future with lack of uncertainty	55	39	56	47	58	18	25	35
29. Tolerance of uncertainty and living in fear e.g. fear of falling or going outside and fear for the future	47	34	50	40	32	11	13	20
30. Being anxious or stressed	47	32	60	40	35	14	25	23
31. Loss of confidence or control and feeling of limitation	50	33	50	41	42	11	13	24
32. Experience of flashbacks to the traumatic event	43	36	40	39	36	11	13	21
33. Emotional vulnerability, volatility and fragility.	44	31	60	38	35	8	25	20
34. Ability to accept the event and life change	60	42	50	50	47	21	25	32
35. Feelings of struggle or fighting against the body	48	20	33	32	33	3	0	15
36. Maintaining a feeling of dignity	55	49	60	52	58	41	38	48
Cognitive functioning								
37. Lack of concentration and focus	48	37	50	42	37	13	13	22
Blood and lymphatic system outcomes								
38. Venous thromboembolism (blood clot in legs or lungs)	67	49	67	57	71	39	57	52

Percentage of stakeholder groups scoring 7-9 (critical) for an outcome in rounds 1 and 2.								
Outcomes	**Delphi Round 1**				**Delphi Round 2**			
	Patients	**Healthcare Professionals**	**Researchers**	**All**	**Patients**	**Healthcare Professionals**	**Researchers**	**All**
Outcomes reaching 'consensus in' at Delphi survey round 1								
Outcomes reaching 'consensus in' at Delphi survey round 2	**n=74**	**n=102**	**n=11**	**n=187**	**n=55**	**n=73**	**n=8**	**n=136**
General outcomes								
39. Sleep and fatigue	54	41	80	48	49	27	25	36
40. Number of unplanned hospital re-admissions	38	49	40	44	24	28	13	25
41. Length of hospital stay	36	34	20	34	13	14	13	14
42. Number of outpatient appointments	36	27	20	31	17	4	0	9
43. Number of Primary Care visits	32	25	30	28	12	6	0	8
Musculoskeletal and connective tissue outcomes								
44. Metalwork failure	63	57	67	60	63	44	63	53
45. Complications resulting from soft tissue (muscle flaps or grafts)	75	60	67	66	69	54	50	60
46. Amputation	86	86	70	85	88	89	88	88
47. Bone healing	85	76	89	80	87	74	71	79
48. Malunion, alignment and rotational deformity	72	54	56	61	65	44	14	51
49. Deep infection	88	86	80	86	88	84	86	86
50. Surface infection	68	37	30	49	52	23	0	33
51. Leg or bone shortening	64	41	50	50	59	27	13	39
52. Change in sensation	51	33	20	39	36	11	0	21
53. Muscle weakness	60	39	40	48	45	13	13	26
54. Pain or discomfort	67	77	90	74	70	82	88	77
55. Unplanned return to the operating theatre	57	51	50	53	50	44	25	45
Global quality of life								
56. Quality of life	88	91	90	90	91	99	100	95
Perceived health status								
57. Degree of perceived loss of general health and wellbeing	52	52	40	51	40	21	0	27

Percentage of stakeholder groups scoring 7-9 (critical) for an outcome in rounds 1 and 2.								
Outcomes	**Delphi Round 1**				**Delphi Round 2**			
	Patients	**Healthcare Professionals**	**Researchers**	**All**	**Patients**	**Healthcare Professionals**	**Researchers**	**All**
Outcomes reaching 'consensus in' at Delphi survey round 1								
Outcomes reaching 'consensus in' at Delphi survey round 2	**n=74**	**n=102**	**n=11**	**n=187**	**n=55**	**n=73**	**n=8**	**n=136**
Delivery of care								
58. Quality of communication of healthcare professionals to patients	69	58	60	63	62	39	38	48
59. Satisfaction with care	59	52	60	55	49	25	50	36
60. Tolerability and acceptability of surgical intervention e.g. exter41nal fixator	60	41	40	48	43	13	13	24
Personal circumstances								
61. Change in lifestyle	59	46	50	51	55	32	25	41
62. Being compensated financially for injury	45	26	50	35	29	8	25	18
63. Personal cost of treatment and care following injury	51	34	40	41	34	13	13	21
64. Effect of injury on personal finances	58	42	60	49	46	23	25	32
Adverse events and effects								
65. Number of adverse events	45	51	70	50	32	30	38	31
66. Side effects of medication	39	27	40	32	21	4	0	11
67. Poor experience during anaesthesia	41	28	30	33	27	4	13	13
Mortality								
68. Survival	83	94	67	88	90	93	100	92
Outcomes added after Delphi survey round 1								
Musculoskeletal and connective tissue outcomes								
69. Chronic pain	-	-	-	-	58	70	50	64
General outcomes								
70. Length of stay (Super Spell)	-	-	-	-	20	19	13	18

Table 5.5. Percentage of stakeholder groups scoring 7-9 (critical) for an outcome in rounds 1 and 2.

Outcomes suggested in Delphi survey round 1		**Included in Delphi round 2**	**Justification of Study management Group decision**
1	Ability to jog and run.	No	Covered by outcomes 4 and 9
2	Duration of treatment/recovery	No	Difficult to define. Duration of treatment loosely covered by outcomes 41, 42, 43 and 70
3	Return to work if working	No	Covered by outcome 16
4	Cost to NHS	No	Not in scope
5	Ability to return recreations	No	Covered by outcomes 9 and 13
6	Being prepared by the Healthcare Staff honestly about future abilities	No	Covered by outcomes 58 and 59
7	Ability to heal due to diabetes type 1	No	Covered by outcomes 45, 50
8	Satisfaction with prosthetic service	No	Covered by outcome 59
9	Access to prosthetic services	No	Covered by outcome 59
10	Chronic pain	Yes	Chronic pain could be argued to be considered separately to outcome 54
11	Home plan	No	Covered by outcomes 58 and 59
12	Burden on the family e.g. partner and children	No	Covered by outcomes 13 and 14
13	Length of Stay (Superspell - to include other health / social care settings)	Yes	Included as an encompassing outcome to include social care interactions as well as healthcare interactions
Suggested outcomes from COS consensus meeting session 1 participants		**Included in session 2**	**Justification of Study management Group decision**
1	Number and length of health encounters	Yes	Included as it is a broad outcome that also combines outcomes 40, 41, 42, and 43
2	Injury characteristics and surgical outcomes	Yes	Included as it intended to combine all objective clinical outcomes, e.g. outcomes 44, 46, 47 and 48 under one unifying outcome

Table 5.6. Additional outcomes suggested by Delphi survey round 1 and COS consensus meeting participants.

5.5.2 COS consensus meeting

The COS consensus meeting was attended by 41 participants, of whom 15 (37%) were patients, 14 (34%) were healthcare professionals, 11 (27%) were researchers, and 1 (2%) was a patient carer. All participants completed both rounds of the Delphi survey.

The majority of patients were male (9, 60%), and the most common type of OLLF was of the tibia/fibula (14, 93%) that required treatment with a skin graft or muscle flap (9, 60%). The mean age of all patients was 53 (range 26-76), male patients was 48 (range 26-72), and female patients was 60 (range 33-76) years. The patient demographic profile was similar throughout rounds 1 and 2 of the Delphi survey and the COS consensus meeting (see Table 5.4).

Healthcare professionals attending were most commonly represented by nurses (3, 21%), trauma and orthopaedic (3, 21%) and plastic and reconstructive surgeons (3, 21%) (see Table 5.4). The majority of the participants allocated to the researcher group were also from a clinical background. The two post-doctoral researchers had backgrounds in nursing and physiotherapy. The five professors/associate professors also worked clinically, three as trauma and orthopaedic surgeons, one as a plastic and reconstructive surgeon and one as a physiotherapist. The student was a trauma and orthopaedic registrar.

5.5.2.1 Breakout session 1

Participants voted to bring 10 outcomes out of the 59 that failed to reach consensus in the Delphi survey forward for consideration in session 2. Also, one breakout group created two novel outcomes by:

1. Combining outcome numbers 42, 43 and 70 to create outcome: 71. ‘Number and length of health encounters’.
2. Combining outcome numbers 44, 45, 48 and 55 to create outcome: 72. ‘Injury characteristics and surgical outcomes’ (see Figure 5.8).

Outcomes 71 and 72 were created as the group felt that the underlying component outcomes were important but recognised that they might not be considered important enough to be included in the COS as individual items. By combining them under an overarching outcome, the group attempted to increase the chance of pushing them through into the COS at later ranking and voting stages.

5.5.2.2 Breakout session 2

On combining the top-10 ranked outcomes from each of the three breakout groups and removing duplicates, 18 outcomes were identified to take forward to the final session (see Figure 5.8).

5.5.2.3 Whole group electronic-voting session 3

The first round of discussion and anonymised electronic-voting on each of the 18 outcomes reached ‘consensus in’ for three outcomes:

6. Walking, gait and mobility

16. Being able to return to life roles (e.g. caring, work and military duty)

56. Quality of life

The second round reached ‘consensus in’ for one additional outcome:

54. Pain or discomfort

See Table 5.7 for the voting results for each outcome. In the second round of voting, 15% and 77% of participants scored ‘pain or discomfort’ as ‘not important’ (out) and ‘critical’ (in), respectively. It was ambiguous whether the ‘consensus in’ criteria had been met (see Table 5.2). However, the Study Management Group made an on-the-spot decision to agree on ‘pain or discomfort’ as ‘consensus in’ for inclusion in the COS. This was decided as the outcome scored seven percentage points above the 70% threshold for ‘consensus in’.

In the discussion between voting rounds 1 and 2, there was much debate over whether ‘bone healing’ and ‘deep infection’ outcomes should be included in the COS. MC chaired the discussion by selecting participants with strong views, either way, to share their thoughts with the group and ensuring all views were heard before voting. The patients felt that fundamentally, being able to walk, return to work and maintain a good quality of life were the most important outcomes to achieve in recovery and that bone healing and infection were secondary. The inclusion of ‘deep infection’ was a sticking point for several consultant trauma and orthopaedic surgeons, arguing that minimising the risk of infection is a guiding principle of modern practice and is a fundamentally important component of achieving a positive treatment outcome. A counter-argument was raised by a healthcare professional pointing out that the COS is intended for use in all research and clinical practice on patients following OLLF. As such, studies on rehabilitation or psychosocial support interventions would not consider infection a key outcome to measure. This argument was supported by an additional point that in any surgical intervention study, infection would be considered an adverse event; as such, its measurement would be mandated by the funder and or an ethics committee. The group agreed that objective surgical outcomes, including ‘deep

infection' and 'bone healing' are important and do need to be measured in surgical intervention trials but not across all OLLF studies. Therefore, it was suggested that there was a need to develop a set of specific, well-defined objective surgical outcomes for OLLF in future work.

As desired, the discussion between rounds helped polarise participant views between voting round 1 and 2. This was well demonstrated by an increase in the Standard Deviation values between rounds 1 and 2 for 'deep infection' and 'bone healing' of 0.82 to 0.97 and 0.81 to 0.96, respectively.

Outcomes reaching 'consensus in' at round 1	**Number of electronic votes counted in session 3, round 1, n=41 (%)**					**Number of electronic votes counted in session 3, round 2, n=41 (%)**				
Outcomes reaching 'consensus in' at round 2	1. Not important	2. Important but not critical	3. Critical	Median	Standard Deviation	1. Not important	2. Important but not critical	3. Critical	Median	Standard Deviation
Outcome										
1. Ability to do activities of daily living	6 (15)	11 (28)	22 (56)	3	0.74	10 (26)	3 (8)	26 (67)	3	0.87
4. Ability to be independent	6 (15)	8 (21)	25 (64)	3	0.75	19 (51)	2 (5)	16 (43)	1	0.97
6. Walking, gait and mobility	**0 (0)**	**8 (21)**	**30 (79)**	**3**	**0.41**	-	-	-	-	-
16. Being able to return to life roles (e.g. caring, work and military duty)	**3 (8)**	**3 (8)**	**33 (85)**	**3**	**0.58**	-	-	-	-	-
19. Feelings of self-identity and body wholeness	23 (57)	16 (40)	1 (2)	1	0.55	34 (92)	3 (8)	0 (0)	1	0.27
21. Feelings of giving up and hopelessness	14 (35)	14 (35)	12 (30)	2	0.8	23 (61)	1 (3)	14 (37)	1	0.96
24. Feelings of hopefulness, positivity and determination	23 (59)	10 (26)	6 (15)	1	0.74	25 (68)	3 (8)	9 (24)	1	0.86
27. Ability to move on and feeling of getting life back	15 (38)	7 (18)	17 (44)	2	0.9	22 (61)	0 (0)	14 (39)	1	0.97
40. Number of unplanned hospital re-admissions	20 (53)	10 (26)	8 (21)	1	0.8	25 (64)	4 (10)	10 (26)	1	0.87
46. Amputation	15 (38)	9 (22)	16 (40)	2	0.88	20 (54)	3 (8)	14 (38)	1	0.94
47. Bone healing	11 (28)	13 (32)	16 (40)	2	0.81	24 (60)	1 (2)	15 (38)	1	0.96
49. Deep infection	10 (26)	11 (28)	18 (46)	2	0.82	16 (40)	1 (2)	23 (57)	3	0.97
54. Pain or discomfort	**5 (12)**	**12 (30)**	**23 (57)**	**3**	**0.71**	**6 (15)**	**3 (8)**	**30 (77)**	**3**	**0.74**
56. Quality of life	**1 (2)**	**7 (18)**	**32 (80)**	**3**	**0.47**	-	-	-	-	-
57. Degree of perceived loss of general health and wellbeing	23 (59)	13 (33)	3 (8)	1	0.64	27 (71)	1 (3)	10 (26)	1	0.88
58. Quality of communication of healthcare professionals to patients	16 (40)	14 (35)	10 (25)	2	0.79	21 (58)	1 (3)	14 (39)	1	0.97
68. Survival	21 (54)	6 (15)	12 (31)	1	0.89	21 (54)	6 (15)	12 (31)	1	0.89
72. Injury characteristics and surgical outcome	15 (38)	6 (15)	18 (46)	2	0.92	10 (27)	1 (3)	26 (70)	3	0.89

Table 5.7. COS consensus meeting whole group electronic-voting session 3 results.

5.6 Discussion

This project provides the first combined patient, healthcare professional and researcher consensus on what outcomes to measure in research on, and the clinical practice of caring for patients following OLLF. Core outcomes identified in this study were scored as critically important by more than 70% of stakeholders, using robust consensus methods to ensure that each stakeholder group was equally represented. This study recommends that all future studies of skeletally mature patients following OLLF in the UK use the CO-OLLF COS as a framework for outcome selection.

5.6.1 Strengths and limitations

This study meets the COMET Core Outcome Set-STAndards for Development (COS-STAD) (71). COS-STAD recommends that 11 standards should be met in COS development. Standards were created by an international group of experienced COS developers, methodologists and potential COS end users. In meeting these recommendations, CO-OLLF objectively demonstrates methodological rigour. Using a combination of consensus gathering methods on over 180 participants representing a diverse spectrum of the OLLF patient population and the healthcare professional body, this study shows generalisability to the UK OLLF population and credibility for use in future research.

This study used two recognised consensus gathering methods; Delphi Technique and Nominal Group Technique, to agree on the COS for OLLF. Combining these two techniques allowed access to a large number of stakeholder views in the Delphi survey, which informed a consensus meeting and provided a base from

which to explore detailed opinions over which outcomes are most important using a Nominal Group Technique. As well as following best practice recommendations by the COMET initiative (70,73), this study also adopted JLA (71) methodological guidance to facilitate the consensus meeting. The modified Nominal Group Technique methods recommended by the JLA have been 'tried and tested' in over 100 PSPs and provide an excellent example of best practice in prioritising a large number of items when using a diverse multi-stakeholder group (71).

COS developers typically use Delphi surveys to either reach consensus for a COS or as a method to reduce the total number of candidate core outcomes to be considered at a consensus meeting. As this study failed to reach 'consensus out' for any outcome in the Delphi survey, it was agreed that all outcomes needed to be considered at the consensus meeting. It was decided that all 59 'no consensus' outcomes should be reviewed at the beginning of the consensus meeting. This approach was used to efficiently reduce the number of outcomes to facilitate better discussion when ranking outcomes for importance in the next session. Other options considered were to exclude all 'no consensus' outcomes at the COS consensus meeting. However, it was agreed that dropping all 59 'no consensus' outcomes would risk losing potential core outcomes. Another option was to retrospectively change the 'consensus out' criteria to a majority rule – i.e. classifying outcomes as having reached consensus for exclusion where 50% of participants or less in each stakeholder group scored the item as critical (7-9), an approach used by other COS developers in dealing with similar issues (247,248). However, setting the consensus criteria a priori is one of the COS-STAD recommendations and amending it would constitute a protocol violation. This study's chosen method demonstrates thoroughness in approach by facilitating a

final 'safety check' of all 'no consensus' outcomes and gave participant groups a last opportunity to create additional outcomes.

It should be acknowledged that there remains uncertainty over the optimal COS development methods, including approaches to the selection of participants and consensus methods (70,256). COMET identifies this as an area for further development (70).

Regarding the Delphi survey, a relatively small number of participants self-identified as researchers suggesting an under-representation in the researcher stakeholder group. However, on review of all registered healthcare professionals, it was clear that a significant number of participants with dual training in academia and clinical practice had self-identified as healthcare professionals at the Delphi registration page; a consequence of the DelphiManager software only allowing participants to allocate themselves to one stakeholder group. As such, researcher views will have also been represented in the healthcare professional stakeholder group. The researcher stakeholder group was well represented at the COS consensus meeting, where stakeholder group sample allocation was decided a priori by AA.

It is recognised that the order in which items are presented in a questionnaire can affect responses and rates of response (257). For example, the ‘consistency effect’ has been described where items are answered in relation to responses to earlier items (258) as well as the ‘context effect’ where responses to earlier items are used as a comparative standard by which to respond to later items (257,259). It has been suggested that the question order and context may lead to bias in scoring outcomes for importance when conducting a Delphi survey in a COS development

study (260). The outcome order was not randomised in this study introducing a potential risk of bias. The randomisation of outcome order was considered but not undertaken due to feedback from patients and healthcare professionals in the SDGs. It was suggested that the life impact outcomes should be ordered before physiological and clinical outcomes with survival last in order to have the outcomes that were considered the most important in the SDGs first. This order was chosen to foster patient engagement and minimise patient attrition. Also, there were practical limitations; at the time of designing the Delphi survey, the DelphiManager platform could not create a randomised list of outcomes for each participant.

This study's attrition rate between Delphi survey rounds was 27%, which was higher than the average attrition rate of 12%, calculated from the 19 COS studies registered on the COMET database in 2018 reporting a Delphi survey (68). The degree of non-response after the first Delphi round has been demonstrated to be highly variable between studies and can be dependent on the timing of the Delphi rounds (for example, clashing with school holidays), survey length, the time elapsed between the first and second rounds and the method of recruitment of participants, among other reasons. Participant attrition was marginally higher in the healthcare professional group (28%) compared to the patient group (26%). This difference may be explained by the different recruitment methods between the two stakeholder groups. Healthcare professionals were recruited by email and use of a snowball sampling strategy (research participants recruiting other participants, e.g. forwarding invitation emails to colleagues). In contrast, patients were recruited by trained research staff directly from the hospital wards or follow up clinics. As a result of human interaction, patients may have felt a more personal connection to the study, resulting in a lower attrition rate compared to healthcare

professionals. Several strategies were used to reduce attrition between rounds, including multiple reminder emails, extending the round 1 completion deadline and, in the case of patients, following up by telephone. It may have been possible to reduce attrition in all stakeholder groups by reducing the length of the survey or not providing feedback in round 2 using graphs that limited each page to displaying only one outcome (participants had to score outcomes over 70 web pages in round 2). However, the desire to reduce survey attrition needed to be balanced with the requirement to present a comprehensive long-list of potential core outcomes. PPI feedback from EB suggested that presenting round 1 scores graphically was more understandable to patient-participants, and it is thought to better promote vicarious thinking (261). However, this study demonstrates a lower attrition rate compared to other COS studies accessing difficult to reach populations, such as Duffy *et al.* 2020 whom developed a COS for pre-eclampsia research reporting an attrition rate of 37% over three Delphi rounds (254). When comparing participant demographics between Delphi survey rounds 1 and 2 by participant percentage, the demographic distribution appears to be relatively similar between rounds (see Table 5.4). Also, no outcomes failed to reach consensus in round 2 after meeting the consensus criteria in round 1, suggesting a limited effect of attrition bias on the Delphi survey results.

It is unknown how representative the patient sample recruited to this project was in terms of the sociodemographic and ethnicity distribution of the UK OLLF population. There was concern that the patient response rate would have been reduced by asking specific questions about employment, income and ethnic background in the DelphiManager registration form, and little is currently known about the demographic distribution of OLLF in different ethnic groups from which

to compare. Most patients were recruited from hospitals based in Oxford, Bristol and Coventry; thus, the patient sample is likely to be mixed in terms of social deprivation due to sociodemographic variation within and between these regions.

The COS consensus meeting was well attended compared to consensus meetings reported in other COS development studies (68). Patients represented the largest stakeholder group attending the consensus meeting (37%), which builds confidence that the patient view was carried into the COS. As all three stakeholder groups were similar in terms of representation, the overall scores were used to define consensus in the final voting session rather than applying the consensus criteria to each stakeholder group. This ensured the real-time votes were displayed in a clear visual format that was easily interpretable for all participants. In addition, displaying the overall score maintained a higher degree of anonymity of participants, which prevented stakeholder groups from attempting to pressurise each other to include or exclude outcomes.

Due to sickness on the day, no patients attended the COS consensus meeting whose OLLF had resulted in an amputation. The majority of patients attending the COS consensus meeting had sustained an OLLF of the tibia (93%) that required plastic surgical intervention for coverage (60%) (see Table 5.4). However, it was unknown how many patients had experienced a severe complication during their treatment, such as a deep infection or non-union requiring a return to theatre. Poor representation of patients who experienced treatment complications may explain the unexpected exclusion of deep infection and bone union in the COS. Without direct experience of these complications, it is unlikely that patients will have insight into the seriousness of such adverse events and, therefore, not advocate for the inclusion of related outcomes. However, this issue was discussed during the final

voting session of the consensus meeting, where surgeons explained the impact of suffering such a complication. The patients felt that the negative impact of such an event would be sufficiently captured by ‘walking, gait and mobility’ and ‘quality of life’ outcomes.

It was also unexpected that no outcomes directly representative of the emotional functioning and wellbeing outcome domain were included in the COS. This may have resulted from the exclusion of an overarching candidate core outcome for this domain, for example, ‘stress and anxiety’. However, three emotional functioning and wellbeing outcomes (outcomes 19, 21 and 24) did reach the final voting session, but all received a majority vote of ‘not important’ in both voting rounds (see Table 5.7). During the discussion, participants felt that emotional functioning and wellbeing would be measured by ‘quality of life’, which achieved consensus for inclusion in the COS in the first round of voting.

5.6.2 Interpretation

Only a minority of research studies identified in Chapter 2 of this thesis reported any of the core outcomes identified in this work. The most commonly reported core outcome reported was pain or discomfort, reported in 9% of studies. Systematic implementation of this COS will help ensure that future research on patients following OLLF report outcomes that matter to patients, healthcare professionals and researchers. This will help limit selective reporting of results by convenience using outcomes collected retrospectively as part of routine clinical practice.

In designing RCTs, it is considered good practice to use the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) Statement (262,263) when writing trial protocols. SPIRIT recommends the use of COSs where they exist

(see Appendix 12). The importance of implementing COSs is also recognised by funders, including the NIHR, who recommend using COSs when applying to the Health Technology Assessment (HTA) research funding programme (see Appendix 10).

5.7 Conclusion

This COS for OLLF in skeletally mature patients should now underpin all future RCTs and systematic reviews evaluating future interventions for OLLF. It is also hoped that this COS will form the basis to ensure measurement of the most important outcomes in local and national audit of OLLF care. Harmonisation of outcome-reporting should help guarantee that future research addresses outcomes agreed as important, consistently facilitating meta-analysis to enhance patient care and ultimately improve patients' treatment result following OLLF.

Chapter 6. How should core outcomes be measured?

6.1 Chapter summary

This Chapter outlines work undertaken to provide an evidence-based recommendation for how to measure core outcomes identified in the COS.

A systematic review was conducted to identify studies on measurement properties of Outcome Measurement Instruments (OMIs) measuring the four core outcomes in the OLLF population established in Chapter 5. Only one candidate OMI was identified, the Wales Lower Limb Trauma Recovery (WaLLTR) scale and a quality assessment was undertaken.

A pragmatic approach was also developed, drawing on OMIs measuring core outcomes identified in Chapter 2 to create a shortlist of 11 candidate OMIs for presentation at a second consensus meeting. Using a Nominal Group Technique (NGT), consensus was found to recommend a set of two OMIs; the EuroQol 5-Dimensions 5-Level (EQ-5D-5L) and the Lower Limb Functional Scale (LEFS) to measure 'quality of life' and 'walking, gait and mobility', respectively. No consensus was achieved over an outcome measure for 'pain or discomfort' or 'being able to return to life roles'.

A Chapter 6 schematic diagram detailing the approach used for the selection of candidate OMIs for consideration at the COMIS consensus is provided on page 251 (Figure 6.2).

6.2 Introduction

Research conducted using OMIs of poor or unknown quality risks wastage of resources and raises ethical concerns over recruitment of patients to methodologically flawed studies (264). It is unclear which OMIs are most suitable for measuring core outcomes identified in Chapter 5. There is considerable variation in how outcomes were measured in the literature referred to in Chapter 2; for example, the core outcome 'quality of life' was measured by eight separate OMIs across 39 studies. To avoid inconsistencies in outcome-reporting in future research studies on OLLF, a clear recommendation on which OMIs to use when measuring core outcomes is required. Methods used for selecting OMIs for a COS are considered similar to selecting OMIs for individual trials. However, arguably, OMI selection methods in COS studies need to be more rigorous and meet higher standards of justification (2).

The process of OMI selection is complex. Choices involve conceptual considerations over the definition of the outcome of interest, practical aspects including feasibility, cost, and the burden the OMI will place on patients and researchers, as well as consideration over the methodological quality of the OMI (265).

In response to a lack of clarity in the literature over the terminology and definitions of measurement properties, a dearth of evidence on the measurement properties of many OMIs, and inconsistency in methods used to determine these measurement properties, the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) initiative was established in 2005 (91). The COSMIN initiative is led by an international multidisciplinary team with

backgrounds in epidemiology, psychometrics, medicine, qualitative research, and healthcare, who have expertise in developing and evaluating OMIs (91). The COSMIN initiative recommends that in order to select an OMI to measure a core outcome of interest using sound methodology requires:

1. Studies that evaluate the measurement properties (see Figure 6.1) of relevant OMIs in the target population.
2. A systematic review of studies on the measurement properties of candidate OMIs where information is gathered and evaluated in order to recommend the most suitable OMI (266-268). Where a high-quality systematic review does not exist, one should be conducted.

Figure 6.1 illustrates the nine measurement properties of OMIs clustered by domains of reliability, validity, and responsiveness that COSMIN recommends for consideration when selecting an OMI.

The COSMIN and COMET initiatives recognised a need for more rigorous and standardised methods when selecting OMIs for COSs. Their collaboration resulted in an international consensus-driven guideline on selecting OMIs for core outcomes in COS development studies (2). This practical guide was used to direct the approach detailed in this Chapter for the selection of OMIs.

The COSMIN preferred approach for selecting OMIs details four steps:

1. Conceptual considerations.
2. Finding existing OMIs.
3. Quality assessment of OMIs.
4. A consensus process to select one OMI for each core outcome.

The COSMIN preferred approach requires studies evaluating the measurement properties of candidate OMIs in the target population (OLLF population in the case of this study).

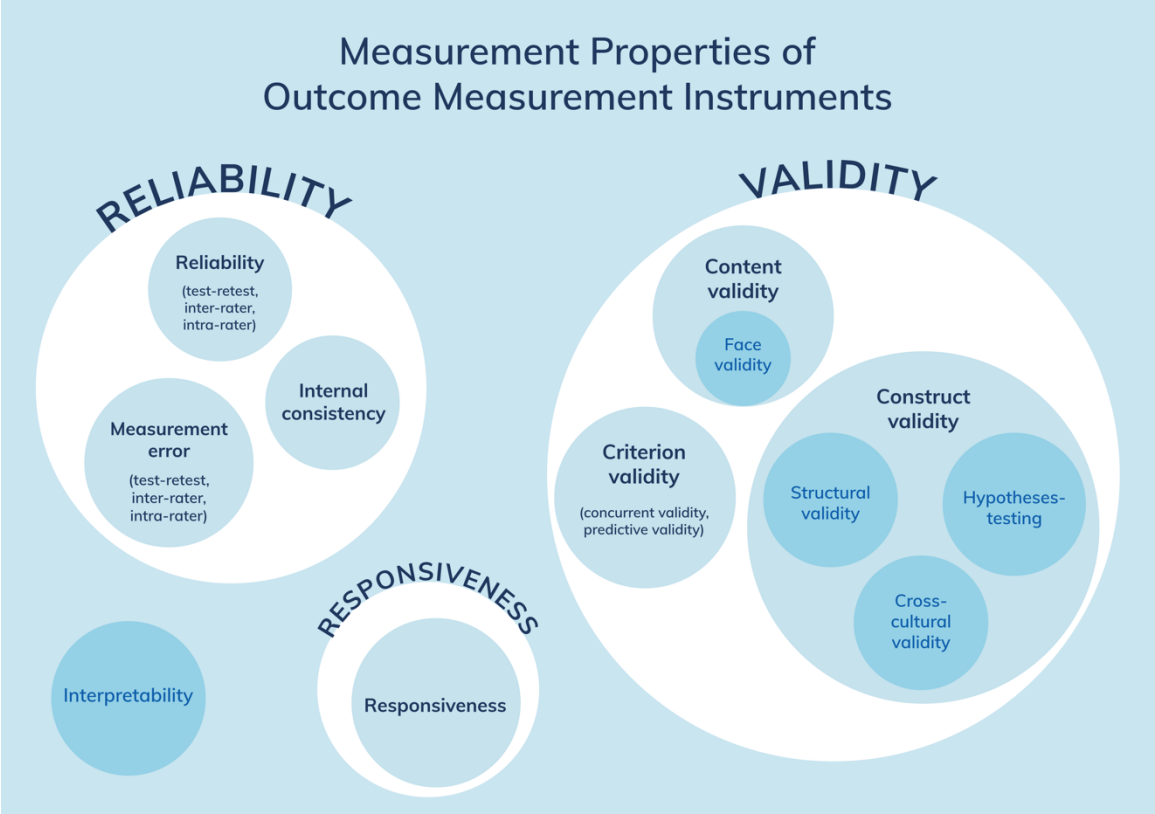


Figure 6.1. COSMIN Taxonomy of measurement properties based on an international consensus (269).

See the COSMIN website (https://cosmin.nl/wp-content/uploads/COSMIN-definitions-domains-measurement-properties.pdf) for the COSMIN definitions of domains, measurement properties, and aspects of measurement properties.

6.3 Objectives

1. Identify OMIs that measure core outcomes where measurement properties have been evaluated in the OLLF population by a systematic review of the published literature.

2. Undertake a quality assessment of OMIs identified using the COSMIN Risk of Bias Checklist (266).
3. Create a shortlist of candidate OMIs to measure core outcomes.
4. Facilitate a consensus meeting of patients, healthcare professionals and expert researchers in the field of measurement in medicine to achieve a consensus for a Core Outcome Measurement Instrument Set (COMIS).

   A COMIS will constitute the CO-OLLF recommendation on how core outcomes should be measured on patients following OLLF.

6.4 Methods

Where possible this Chapter follows the latest consensus-driven COSMIN guidance for the selection of OMIs for core outcomes (2,266-268). However, as described below, due to a lack of OMIs demonstrating evidence for the assessment of measurement properties in the OLLF target population, a pragmatic approach was required in addition to the COSMIN preferred approach to identify suitable candidate OMIs for measurement of core outcomes. See Figure 6.2 for a schematic overview of the methodological steps undertaken in this Chapter adapted from the COSMIN 'Guideline for selecting OMIs for outcomes included in a COS' (2). Figure 6.2 shows the preferred COSMIN approach shaded in dark grey, and the pragmatic steps developed for this study shaded in light grey.

6.4.1 Conceptual considerations

COSMIN recommends that the first step in selecting OMIs is to define the 'constructs' and the target population in which they will be measured. The

constructs constitute the core outcomes identified in Chapter 5, and the target population remains as defined in the CO-OLLF scope (see Table 1.8).

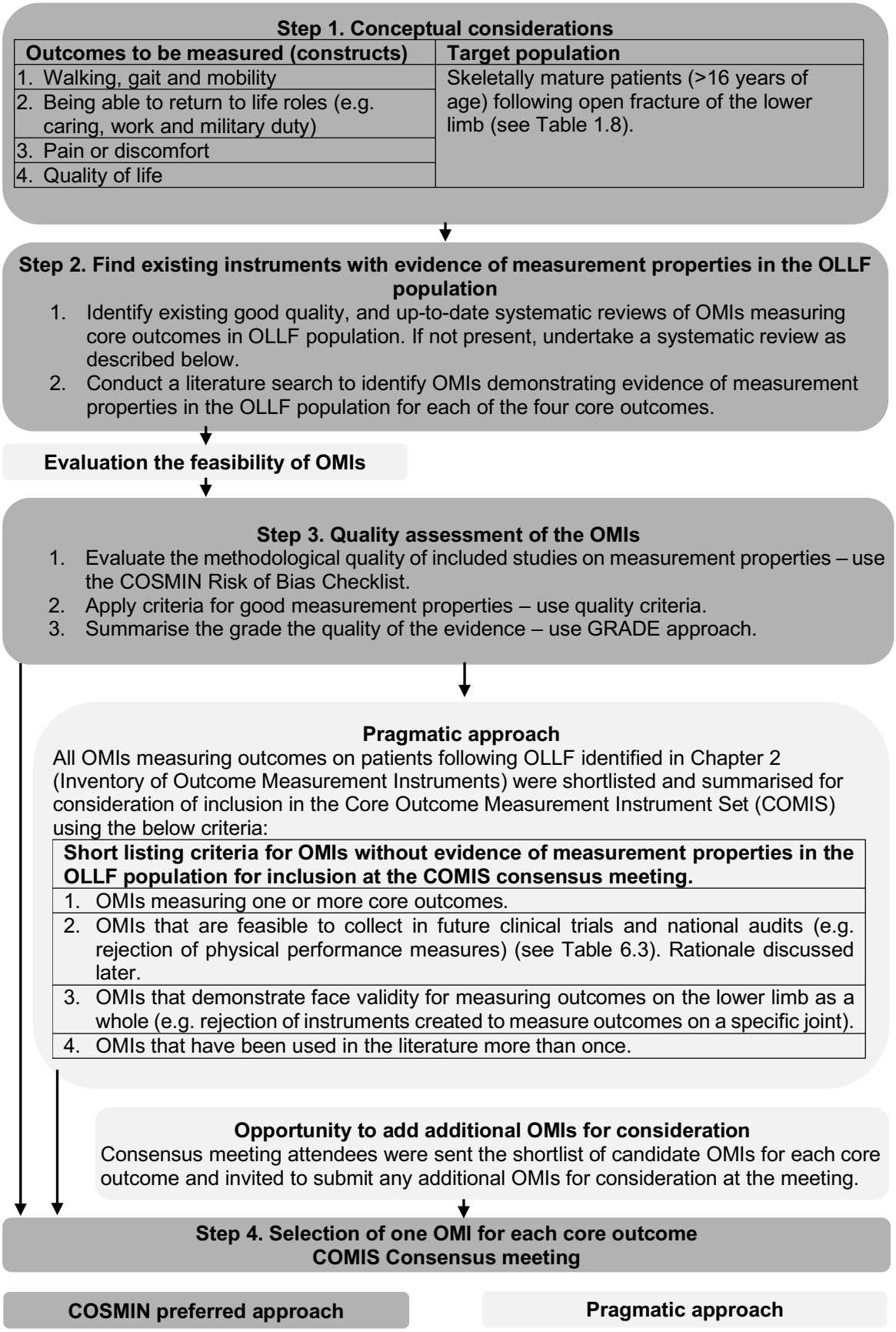


Figure 6.2. Schematic flow diagram representing the approach used for the selection of candidate OMIs for consideration at a consensus meeting for inclusion in the COMIS. Adapted from Prinsen *et al.* 2016 (2).

6.4.2 Finding existing OMIs

COSMIN guidance recommends searching for all existing OMIs with evidence of measurement properties in the target population by (2):

1. Searching for systematic reviews of OMIs.
2. Conducting literature searches.

6.4.2.1 Searching for systematic reviews

No systematic review of measurement properties of OMIs validated in the OLLF population was identified in Chapter 2. The search strategy used was broadly inclusive of all studies on OLLF undertaken from 2009 to July 2019, and such a systematic review would have been shortlisted and identified at the title and abstract screening.

Also, the COSMIN database of systematic reviews of OMIs (http://database.cosmin.nl/) was searched on the 18th of December 2020 using the broad search term ‘fracture’ to achieve maximum inclusion.

6.4.2.2 Conducting a systematic review of studies assessing measurement properties of OMIs measuring core outcomes in the OLLF population

This systematic review was conducted in line with the ‘COSMIN manual for systematic reviews of Patient-Reported Outcome Measures (PROMs)’ (available from https://www.cosmin.nl/wp-content/uploads/COSMIN-syst-review-for-PROMs-manual_version-1_feb-2018-1.pdf) (2,266-268) and reported by the aid of the PRISMA Statement (195).

6.4.2.2.1 Aim of systematic review

To critically appraise, compare and summarise the quality of measurement properties of all OMIs for; 1) walking, gait and mobility; 2) being able to return to life roles; 3) pain or discomfort; 4) quality of life, validated on patients following OLLF.

6.4.2.2.2 Search strategy

Four search strategies were devised, consisting of four key elements, except search 1 (walking, gait and mobility: was not limited to identification of studies on PROMs) (see Figure 6.3). Comprehensive search terms were adapted from 'search blocks' and filters detailed in Table 6.1 to develop search strategies. Full search block search terms are detailed in Appendix 30.

Search blocks and filters
1. The Biomedische Informatie (BMI Group). A group of Dutch medical information specialists have compiled a series of open access search strategy building blocks for common constructs; including for walking or gait, return to work, pain and quality of life. Use of BMI Group search blocks are recommended by COSMIN (available form https://www.bmi-online.nl/searchblocks/search-blocks-bmi/) (270).
2. The University of Oxford, PROM Group search filter for identifying PROMs (available from https://cosmin.nl/wp-content/uploads/prom-search-filter-oxford-2010.pdf) (270).

3. The COMSIN highly sensitive and validated search filter for identifying studies on measurement properties (available from https://www.cosmin.nl/tools/pubmed-search-filters/) (271).

Table 6.1. Search blocks and filters.

MEDLINE and Embase databases were searched using the Ovid advanced search function (Ovid Technologies, Inc 2020, Wolters Kluwer) on the 17th of July 2019. Search blocks and filters were translated for use on the Ovid search platform where necessary. See Appendix 32 for full search strategies.

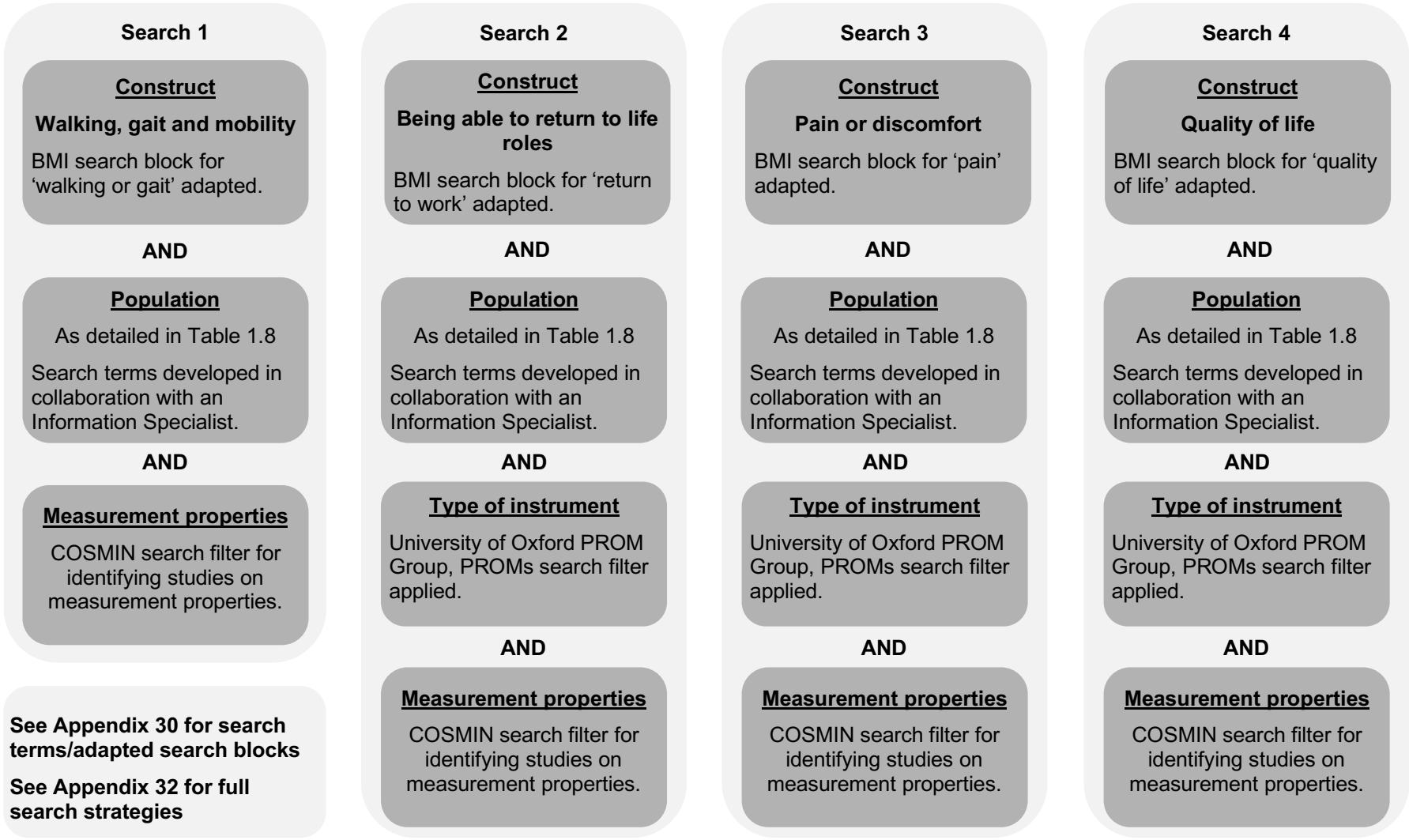


Figure 6.3. Search strategies to identify validated OMIs for each core outcome in the OLLF population.

6.4.2.2.3 Study eligibility criteria

See Table 6.2 for eligibility criteria for studies evaluating the measurement properties of a PROM to be included in the systematic review.

Eligibility criteria for studies evaluating the measurement properties of a PROM to be included in the systematic review	
Key area	**Criteria for inclusion**
1. Constructs	The studies should evaluate OMIs measuring the following core outcomes that constitute the constructs of interest: 1. Walking, gait and mobility 2. Being able to return to life roles 3. Pain or discomfort 4. Quality of life
2. Population	At least 80% of the study sample should represent the OLLF target population as described in Table 1.8
3. Type of OMI	Except for studies on 'walking, gait and mobility', all studies should concern a PROM evaluation. 'Walking, gait and mobility' can be measured using a physical performance measure that should be reviewed for the feasibility of use within the study's scope.
4. Evaluation of measurement properties	The aim of included studies should be the evaluation of one or more measurement properties in the development of the OMI (see Figure 6.1 for measurement properties)

Table 6.2. Study eligibility criteria.

All studies were excluded where the OMI of interest was used solely to measure an outcome (e.g. an OMI used in an RCT), or used in a validation study of another instrument. Only full-text articles published in English were included.

6.4.3 Title, abstract and full text screening

All titles and abstracts were screened independently by two researchers, AA and HC, using Rayyan (Qatar Computing Research Institute, Doha) against eligibility criteria (see Table 6.2). Disagreements were resolved by discussion between reviewers.

6.4.4 Full-text review and data-extraction

The full-text review was undertaken by AA and HC, who extracted data directly into study overview table templates recommended by COSMIN (see Appendix 31, for example data extraction tables) (266-268). Data fields extracted from studies on each OMI included characteristics of the OMI, sample(s) used, results on the measurement properties and information about interpretability and feasibility.

Citation searching was undertaken on all articles identified for full-text review. In addition, where AA or the Study Management Group became aware of any further relevant studies published following July 2019, articles were also included at the full-text review.

6.4.5 Pragmatic feasibility screening of included studies

COSMIN guidance recommends a review of the interpretability and feasibility of OMIs to be undertaken following quality assessment of identified OMIs (266-268). This study takes a pragmatic approach to exclude studies failing to meet OMI

feasibility criteria (see Table 6.3) at the full-text review before quality assessment to increase efficiency. OMI feasibility criteria were developed to align with the CO-OLLF project scope (see Table 1.8) following discussion among the Study Management Group and Patient and Public Involvement (PPI) lead.

CO-OLLF OMI feasibility Criteria
1. OMIs selected should be feasible to use in clinical effectiveness trials. As such, they should preferably be patient-reported such that they could be collected over telephone or online questionnaire. PROMs will be checked for demonstration of validity if collected remotely in future work where indicated.
2. OMIs should be feasible to collect as part of routine clinical practice. For example, they should be able to be collected as part of the Trauma, Audit and Research Network (TARN) routine follow up data. As such, physical performance measures would not be feasible to collect.
3. OMIs should not require access to technology that is not widely available in routine clinical practice. For example, the use of gait analysis software or worn accelerometers will not be feasible to use.

Table 6.3. CO-OLLF feasibility criteria for OMI inclusion.

6.4.6 Quality assessment of OMIs

COSMIN guidance recommends three steps in the quality assessment of identified OMIs (see Figure 6.2) (2,266-268):

1. Evaluation of the methodological quality of the included studies

Evaluation of the methodological quality of each included study was independently undertaken by AA and HC using the COSMIN Risk of Bias Checklist (2,266-268), and disagreements were resolved by discussion (266). The checklist is a modular system consisting of 10 ‘boxes’ used as a framework to assess the methodological quality of studies on measurement properties deemed important by COSMIN (see Table 6.4) (266). After determining which measurement properties are assessed in each article, the corresponding risk of bias assessment boxes were completed. Each study's quality on a measurement property was assessed separately; a single article often contains multiple studies on measurement properties, i.e. one study for each measurement property, for example, a study on internal consistency, construct validity, and reliability, each with specific design requirements.

COSMIN boxes use a rating scale of ‘very good’, ‘adequate’, ‘doubtful’ or ‘inadequate quality’. The lowest rating of any standard in the box was taken as the overall rating generated for each measurement property.

Risk of bias assessment boxes comprising the COSMIN Risk of Bias Checklist
Content validity
Box 1. PROM development Box 2. Content validity

Internal structure
Box 3. Structural validity Box 4. Internal consistency Box 5. Cross-cultural validity\measurement invariance
Remaining measurement properties
Box 6. Reliability Box 7. Measurement error Box 8. Criterion validity Box 9. Hypotheses testing for construct validity Box 10. Responsiveness

Table 6.4. Boxes of the COSMIN risk of bias checklist. Adapted from the COSMIN manual of systematic reviews of PROMs (2,266-268).

2. Evaluation of the quality of the measurement properties for each included OMI

The result of each study on a measurement property was rated against the COSMIN updated criteria for good measurement properties (2,266-268). Each result was rated as either ‘sufficient’ (+), ‘insufficient’ (-) or ‘indeterminate’ (?).

3. Best evidence synthesis

Each study's results rated against the updated COSMIN criteria for good measurement properties was qualitatively summarised for each OMI identified, and the quality of the evidence graded for trustworthiness. A modified Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach was used to grade the quality of evidence for each OMI as 'high', 'moderate', 'low', or 'very low' evidence (2,272).

6.4.7 A pragmatic approach to identify additional candidate OMIs not validated in the OLLF population

A posthoc decision was made to develop a novel approach to identify additional OMIs due to the small number of OMIs validated in the OLLF population (i.e. the result of the systematic review described above, detailed in the results section below). AA and the Study Management Group concluded that additional OMIs not explicitly validated in the OLLF population should be considered at the consensus meeting for inclusion in the COMIS. The decision was justified as a failure to recommend the best OMIs to use when measuring core outcomes will result in continued inconsistencies in outcome-reporting in trials on patients following OLLF. It was also recognised that the core outcome constructs this study aimed to measure in the context of OLLF are applied and measured in other related areas of healthcare; thus, the results of validation work in other similar contexts are relevant to OLLF. As demonstrated in Chapter 2, many OMIs have been widely reported in research on OLLF, some of which may show promise.

As a result of discussion among the Study Management Group, this study takes a novel approach to select OMIs that have been reported in the OLLF population identified from the systematic review in Chapter 2 for consideration at the COMIS consensus meeting. Four inclusion criteria were agreed upon for shortlisting OMIs (see Figure 6.2).

All OMIs identified in Chapter 2 were added to a summary table (see Table 6.5 for OMI characteristics summarised).

Characteristics described in OMI summaries:
1. Type of OMI e.g. patient or professional reported OMI or a physical performance measure.
2. Number of domains/dimensions/items and outcomes measured.
3. Method of measurement e.g. Likert score, Visual Assessment Score, etc.
4. OMI source references.

Table 6.5. OMI summary characteristics described.

AA and HC independently compared all identified OMIs against inclusion criteria, and disagreements were resolved by discussion (see Figure 6.2 for inclusion criteria). Particular attention was made to identify if OMIs had good face validity for measuring core outcomes by reviewing source references. OMIs were included for consideration at the COMIS consensus meeting, where all four criteria were met.

It was recognised that OMIs might exist that could be suitable for measuring core outcomes in the OLLF population that had not been identified in systematic review work. As a safety check to mitigate against this risk, all summarised OMIs were sent to COMIS consensus meeting participants as part of the pre-consensus meeting reading package one week before the meeting. Participants were asked to review each OMI and contact AA if they felt additional OMIs warranted further consideration.

6.4.8 COMIS Consensus meeting

The COMIS consensus meeting was held over a full day on the 6th of February 2020. The aim of the meeting was to review and discuss the measurement properties and practicality of candidate OMIs in order to make a consensus-driven

recommendation over which OMI to use when measuring each core outcome identified in Chapter 5.

Participants were sampled purposively using a sampling matrix to maximise participant diversity (as described in Chapter 5) within three stakeholder groups: patients, healthcare professionals and researchers with experience in the field of measurement in medicine. Approximately equal numbers of participants were invited from each stakeholder group. Participants were sent a pre-meeting reading pack one week before the meeting, which they were encouraged to familiarise themselves with. The pre-reading information detailed characteristics of OMIs shortlisted and rejected for the meeting (see Table 6.5 for OMI characteristics summarised).

The meeting structure and methods were discussed and agreed among the Study Management Group and guided by the COMET handbook (70) and adapted from the James Lind Alliance (JLA) Priority Setting Partnerships (PSP) methods for a final priority setting meeting described in the JLA guidebook (87). The meeting was chaired by Professor Matt Costa (MC) following good practice principles described in Chapter 5. The meeting was divided into three sessions:

6.4.8.1 Session 1

A presentation was delivered by AA describing the aims of the project, why a COS for OLLF is important and detailing how consensus was gained for core outcomes established in the COS consensus meeting before setting out the meeting aims and objectives.

6.4.8.2 Session 2

A summary was presented for each shortlisted OMI in turn (see Table 6.5 for OMI characteristics detailed), and participants were asked to review the degree to which the content/items of the OMI appeared to be an adequate reflection of each of the four core outcomes to be measured (face validity check). Participants were provided with printouts of each of the OMIs taken or adapted from source references (e.g. the exact wording, text size and font). Following a review period, participants were invited to vote for which core outcomes they believe the OMI demonstrates face validity. Voting was conducted using TurningPoint© software and handsets (Turning Technologies LLC, Youngstown, USA) as previously described in Chapter 5; however, participants could vote for any combination of core outcomes for which an OMI may demonstrate face validity. A step specifically assessing face validity was included as:

1. It ensured all participants were familiarised with the candidate OMIs and their domains/items regardless of having engaged with the pre-meeting reading.
2. It checked whether items within each OMI domain are sensible, appropriate, and relevant to patients recovering from OLLF by stakeholders who may use the PROMs on a day-to-day basis or have the PROMs used on them (273).
3. As most PROMs reviewed were not validated in the OLLF population, using the COSMIN methodology for assessing the content validity of PROMs (268) was therefore not applicable.
4. A face validity checking exercise was likely to be easily understood by all participants.

6.4.8.3 Session 3.

Collated voting results from the face validity checks in session 2 were presented to participants before two rounds of discussion, and voting on which OMI should be recommended for measuring each core outcome was undertaken.

OMIs were presented as voting options where they received one or more votes in session 2 for possessing face validity for the core outcome in question. Participants could only vote for one OMI in each round of voting. Before each poll opened, MC chaired a discussion inviting participants to share their views over which OMIs may be best and explain their rationale to the group.

Following discussion, two candidate COMIS options were presented, and a final vote was conducted to define the COMIS.

OMIs and COMIS options reached 'consensus in' where they received equal to or more than 70% of the vote.

6.5 Results

6.5.1 Identification of systematic reviews of OMIs measuring core outcomes in the OLLF population

A search of the COMSIN database of systematic reviews of OMIs identified 16 studies, none of which were relevant to this project.

6.5.2 Systematic review of studies assessing measurement properties of OMIs measuring core outcomes in the OLLF population

Search strategies (summarised in Figure 6.3) undertaken for each core outcome construct; 'walking, gait and mobility', 'return to life roles', 'pain or discomfort' and 'quality of life' identified 372, 90, 111, and 163 articles, respectively. After rejecting duplicates, 580 articles were identified for title and abstract review, which excluded all but one article (see Figure 6.4). Most excluded articles failed to meet the inclusion criteria due to assessing treatment outcomes, not OMI validity. Where studies were identified assessing the measurement properties of OMIs, the majority were rejected as they were not conducted on the OLLF target population. AA and HC discussed why so few articles were identified for full-text review; it was concluded that the search results were representative of the sparsity of measurement instruments validated in the OLLF population.

One article by Kwasnicki *et al.* 2015 was identified for full-text review, which evaluated the Hamlyn Mobility Score's measurement properties on a prospective cohort of 20 patients (208). The Hamlyn Mobility Score combines physical performance measures, including a measure of step variation using an ear-worn accelerometer and patient-reported question items (see Appendix 34 for a description of the Hamlyn Mobility Score). The Hamlyn Mobility Score was excluded at full-text review for failure to meet the OMI feasibility criteria (see Table 6.3) due to inclusion of physical performance measures and use of technology that is not widely available in clinical practice.

AA and the Study Management Group were aware of ongoing work at the University of Swansea, developing a new measurement instrument designed for

assessing recovery in patients following open tibial fractures. However, the validation paper had not been published by the time the literature searches were undertaken in this systematic review. Once published, the study by Trickett *et al.* 2020 was included for full-text review. The article described the development and assessment of the measurement properties of the Wales Lower Limb Recovery (WaLLTR) scale; a novel PROM designed to measure recovery from open tibial fractures (214). Citation searching identified a qualitative study leading to the development of the WaLLTR scale (213). Both articles met eligibility criteria and were included for data extraction and quality assessment.

The WaLLTR scale is an open fracture specific scale developed on and for patients with open tibia fractures. The validated component of the scale contains 10-items, takes less than five minutes to complete and assess eight domains: Self-efficacy, Pain, Body image, Activity participation, Fear, Social impact, Financial considerations and Perception of recovery (214).

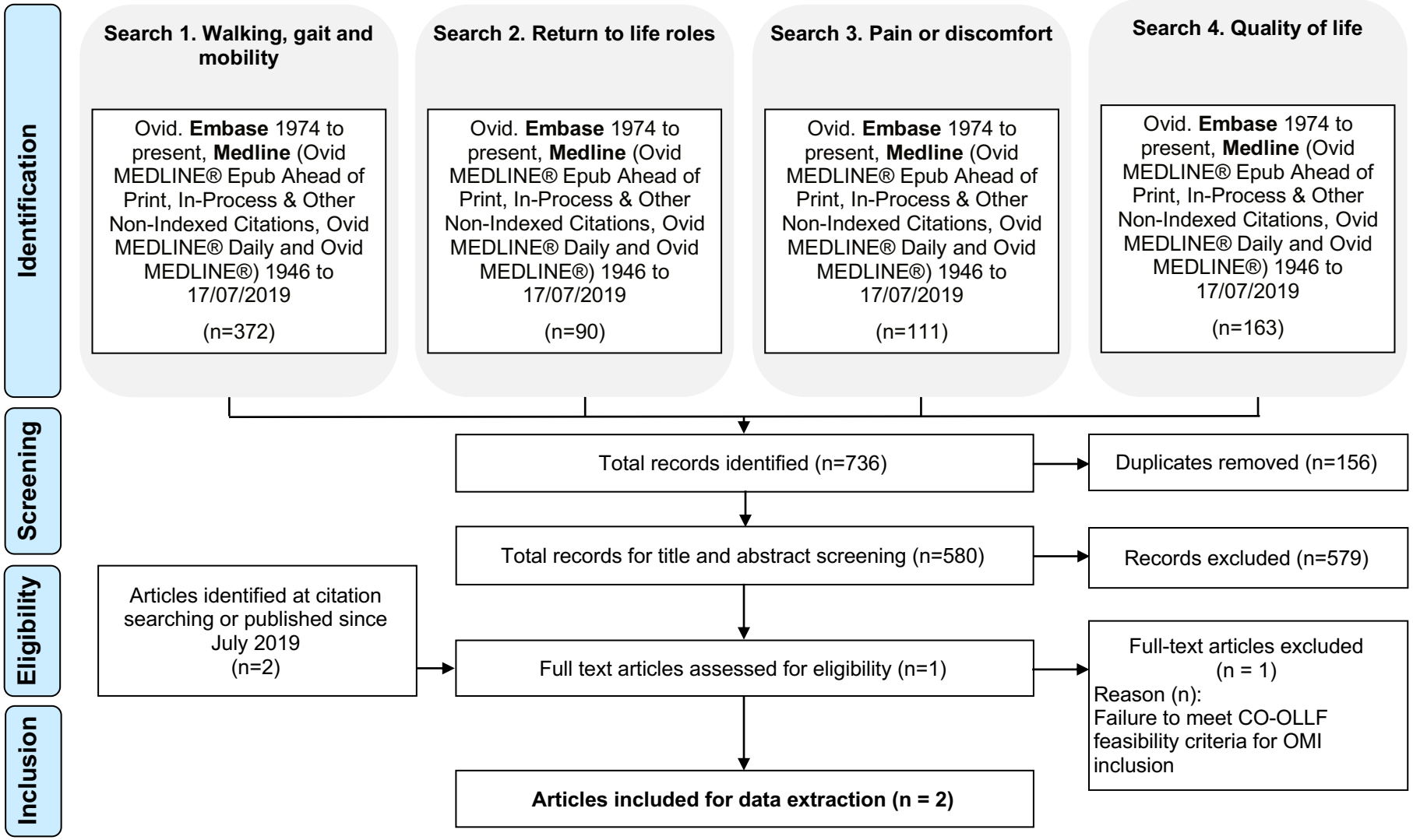


Figure 6.4. Chapter 6 PRISMA flow diagram.

6.5.3 Quality assessment of the WaLLTR scale

6.5.3.1 Evaluation of the methodological quality of the studies on the WaLLTR scale

Trickett *et al.* 2012 describe a qualitative study used in the concept elicitation to develop the WaLLTR scale items (213). Trickett *et al.* 2020 describe the development of the WaLLTR scale and evaluation of the scale's measurement properties, including content validity, internal consistency, reliability, measurement error, construct validity and responsiveness (see Appendix 33) (214).

Using the COSMIN standards, the quality of the development of the WaLLTR scale was given an overall score as 'doubtful' (2,266-268) (see Table 6.6 and Appendix 33). This was due to a failure to include an appropriate cognitive interview study and a lack of clarity over the description of, or failure to assess comprehensibility and comprehensiveness of questionnaire items on patients and healthcare professionals when trialling the alpha and beta scales. The WaLLTR alpha scale consisted of an initial pool of 109 randomly ordered response items jointly created by four study authors drawing on data from qualitative interviews. The alpha scale was completed by 25 patient participants and analysed for respondent redundancy, missing values, item redundancy, and interitem correlation coefficients. Following analysis and refinement of the alpha scale, the beta scale was created. The beta scale consisted of 50 Likert items and eight non-Likert items. It was completed 228 times by 204 participants. Following a multiple principles component analysis, ten items were retained to create the validated portion of the WaLLTR scale. At no point did the WaLLTR study authors describe undertaking a cognitive interview study of either the alpha or beta scale items. This

led to inconsistencies in assessing the content validity of WaLLTR, where a score of ‘adequate’ was achieved for item relevance and comprehensiveness, and a score of ‘inadequate’ was given for comprehensibility (see Table 6.7 and Appendix 33). Otherwise, the WaLLTR scale demonstrated ‘very good’ general design requirements, including clear descriptions of constructs, the origin of constructs, construct elicitation, target population and context of use (see Table 6.6).

The WaLLTR scale demonstrated very good internal consistency and responsiveness between subgroups of patients with differing Gustilo Anderson (GA) grades of open fracture. The scale was rated as having adequate reliability and construct validity when undertaking hypothesis testing between known groups. An inadequate assessment of measurement error was made due to a failure to calculate a summary measurement of instrument error, e.g. standard error of measurement, smallest detectable change or a limits of agreement (see Table 6.7 and Appendix 33).

No assessments of structural validity were given, e.g. factor analysis of items or Rasch analysis; although not explicitly described, it was assumed that the WaLLTR scale was based on a formative model, i.e. question items together form the construct (274,275). As such, the COSMIN box for structural validity was not completed as per COSMIN guidance. No evidence for assessment of cross-cultural validity was presented, and assessment of criterion validity was not possible to conduct.

6.5.3.2 Evaluation of the quality of the measurement properties for the WaLLTR scale

Using the COSMIN updated criteria for good measurement properties (2,266-268), the WaLLTR scale was rated as having ‘sufficient’ measurement properties for internal consistency, reliability, construct validity and responsiveness. WaLLTR received a content validity rating of ‘inconsistent’ due to inadequacies in conducting an appropriate cognitive interview study; in particular, an insufficiency in assessing the comprehensibility of questionnaire items to patients and professionals. WaLLTR was, however, demonstrated to be sufficiently relevant to the OLLF population (see Table 6.8).

6.5.3.3 Best evidence synthesis

A quantitative summary of studies evaluating the measurement properties of the WaLLTR scale against the COSMIN criteria for good measurement properties was not possible due to a lack of published studies. Thus, evaluation of the measurement properties for the WaLLTR scale from Trickett *et al.* 2012 and 2020 was used to grade the quality of evidence detailed in Table 6.8

Quality of studies on the Wales Lower Limb Trauma Recovery (WaLLTR) scale development (213,214)											
Score: V= very good; A = adequate; D = doubtful; I = inadequate; N= not applicable											
PROM design							Cognitive interview (CI) study				TOTAL PROM DEVELOPMENT
General design requirements					Concept elicitation	Total PROM design	General design requirements	Comprehensibility	Comprehensiveness	Total CI study	
Clear construct	Clear origin of construct	Clear target population for which the PROM was developed	Clear context of use	PROM developed in sample representing the target population			CI study performed in sample representing the target population				
V	V	V	V	V	V	V	V	D	D	D	D

Table 6.6. Summary table of the quality of studies on the development of the Wales Lower Limb Trauma Recovery (WaLLTR) scale (see Appendix 33 for results in full).

Quality of studies on the measurement properties of the Wales Lower Limb Trauma Recovery (WaLLTR) scale (214)																
Score: V= very good; A = adequate; D = doubtful; I = inadequate; N= not applicable																
Content validity					Structural validity	Internal consistency	Cross-cultural validity	Reliability	Measurement error	Criterion validity	Construct validity		Responsiveness			
Asking patients			Asking experts													
Relevance	Comprehensiveness	Comprehensibility	Relevance	Comprehensiveness							Convergent validity	Known groups validity	Comparison with gold standard	Comparison with other instruments	Comparison between subgroups	Comparison before and after intervention
A	A	I	I	I	N	V	D	A	I	N	N	A	N	N	V	N

Table 6.7. Summary table of the quality of studies on the measurement properties of the Wales Lower Limb Trauma Recovery (WaLLTR) scale (see Appendix 33 for results in full).

Evaluation of the Wales Lower Limb Trauma Recovery (WaLLTR) scale (213,214) **against the updated COSMIN criteria for good measurement properties and rating the quality of evidence using a modified GRADE approach.**		
Score: + = sufficient; - = insufficient; ? = indeterminate; ± = inconsistent	**OVERALL RATING**	**QUALITY OF EVIDENCE**
	+ / - / ?	**High, moderate, low, very low**
Content validity	±	Moderate
Relevance	+	Moderate
Comprehensiveness	?	Unable to rate
Comprehensibility	-	Unable to rate
Structural validity	Not applicable (formative model)	Unable to rate
Internal consistency	+	High
Cross-cultural validity	?	Very low
Measurement invariance	?	Very low
Reliability	+	Moderate
Measurement error	-	Very low
Criterion validity	Not undertaken	Unable to rate
Construct validity	+	Moderate
Responsiveness	+	High

Table 6.8. Evaluation of the Wales Lower Limb Trauma Recovery (WaLLTR) scale against the updated COSMIN criteria for good measurement properties and rating the quality of evidence using a modified GRADE approach.

6.5.4 Identification of additional candidate OMIs not validated in the OLLF population using a pragmatic approach

A total of 77 OMIs identified from the Inventory of Outcome Measures reported in Chapter 2 were summarised and assessed against four inclusion criteria detailed in Figure 6.2; where OMIs were rejected, reasons were given (see Appendix 34 for all OMI summaries and reasons given for exclusion). Assessor conflict was limited to a 2% disagreement rate over face validity checks of OMIs for measuring each core outcome constructs (OMI shortlisting criteria 1 see Figure 6.2) and resolved by discussion. Conflict was not encountered for the remaining three shortlisting criteria (see Appendix 34) resulting in 10 OMIs shortlisted for inclusion at the COMIS consensus meeting along with the WaLLTR scale (see Table 6.9).

Shortlisted OMIs identified from the Inventory of Outcome Measures included six general health-related quality of life measures, two measures assessing musculoskeletal functioning, and two pain measures, reported in the literature between 2 and 17 times. OMIs shortlisted have been commonly used in musculoskeletal research and other fields of healthcare. They each have well-established validation evidence in other areas of disease which was checked using scoping searches, including the COSMIN database of systematic reviews of measurement instruments (276).

Table 6.9 below details an overview of the information presented to participants on each shortlisted OMI, including the number of times reported in the literature.

Outcome Measurement Instruments (OMIs) identified from the Inventory of Outcome Measures	**Number of times reported in the literature**
EuroQol 5-Dimensions 3-Level (EQ-5D-3L) (277)	2

• Introduced by the EuroQol Group in 1990
• 2 pages – EQ-5D descriptive system and the EQ visual analogue scale
• Dimensions:
  • Mobility, self-care, usual activities, pain/discomfort and anxiety/depression
  • Three levels: no problems, some problems, and extreme problems
• Widely used as a utility measure across many clinical areas
• Recommended by NICE (278)	

EuroQol 5-Dimensions 5-Level (EQ-5D-5L) (200)	6
• Introduced by the EuroQol Group in 2009 • Improve sensitivity and reduce ceiling effects of the shorter version • Each dimension has 5 levels: no problems, slight problems, moderate problems, severe problems and extreme problems. • Recommended by NICE (278) • Widely used as a utility measure across many clinical areas • Recommend for measurement of health-related quality of life in trauma patients following rib fracture (279)	
Short Form-36 (SF-36) (165)	17

• SF-36 developed following a two-year study on clinical outcomes on chronic health conditions in over 22,000 patients.
• Likely the most widely evaluated generic patient assessed health outcome measure
• The SF-36 consists of 11 questions asking about 36 items across 8 domains and is available in over 170 languages
• The SF-36 and SF-12 measure the following domains:
  1. Physical functioning
  2. Role-physical
  3. Bodily pain
  4. General health
  5. Vitality
  6. Social functioning
  7. Role-emotional
  8. Mental health
• Each domain is scored independently between 0 and 100
• Scores can be directly transformed into a scale between 0 and 100; a score of 0 is complete disability and 100 is no disability.
• Produces a physical component summary and mental component summary
• Widley validated in a range of disease populations, including rheumatoid arthritis (280)	

Short Form-12 (SF-12) (281)	5
• As above • The SF-12 is a shortened version of its predecessor, the SF-36 and uses 12 questions to measure the 8 domains listed above. • Widely validated in a range of disease populations as per the SF-36	
Sickness Impact Profile (SIP) (202,203)	5
• The SIP was developed in 1975 as a measure of sickness-related dysfunction • The SIP is a comprehensive descriptor of dysfunction • The SIP is scored to provide an overall score, 2 domain scores, and 12 category scores; items are weighted according to a standardised weighting scheme. • Up to 30 mins to complete • The SIP consists of 136 items within 12 domains: 1. Sleep and rest 2. Eating 3. Work 4. Home management 5. Recreation and pastimes 6. Ambulation 7. Mobility 8. Body care and movement 9. Social interaction 10. Alertness behaviour 11. Emotional behaviour 12. Communication • Used widely across many clinical areas	
Disability Rating Index (DRI) (282,283)	3
• The DRI was developed in 1994, aiming to measure physical disability in a clinical setting. • It consists of 3 domains with the following 12 response items: 1. Basic activities of daily life: • dressing, outdoor walks, climbing stairs and sitting a long time. 2. Daily physical activities: • standing bent over a sink, carrying a bag, making a bed and running. 3. Work-related/more vigorous activities: • light work, heavy work, lifting heavy objects and participating in exercise/sports. • Used widely across many clinical areas • Was used as the primary outcome measure in the Wound management of Open Lower Limb Fractures Trial	
Lower Extremity Functional Scale (LEFS) (166)	3
• The LEFS was developed in 1991 as an easy to administer score applicable to a wide range of patients with orthopaedic pathology affecting their lower limbs (189)	

• The LEFS is often used as a criterion in the validation of other lower limb functional measures • The LEFS contains 20-items specifically assessing the International Classification of Functioning, Disability, and Health model (ICF) domains of activity and participation • Used widely across many clinical areas	
Short Musculoskeletal Function Assessment Questionnaire (SMFA) (284)	3
• The Musculoskeletal Function Assessment was developed to provide a comprehensive tool to measure functioning across all musculoskeletal conditions • The SMFA was later developed in 1999 to facilitate use in clinical studies • There are two parts to the SMFA: 1. Dysfunction index (34 items assessing patient perceptions of functional performance in 4 categories including daily activities, emotional status, function of the arm and hand and mobility) 2. Bother index (12 items assessing broad functional areas including recreation and leisure, sleep and rest, work and family) • The SMFA has been shown to be valid for physician grading of functioning across a wide range of musculoskeletal pathologies (189,285)	
Brief Pain Inventory (BPI) (286)	2
• The BPI is a short, self-administered questionnaire that was developed for use in cancer patients • It assesses the severity of a patient's pain and the impact of this pain on the patient's daily functioning • The BPI consists of 9 items assessing the following: 1. Pain other than everyday kind of pains 2. Location of pain (shading diagram) 3. Worst pain in the last 24-hours 4. Least worst pain in the last 24-hours 5. Pain on average 6. Pain right now 7. Treatments/medications for pain 8. Relief of pain from treatment/medication 9. Pain interference in the last 24 hours (general activity, mood, walking ability, normal work, relations with other people, sleep, enjoyment of life)	
Visual Analogue Scale for Pain (VAS) (287)	6
• The VAS is an analogue measure often used to determine pain • The VAS is a unidimensional measure of pain intensity • Often assessed by making a mark on a 0-100mm scale • Used widely across many clinical areas	

Outcome Measurement Instruments (OMIs) identified from the Systematic review of studies assessing measurement properties of OMIs measuring core outcomes in the OLLF population	**Number of times reported in the literature**
Wales Lower Limb Trauma Recovery (WaLTTR) scale (213,214)	0
• Novel OMI developed on and for patients with open tibia fractures • Open fracture specific quality of life measure • It consists of a Likert and non-Likert section. The Likert section has 10 items covering 8 domains: 1. Self-efficacy 2. Pain 3. Body image 4. Activity participation 5. Fear 6. Social impact 7. Financial considerations 8. Perception of recovery • Evidence of validation in the OLLF assessed above.	

Table 6.9. Outcome Measurement Instruments (OMIs) identified from the Inventory of Outcome Measures using a pragmatic approach and systematic review.

See Appendix 35 for each OMI as they were presented at the COMIS consensus meeting.

6.5.5 COMIS consensus meeting

The COMIS consensus meeting was attended by 25 participants, consisting of 5 (20%) patients, EB as PPI lead, 8 (32%) healthcare professionals of which 6 also had academic positions, and 11 (44%) researchers with academic backgrounds relevant to measurement in medicine (see Table 6.10 for COMIS consensus meeting demographics). The patient sample was representative of the OLLF population in terms of gender and age (range 26 to 74 years of age). All patients had sustained an open tibial fracture requiring plastic surgical intervention between 6 months and 2 years before the meeting. The meeting was well represented by

academics with relevant experience to help address the meeting aims (see Table 6.10).

COMIS consensus meeting participant demographics table.	**COMIS Consensus meeting**
	n=25 (%)
Patients	5 (20%)
Anatomical area of open fracture	
Open fracture of the leg including ankle (tibia/fibula)	5
Indication of severity of open fracture	
Open fracture required a skin graft or muscle flap.	5
Gender, n (%)	
Male	3
Female	2
Age, n (%)	
20-29	1
50-59	2
Over 70	2
PPI lead	1 (4%)
Healthcare professionals (academic position)	8 (32%)
Nurse Consultant for Trauma Care	1
Physiotherapist (Professor of Trauma and Orthopaedic Rehabilitation)	1
Plastic and Reconstructive Surgeon (Professor of Hand, Plastic and Reconstructive Surgery)	1
Plastic and Reconstructive Surgeon	1
Trauma and Orthopaedic Surgeon (Professor of Orthopaedic Trauma)	2
Trauma and Orthopaedic Surgeon (Academic Clinical Fellow)	1
Trauma and Orthopaedic Surgeon (DPhil candidate)	1
Researchers (academic background)	11 (44%)
Senior Research Fellow (Qualitative Researcher, patient experience of recovery from trauma)	1
Research Fellow (PROMs Researcher)	3
Professor of Public Health and Primary Care (Measurement in medicine)	1
Associate Professor (Evaluation of health and care services)	1
Medical Statistician (use of PROMs in trials)	4
Executive Director of the Trauma, Audit and Research Network (PROMs in trauma)	1

Table 6.10. COMIS consensus meeting participant demographics table.

6.5.5.1 Session 2: OMI face validity checks

Following a review of each candidate OMI (see Appendix 35 for each OMI as they appeared to participants), participants confirmed that all OMIs shortlisted demonstrated face validity for measuring one or more core outcome (see Table 6.11 for the voting results of face validity checks).

6.5.5.2 Session 3: Voting on an OMI for each core outcome

Two rounds of discussion and voting were undertaken for each of the four core outcomes. Consensus was reached for the Lower Extremity Functional Scale (LEFS) and the EuroQol 5-Dimensions 5-Level (EQ-5D-5L) to measure 'walking, gait and mobility' (consensus achieved in voting rounds 1 and 2) and 'Quality of Life' (consensus achieved in voting round 2), respectively. Consensus was not achieved for selecting an OMI for 'being able to return to life roles' and 'pain or discomfort' (see Table 6.12).

6.5.5.2.1 Walking, gait and mobility

The LEFS received 72% and 83% of the votes in rounds 1 and 2, respectively, for inclusion in the COMIS (see Table 6.12). In addition, 96% of participants felt the LEFS demonstrated good face validity for walking, gait and mobility (see Table 6.11). Participants favoured the varied number of question items assessing multiple aspects of the core outcome, for example, standing, walking, going up or downstairs, running, rolling over, squatting (see Appendix 35, page 674 for LEFS items). Patient participants supported the LEFS as it also measures outcomes related to mobility, including the ability to do hobbies, recreational or sporting activities, lifting objects, putting on shoes and socks and getting into or out of a car

that were also identified as important. Patients approved that the LEFS contains several items assessing multiple walking abilities – walking between rooms, walking two blocks, and walking a mile. Some patients commented that items in the LEFS were not relevant to them, e.g. hopping, as they could not hop before their OLLF. There was a concern raised over the length of LEFS as it consists of 20 items that may risk questionnaire burden when used in combination with other PROMs in future studies. However, its length and comprehensive nature were felt to reduce the risk of ‘ceiling effect’ when measuring walking, gait and mobility on a wide range of OLLF patients of various severity of injury and age. Some issues were raised around the understandability of the language due to Americanisms, e.g. 'walking two blocks'.

6.5.5.2.2 Being able to return to life roles

The WaLLTR scale was very close to achieving ‘consensus in’ after gaining 56% and 68% of the votes in voting rounds 1 and 2, respectively (see Table 6.12). Patient participants felt that question items on the second page of the WaLLTR scale (see Appendix 35, page 678) demonstrated the best face validity for measuring ‘being able to return to life roles’ (see Table 6.11). Question items included a free text box asking about occupation followed by a series of yes/no questions asking if ‘you are not in work due to injury’ and enquiring about whether ‘you were able to return to work in the same capacity as before injury’. However, the second-page items do not contribute towards the WaLLTR scale score. The research and healthcare professional participants also noted that the second-page items have not been validated and include a free text box which poses significant

practical difficulties when undertaking a meaningful analysis of OMI scores/answers.

Participants also felt that the core outcome ‘being able to return to life roles’ was measured to some degree by the SF-36 and SMFA. However, the overall feeling was that none of the candidate OMIs sufficiently captured the complexity of the core outcome; for example, patients may return to work but have to make major adaptations, or can do normal daily activities but are unable to return to doing some aspects of normal life roles and work. Participants recommend that a new OMI may be needed to sufficiently measure this core outcome or further validation work be undertaken on the WaLLTR scale.

6.5.5.2.3 Pain or discomfort

The majority of participants voted for the EQ-5D-5L to measure ‘pain or discomfort’, receiving 60% and 68% of the votes in voting rounds 1 and 2, respectively (see Table 6.12). Participants voted in favour of the EQ-5D-5L as one of the five question items specifically measures pain or discomfort (see Appendix 35, page 662). However, the EQ-5D-5L failed to meet the ‘consensus in’ threshold, which was likely due to concern raised over a lack of ability to capture the granularity of the experience of pain, and that five response options may not be sensitive enough to identify a change in pain or discomfort over time.

Participants felt a VAS on its own would be insufficient to capture the complexity in the experience of pain and discomfort following OLLF. The BPI was thought to capture more of the granularity in the experience of pain during recovery, but participants felt that the questionnaire was too long, contains repetition in questions, and many of the items are nonspecific for OLLF.

The participants' general view was that pain is a complex and multifaceted outcome to measure, especially in the context of OLLF. Participants felt that future work is required to develop a better measure of pain or discomfort, specifically for the OLLF population.

6.5.5.2.4 Quality of Life

Participants justified a strong preference for EQ-5D-5L to measure Quality of Life in the OLLF population as it is a generic measure that is robust and widely used across the UK population. The EQ-5D-5L received 64% and 72% of the votes in voting rounds 1 and 2, respectively (see Table 6.12). From professional experience, researcher participants recognised that the EQ-5D-5L is valid, reliable and responsive in a wide range of health conditions and populations. The EQ-5D-5L was noted to have many benefits over other OMIs measuring Quality of Life as it is recommended by NICE for use in health economic analysis, making it highly applicable to clinical effectiveness studies on the UK population. Also, previous use of the EQ-5D-5L to measure Quality of Life in the published literature on the OLLF population and current use by the Trauma, Audit and Research Network (TARN) to measure quality of life in patients following major trauma reassured participants of its utility as an OMI for inclusion in the COMIS. Participants took a favourable view over the short length of EQ-5D-5L compared to the SF-12 and SF-36, agreeing that it would be practical to use in the context of a COMIS. A judgment was taken that where future studies may require greater specificity or sensitivity when measuring quality of life, the EQ-5D-5L can be used in addition to other disease-specific quality of life OMIs, e.g. the WaLLTR scale.

Participants thought that the WaLLTR scale was a more specific measure of quality of life for the OLLF population than other quality of life OMIs presented. Patient participants felt that the WaLLTR scale provided a fair reflection of their recovery experience. However, a lack of use of the WaLLTR scale to measure quality of life in the published literature and other concerns discussed below led to trepidation among participants for recommending its inclusion in the COMIS.

Additional issues raised about the EQ-5D-5L was that variability of experience overtime is not taken into account as it only considers outcomes over a day; as such outcomes reported could be entirely dependent on the time of day the EQ-5D-5L is completed, and it ignores previous ‘bad’ days, weeks or months. The EQ-5D-5L was also identified as being generally less sensitive to change over time when compared to the SF-12 and SF-36. Participants preferred the EQ-5D-5L over the EQ-5D-3L as it has five response options enhancing sensitivity.

6.5.5.2.5 Consensus for a COMIS

A pragmatic decision was made to conduct an additional two rounds of discussion and voting over whether the COMIS should consist of the EQ-5D-5L and LEFS or include the WaLLTR scale in addition. Opinion appeared to favour including the WaLLTR scale, with 64% of participant votes in round 1. However, following discussion, 84% of participants voted in favour of excluding the WaLLTR scale in round 2, achieving a consensus decision for the COMIS to contain the EQ-5D-5L and the LEFS (see Table 6.13).

The decision was made amongst the Study Management Group to give participants an additional opportunity to consider the WaLLTR scale's inclusion. This was felt appropriate as the WaLLTR scale was the only OMI presented at the

meeting that had been specifically developed and validated for use on the OLLF target population. Also, the WaLLTR scale came close to achieving consensus for measuring ‘being able to return to life roles' and measures outcomes identified as important at patient interviews and the Delphi survey but failed to make the COS, e.g. compensation and financial concerns.

Discussion between the first and second rounds of voting highlighted several issues with the WaLLTR scale's inclusion. Throughout the consensus meeting, several concerns had been raised over the use of language in the WaLLTR scale. Participants felt that the scale could benefit from a linguistic assessment and further work to establish good content validity around comprehensibility of the question items identified as problematic at quality assessment using the COSMIN checklist. Researcher participants felt that there were problems with the scale by including the middle response option as 'neither agree or disagree', which creates issues regarding structural validity, e.g. such a response would be identified as problematic when undertaking a Rasch analysis. As only the 10 items on the first page of WaLLTR contributed to the overall score and had undergone validation work, the consensus group could only recommend these items for consideration. Finally, a feasibility concern was raised that the inclusion of the WaLLTR scale in addition to EQ-5D-5L and the LEFS would result in the COMIS consisting of 35 question items which may make the COMIS burdensome for implementation in some future trials where trialists wish to include additional OMIs specific to their study aims.

Discussion points raised in favour of a two-measurement instrument COMIS (EQ-5D-5L and LEFS) excluding the WaLLTR scale between voting rounds 1 (16% of participant votes) and 2 (84% of participant votes reaching consensus) included:

1. Participants initially wished to include the WaLLTR scale because the page two items demonstrated the best face validity out of all instruments presented for measuring 'return to life roles' (80% of participants votes). However, only the 10-item scale on page one had undergone validation work, and the page two items will pose practical difficulties to interpret when used in a trial. As such, participant opinion was that only the page one scale could be recommended, which they felt did not add any significant advantages over the EQ-5D-5L and LEFS, particularly for older female patients.
2. Participants were persuaded to exclude WaLLTR at this stage due to an argument that simplicity is key to the successful implementation of a COMIS. Therefore, adding a third instrument that participants felt required further work was not currently justifiable.
3. Several of the participants with backgrounds in PROM development advised against the inclusion of a new PROM that has not yet been used in published literature and requires further validation work, including considering the inclusion of a suitable measure of pain or discomfort. Ultimately this argument appeared to hold traction with the group pushing consensus to the inclusion of the EQ-5D-5L and LEFS only.

Electronic voting scores for face validity for each shortlisted OMI against core outcomes				**(number of voters = 25)**
Outcome Measurement Instrument (OMI)	**Quality of life** Number of votes (%)	**Being able to return to life roles** Number of votes (%)	**Walking, gait and mobility** Number of votes (%)	**Pain or discomfort** Number of votes (%)
EuroQol 5-Dimensions 3-Level (EQ-5D-3L) (277)	20 (80)	11 (44)	13 (52)	16 (64)
EuroQol 5-Dimensions 5-Level (EQ-5D-5L) (200)	16 (64)	12 (48)	20 (80)	17 (68)
Short Form-12 (SF-12) (281)	22 (88)	11 (44)	10 (40)	11 (44)
Short Form-36 (SF-36) (165)	21 (84)	15 (60)	17 (68)	15 (60)
Sickness Impact Profile (SIP) (202,203)	12 (48)	5 (20)	9 (36)	3 (12)
Disability Rating Index (DRI) (282,283)	1 (4)	6 (24)	18 (72)	0 (0)
Lower Extremity Functional Scale (LEFS) (166)	3 (12)	8 (32)	24 (96)	1 (4)
Short Musculoskeletal Function Assessment Questionnaire (SMFA) (284)	7 (28)	10 (40)	16 (64)	2 (8)
Brief Pain Inventory (BPI) (286)	0 (0)	3 (12)	0 (0)	23 (92)
Visual Analogue Scale for Pain (VAS) (287)	0 (0)	1 (4)	0 (0)	22 (88)
Wales Lower Limb Trauma Recovery (WaLTTR) scale (213,214)	15 (60)	20 (80)	10 (40)	11 (44)

Table 6.11. Results of face validity checks for each OMI against core outcomes.

Electronic voting scores on Outcome Measurement Instruments (OMI) for each core outcome											**(number of voters = 25)**
Core outcome voting rounds	Number of votes (%) for OMIs, consensus threshold met at 70% highlighted in **bold**										
	EuroQol 5-Dimensions 3-Level (EQ-5D-3L)	EuroQol 5-Dimensions 5-Level (EQ-5D-5L)	Short Form-12 (SF-12)	Short Form-36 (SF-36)	Sickness Impact Profile (SIP)	Lower Extremity Functional Scale (LEFS)	Short Musculoskeletal Function Assessment Questionnaire (SMFA)	Disability Rating Index (DRI)	Wales Lower Limb Trauma Recovery (WaLTTR) scale	Brief Pain Inventory (BPI)	Visual Analogue Scale for Pain (VAS)
Walking, gait and mobility											
Voting round 1	-	2 (8%)	-	-	2 (8%)	**18 (72%)**	2 (8%)	1 (4%)	-		
Voting round 2	-	2 (8%)	-	-	-	**20 (83%)**	1 (4%)	1 (4%)	-		
Being able to return to life roles											
Voting round 1	-	-	1 (4%)	8 (32%)	-	1 (4%)	1 (4%)	-	14 (56%)		
Voting round 2	1 (4%)	-	2 (8%)	4 (16%)	-	-	1 (4%)	-	17 (68%)		
Pain or discomfort											
Voting round 1	-	15 (60%)	-	-	-	-	-		-	7 (28%)	3 (12%)

Voting round 2	-	17 (68%)	-	-	-	-	-		-	2 (8%)	6 (24%)
Quality of Life											
Voting round 1	1 (4%)	16 (64%)	1 (4%)	2 (8%)	-	-	-	-	5 (20%)		
Voting round 2	1 (4%)	**18 (72%)**	-	1 (4%)	-	-	-	-	5 (20%)		

Table 6.12. Electronic voting scores on Outcome Measurement Instruments (OMI) for each core outcome.

Electronic voting scores on a Core Outcome Measurement Instrument Set (COMIS) for Open lower Limb Fracture (OLLF).		**(number of voters = 25)**
Proposed OMI combination for COMIS	**Number of votes (%) for COMIIS options**	
	Voting round 1	Voting round 2
COMIS option 1	9 (36%)	**21 (84%)**
EuroQol 5-Dimensions 5-Level (EQ-5D-5L) + Lower Extremity Functional Scale (LEFS)		
COMIS option 2	16 (64%)	4 (16%)
EuroQol 5-Dimensions 5-Level (EQ-5D-5L) + Lower Extremity Functional Scale (LEFS) + Wales Lower Limb Trauma Recovery (WaLTTR) scale		

Table 6.13. Electronic voting scores on a Core Outcome Measurement Instrument Set (COMIS) for Open lower Limb Fracture (OLLF).

6.6 Discussion

This study followed guidelines laid out by the COSMIN initiative demonstrating methodological rigour. By considering which currently available OMIs are best for measuring core outcomes, this study goes beyond work undertaken to develop the COS by recommending a set of two ‘ready to use’ OMIs. Recommendation on preferred OMIs to use when measuring the OLLF COS will result in further reductions in outcome-reporting heterogeneity in future OLLF research.

6.6.1 Strengths and limitations

This study took a novel approach to overcome a lack of OMIs validated in the OLLF population to recommend a set of robust and well respected OMIs with a proven track record of use in past research on patients following OLLF. This was achieved

by drawing on a panel of expert researchers in the field of measurement in medicine. The practicality and acceptability of the OMIs were also considered by the inclusion of patients and healthcare professionals with expertise in caring for and conducting research on patients following OLLF.

OMIs recommended in this study do not currently have any evidence for validation in the OLLF population. According to COSMIN guidance, a new instrument should be developed before a COMIS can be recommended. Development of a well-validated OMI and demonstration of its practical utility is a demanding process that is costly, lengthy and requires specialist expertise. This study recognises a need for an OMI designed for, and validated in the OLLF population for recommendation in the COMIS. However, the study authors and a panel of professional experts and patients assembled at the COMIS consensus meeting supported the view that in the short to medium term, it is more important to gain consensus over and recommend an appropriate set of OMIs that have already demonstrated a good utility for measurement in the OLLF population. This is to promote immediate continuity of outcome measurement in research studies and national audit on the OLLF population going forward.

Recommendation of the EQ-5D-5L and LEFS for inclusion in the COMIS, which have both been widely used for outcome measurement in previous OLLF research, suggests they have beneficial measurement properties and practical utilities that previous study designers found desirable. As both the EQ-5D-5L and LEFS have been previously used to measure outcomes in this research field, study designers are more likely to be familiar with the measures that may increase COMIS implementation, uptake and the inclusion of historical studies in future meta-analysis.

The development of the WaLLTR scale shows promise, and it is the recommendation of this study that additional work is conducted on WaLLTR to address issues raised at the COMIS consensus meeting. The COMIS for OLLF will remain flexible to change, and where evidence emerges for additional suitable OMIs, the consensus process should be revisited. The Study Management Group intend to act as guardians over the OLLF COMIS and action updates to ensure the best available OMIs are recommended to measure core outcomes. Future updates will be supported under the oversight of interested national parties, including the Orthopaedic Trauma Society and the Trauma, Audit and Research Network, who have supported this project from its conception.

6.7 Conclusion

The CO-OLLF project recommends the EQ-5D-5L and LEFS to be used in future trials and as part of routine clinical assessment of patients recovering from OLLF to measure the core outcomes: ‘quality of life’ and ‘walking, gait and mobility’, respectively. While consensus was not achieved for an OMI to measure ‘being able to return to life roles’ or ‘pain or discomfort’, the EQ-5D-5L does demonstrate face validity in measuring both these outcomes.

Chapter 7. Thesis Discussion

This concluding Chapter reviews the thesis objectives and provides a summary of key results. The methodological rigour demonstrated in this work will be described, and the study's strengths and limitations, contribution to original knowledge and COS development methods will be discussed. The project dissemination plan will be detailed, and the impact CO-OLLF may have in the field outlined. Future research avenues to build on this work will be explored before concluding with the thesis recommendations.

7.1 Review of objectives and summary of key results

7.1.1 What outcomes have been reported in the literature and which outcome measurement instruments have been used to measure them?

Chapter 2 identified 1803 outcomes and 479 outcome measurement instruments reported in 532 studies on OLLF. The majority of outcomes reported were objective clinical outcomes categorised to the musculoskeletal and connective tissue disease domain (1335 outcomes). Widespread heterogeneity was demonstrated in the reporting of objective clinical outcomes, which likely resulted from the majority of included studies reporting outcomes collected retrospectively as part of routine follow-up practices.

Only 330 outcomes were categorised to the life impact outcome domain, most of which measured physical functioning (258 outcomes). Quality of life was measured on only 39 occasions using eight recognised health-related quality of life measures.

7.1.2 What outcomes are important for patients within their experience of recovery from OLLF?

A Thematic Analysis of 25 interview transcripts exploring the lived experience of recovery from OLLF identified 88 outcomes, 62 of which were categorised under the life impact outcome domain. The dissonance between outcomes reported in the literature and those interpreted as important from the patient narratives justifies a need for a joint patient and healthcare professional COS for OLLF.

7.1.3 What is the COS that should be reported for patients sustaining OLLFs?

Outcomes identified from the literature and patients were brought together to create an Inventory of Outcomes that was presented at a healthcare professional, and patient, structured discussion group (SDG) to create a shortlist of 68 candidate outcomes for consideration at a two-round Delphi survey. Two additional outcomes were included following Delphi survey round 1 and 11 outcomes were identified as ‘consensus in’ at Delphi survey round 2.

A well-attended multi-stakeholder consensus meeting using a Nominal Group Technique (NGT) found consensus for the inclusion of four outcomes in the COS:

1. **Walking, gait and mobility**
2. **Being able to return to life roles (e.g. caring, work and military duty)**
3. **Pain or discomfort**
4. **Quality of life**

7.1.4 Do OMIs exist for outcomes identified in the COS, what are their measurement properties, and how should they be measured?

A systematic review was conducted to identify outcome instruments measuring core outcomes with evidence of validation in the OLLF population with feasibility properties within scope for this study. The Wales Lower Limb Trauma (WaLLTR) scale was the only instrument identified. Using the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) checklist, WaLLTR was shown to have good internal consistency, reliability, construct validity and responsiveness. However, evidence of good content validity and measurement error was inconsistent and insufficient, respectively.

Due to the WaLLTR scale's inclusion as the sole candidate instrument validated in the OLLF population, a novel approach was developed to identify additional suitable candidate instruments used in previous research on OLLF. A review of outcome measurement instruments identified in the systematic review in Chapter 2 led to the inclusion of 10 additional measurement instruments to be presented at the Core Outcome Measurement Instrument Set (COMIS) consensus meeting.

Consensus was reached for the **Lower Extremity Functional Scale (LEFS)** and the **EuroQol 5-Dimensions 5-Level (EQ-5D-5L)**, to measure 'walking, gait and mobility' and 'quality of life', respectively. Although consensus was not achieved for the selection of an OMI for 'being able to return to life roles' and 'pain or discomfort', face validity checks suggest the EQ-5D-5L demonstrates some usefulness in measuring both these core outcomes in addition to 'quality of life'.

7.2 Demonstration of rigour

This study recommends which outcomes to report and how they should be measured in all research and clinical practice on patients following OLLF, thus positively influencing the outcome choices of future research trialists and auditors of clinical practice. To responsibly make such far-reaching recommendations, rigour, trustworthiness, and transparency must be demonstrated throughout the COS development process. This is with a view to best serve future patients and instil confidence in the study results, which will enhance impact.

There is no single best methodological approach to developing a COS, and research investigating optimal methodologies is ongoing (68,70). To address concerns raised over the quality of conducting and reporting of COS projects, the Core Outcome Measures in Effectiveness Trials (COMET) initiative have published the 'COMET Handbook' (70), as well as several quality standards and checklists (see Appendix 9), all of which guided this project. This study meets development standards set in the Core Outcome Set-STAndards for Development (COS-STAD) (71), which are discussed in Table 7.1. This thesis also meets the 18 reporting standards for a COS described in the Core Outcome Set-STAndards for Reporting (COS-STAR) Statement (72).

Domain	Standard number	Methodology	Demonstration of rigour in the CO-OLLF project
Scope Specification	1	The research or practice setting(s) in which the COS is to be applied.	CO-OLLF will be applicable for all research (e.g. clinical trials, cohort studies and case series) and routine clinical practice (e.g. local to national audit of clinical practice outcomes) (see study scope detailed on Table 1.8).
	2	The health condition(s) covered by the COS	Open Lower Limb Fracture (OLLF) (see study scope detailed on Table 1.8).
	3	The population(s) covered by the COS	Skeletally mature patients (from the age of 16 years) following OLLF (see study scope detailed on Table 1.8).
	4	The intervention(s) covered by the COS	No limitations envisaged (see study scope insert caption).
Stakeholders involved	5	Those who will use the COS in research	A panel of researchers and academic healthcare professionals were recruited to participate in a Delphi survey and consensus meetings with expertise in clinical effectiveness studies in trauma and measurement in medicine (e.g. Clinical trialists, PROMs researchers and medical statisticians). See Table 5.4 and Table 6.10 for demographics tables of professionals involved in consensus gathering stages.
	6	Healthcare professionals with experience of patients with the condition	A purposive sample of healthcare professionals involved in patient care following OLLF (see study demographics tables, as above).
	7	Patients with the condition or their representatives	A purposive sample of patients was used (see study demographics tables, as above).
Consensus process	8	The initial list of outcomes considered both healthcare professionals' and patients' views	Healthcare professional views considered in a systematic review of the literature and structured discussion group. Patient opinions considered in qualitative analysis of 25 interview transcripts exploring the lived experience of recovery and structured discussion group.

	9	A scoring process and consensus definition were described a priori.	A study protocol was published a priori registered on the COMET database (see Appendix 5). However, on reflection, the consensus criteria were not explicitly detailed. This project follows the consensus criteria and inclusion/exclusion processes recommended in COMET Handbook. Also, evidence that this study did not deviate from planned consensus methodology is demonstrated in the study protocol submitted for ethical approval and funding applications to the NIHR.
	10	Criteria for including/dropping/adding outcomes were described a priori.	
	11	Care was taken to avoid ambiguity of language used in the list of outcomes.	A patient and healthcare professional structured discussion group were used to assess the comprehensibility of language.

Table 7.1. How the CO-OLLF project meets the Core Outcome Set-STAndards for Development: The COS-STAD recommendations (71).

Rigour at each methodological stage in this study has been previously described and discussed in preceding Chapters. Table 7.2 below summarises key methodological approaches demonstrating rigour.

Summary of key methodological approaches demonstrating rigour throughout the CO-OLLF study.
Systematic reviews of the literature
1. Search strategies were developed following guidance from a medical information specialist. Search filters and blocks used were adapted from trusted sources recommended by the COMET and COSMIN initiatives. 2. Title and abstract screening were undertaken in duplicate throughout this project. Full-text review, data extraction, and grading using the COSMIN checklist were also undertaken in duplicate, with the exception that only a random selection of articles were double data extracted for compared in work described in Chapter 2. This was due to the large number of articles identified for data extraction.
Qualitative analysis: Secondary Thematic Analysis of 25 interview transcripts
1. Experienced researchers in qualitative research methods and exploration of lived patient experiences conducted 25 in-depth interviews, the transcripts of which were thematically analysed. 2. Data saturation was demonstrated by the emergence of no new outcome themes after analysing the fifteenth interview transcript. 3. Thematic analysis was supervised by, and coding duplicated for five transcripts by Dr Elizabeth Tutton (ET). ET was familiar with all interview transcripts following involvement in conducting the interviews. Where coding inconsistencies were identified, they were discussed, and agreement was sought.
Creation of a list of candidate outcomes for the Delphi survey
1. Outcomes identified from the systematic review of the literature and patients' lived recovery experience were brought together into the

Inventory of Outcomes and categorised using the COMET Taxonomy of Outcomes (12) described in Appendix 9. The taxonomy represents a made for purpose categorisation system designed to comprehensively help capture and group all outcomes in COS development studies. 2. Outcomes were presented and discussed in two SDGs, a healthcare professional, and a patient SDG. The use of SDGs demonstrated a novel approach to ensuring candidate outcomes demonstrated comprehensiveness and comprehensibility.
Large online Delphi survey
1. COMET guidance aided the design of the Delphi Survey, and the Delphi study protocol was discussed with, and feedback was provided by Professor Paula Williamson, Chair of the COMET initiative. 2. DelphiManager (University of Liverpool), a 'made for purpose' software package developed by the COMET initiative for COS development projects was used to facilitate the survey. 3. Many stakeholder views were accessed by recruiting good numbers of participants (136, of which 55 were patients) who completed both rounds of the Delphi survey, comparable to other recently published COS projects (68).
Multi-stakeholder consensus meetings
1. Meeting participants were purposively selected, and attendee numbers were comparable to recently published COS projects (68). 2. Meetings were conducted and used a modified NGT (70,87,250) to facilitate consensus gathering following guidance from the James Lind Alliance (JLA) Priority Setting Partnership (PSP) Handbook (87). The JLA provides an excellent example of best practice in facilitating mixed patient and professional consensus meetings.
Use of Patient and Public Involvement (PPI)
Patient involvement is a critical component to ensuring the successful delivery of accountability and rigour in a COS development study. PPI was accessed throughout this study, as described in Appendix 4. Of note, Elizabeth Baird (EB) has championed the role of PPI representative and has been involved

throughout this study. EB was present at each patient, healthcare professional and researcher facing element of this project, providing independent oversight.

Table 7.2. Summary of key methodological approaches demonstrating rigour throughout the CO-OLLF study.

7.3 Strengths and limitations

7.3.1 Strengths

Throughout this project, every effort was taken to identify key stakeholder groups and ensure their views were equally represented at each consensus generating stage. Equal representation was considered a fundamental requirement due to discordance of views over outcome importance identified in the literature compared to those interpreted in the Thematic Analysis. Strategies used to ensure that each stakeholder group received equal footing in terms of view representation, included near equal representation at each consensus meeting (70,87,250), and only defining outcomes as 'consensus in' at the Delphi survey where both 70% of the patient and professional groups scored outcomes as critically important. Independent help was also employed by recruiting a PPI representative whose mandate was to advocate for patient views and encourage engagement throughout the project.

Previous COS developers have advocated for separate consensus meetings for patients and healthcare professionals due to concern that healthcare professionals may dominate patient viewpoints during discussion (288,289). This study chose to use mixed patient-professional consensus meetings to enhance the depth of discussion, allowing both stakeholder groups to listen to and understand each

other's viewpoints. An atmosphere of co-operative decision making was fostered at the COMIS consensus meeting, where research professionals shared their assessments of the quality and suitability of outcome instruments. In return, patients shared their views over how burdensome questionnaires may be, and how relevant question items were to their recovery experience. Subsequently, a dialogue was created where participants respected and took into account each other's views based on professional and lived experiences, resulting in a convergence of votes between rounds of discussion and polling. Specific steps were taken at consensus meetings to ensure that all participants felt comfortable sharing views, and no one stakeholder group dominated the discussion. All participants were sent a detailed pre-meeting reading pack and received a brief before the start of each meeting to ensure they knew what to expect. Meeting briefs also aimed to promote an informal environment where participants felt safe to share their views. Meetings were chaired with an aim that a balanced mix of views were shared between stakeholder groups, and contrasting views were actively sought. Many patients participated in the structured discussion group workshop, and both consensus meetings allowing them to become familiar with the faculty and comfortable expressing their views. The study PPI lead acted as an independent advocate to ensure the patient voice was not stifled in the discussion.

The involvement of a diverse sample of patients used throughout this study in terms of age and gender, demonstrates the validity of the COS for use in both the younger male and older female patient populations typical of the bimodal age and gender distribution commonly identified in epidemiological studies on OLLF (101,117,290,291). Despite differences in functional recovery expectations, e.g. return to playing football versus walking, younger and older patient groups were

both demonstrated to identify the absence of pain, quality of life and return to employment/life roles as fundamentally important endpoints in recovery. As a result, confidence that the CO-OLLF is applicable across the age and gender diversity gap encountered when treating patients following OLLF is generated.

Raising awareness of the importance of selecting a small number of only the most critical outcomes for inclusion in the COS was a message that was consistently delivered to participants throughout the consensus development stages of this project. The creation of a four-core outcome COS, and a two-measurement instrument COMIS that consists of only 25 question items, has resulted in a concise tool. A concise COS helps ensure good feasibility and practicality of implementation in future research studies and clinical practice audits, which will likely enhance CO-OLLF uptake.

7.3.2 Limitations

While the patient sample as described above represents the typical age and gender mix of patients presenting with OLLF in the UK, there was a lack of representation of patients at consensus meetings who had experienced the most extreme outcomes, e.g. multiple infections leading to amputation. Reasons why this was the case, may include:

1. Owing to the UK Major Trauma Network and regional orthoplastic units' ongoing success story, patients are less likely to suffer from a deep infection that goes on to delayed amputation. As such, there are low numbers of patients suffering the most severe complications from which to recruit. A recent multicentre UK audit on 239 patients presenting with OLLF identified an all-cause amputation rate of 7.8%, over a 30-day follow-up period (291).

2. This study's experience was that patients having suffered a more arduous treatment course, resulting in amputation, were harder to recruit and, when recruited, posed challenges in facilitating attendance at the consensus meetings. For example, a patient who was due to attend the COS consensus meeting could not make it on the meeting day due to ill health.

A lack of amputees or patients having experienced prolonged treatment courses for deep infection present at the COS consensus meeting may have contributed to the unexpected result of neither bone healing, nor deep infection, reaching 'consensus in' for the COS as previously discussed. However, one amputee participated in the patient SDG, and 3 (6% of patients) completed both rounds of the Delphi survey, indicating that amputee views were represented in this study. Further work to explore whether virtual attendance of difficult to access patient groups is feasible in future consensus meetings is warranted. Such an approach may help overcome the practical difficulties posed by patients' physical attendance with more severe disability and chronic pain. In such future work, thought and care would be required to ensure all views are heard.

Patients were predominantly recruited from three Hospitals based in the midlands and south of England (Coventry, Oxford and Bristol, one patient was recruited from Hull, Yorkshire and the Humber). As such, there is a risk that patient views may not have been representative of those in the North of the UK. However, recruitment of patients from each of those cities was likely to have delivered a socio-economically diverse sample representative of the wider geographic areas of those cities.

It is also unknown how successful the patient sample was in representing UK ethnic minority groups. A priori decision to not collect details regarding ethnic diversity was taken due to concern that additional, direct, personal questioning at Delphi survey registration may have adversely affected the survey completion rate. However, the failure of this study to collect demographic information on ethnic diversity or to purposively sample patients by ethnicity represents a limitation that is worthy of further reflection. It is becoming increasingly recognised and is topical of the current era that every effort should be made to ensure research is respectful, representative and considers the views and experiences of whole populations, including minority groups; this is particularly important in research that involves consensus work with patients. This study cannot comment on whether there were diverging views over outcome importance depending ethnic background, which may introduce the risk of ethnicity bias in the study findings. Failure to represent the views of ethnic and cultural minorities in Western populations is likely to be a systemic issue. It is recognised that many commonly used PROMs have been predominantly developed for and validated in White English-speaking populations. As such, many question items may not be as directly relevant, or relevant items omitted when PROMs are collected in minority groups raising questions over the wider validity of commonly used PROMs in changing Western societies.

This study does not consider or make recommendations over the timing of core outcome measurement. Considerable variation in the timing of commonly reported outcomes in the OLLF literature was noted. As such, it can be argued that failure to make a recommendation on the timing of measurement is a missed opportunity leading to potential heterogeneity in future core outcome-reporting. However, a view was taken that decisions over the timings of measurement should remain

flexible to allow trial designers autonomy over deciding on the most practical time points of measurement for their studies depending on the context of use and choice of additional measurement instruments. Systematic reviewers that wish to meta-analyse outcomes reported at different time points may adopt pragmatic approaches to unify the data. Recommending fixed time points for measurement of core outcomes may adversely affect the COS uptake due to practical issues encountered by trial designers, which may ultimately lead to more significant outcome-reporting heterogeneity overall. The omission of recommendations over the timing of core outcome measurement is consistent with many other high-quality COS development projects (247,248,254) and is considered a reasonable approach in the COMET handbook (70).

This study's principal limitation is that it could not make a recommendation over the measurement of two of the four core outcomes; 'being able to return to life roles' and 'pain or discomfort'. The WaLLTR scale and the EQ-5D-5L came close to achieving 'consensus in' for measuring each outcome, respectively. However, as discussed in Chapter 6, there were several limitations identified for each instrument. Limitations were mainly; concern over the methodological quality of the WaLLTR scale and lack of validation of the page two items, and a view that the EQ-5D-5L would not adequately capture the granularity in the patient experience of 'pain or discomfort' and 'return to life roles' when recovering from OLLF.

Failure to find consensus was a likely consequence of recruiting several methodologists experienced in PROM development and assessment to the COMIS meeting, as their views over instrument suitability, or lack thereof, strongly influenced other participants. Not recommending an instrument where no suitable instruments exist reflects the relative lack of adequately validated instruments in

this disease area. Current instruments do not sufficiently measure the granularity and complexity of the OLLF recovery experience regarding 'pain or discomfort' and 'being able to return to life roles'. This study recommends that further work is needed around either the amendment of current outcome measures, e.g. the WaLLTR scale, or more likely the development of a new measure to address current shortcomings in measuring the core outcomes discussed. The development of a new instrument should have a focus on understanding and comprehensively capturing the complex and varied experiences patients have coping with and treating their pain following OLLF. At such a time as this work is completed, an update of the COS for OLLF would be prudent. Presently, the EQ-5D-5L may be used to measure these outcomes in addition to 'quality of life' owing to its demonstration of good face validity for all four core outcomes. However, this is with the limitation that CO-OLLF participants did not feel that the EQ-5D-5L is sufficiently sensitive enough to measure the complexity of the experience of 'pain or discomfort' and 'being able to return to life roles' after an OLLF.

7.4 Contribution to original knowledge

This study demonstrates a contribution to original knowledge in two principal ways:

1. Directly.

   Identification and assessment of outcomes and measurement instruments:

   a. Outcomes reported in the literature and how they were measured.
   b. Outcomes important to patients recovering from an OLLF.

c. Demonstration of the differences in outcomes considered important by professionals through reporting in the literature and those interpreted from patient recovery experiences.
d. A multi-stakeholder consensus opinion over the most important outcomes and how they should be measured on patients recovering from OLLF in research studies and UK clinical practice.

2. Indirectly.

   Methodological advancement and novelty in approach to COS development:

   a. Use of professional and patient SDGs as a safety check to ensure outcomes were both comprehensive and comprehendible. The SDG methodology was similar in process to cognitive interview studies used in PROM development research (292) as required by COSMIN for assessment of content validity (268). As a result, the outcomes presented at the Delphi survey demonstrate excellent content validity. Novelty is shown, as previous COS developers tended to only use either interviews or group work at the outcome generation stage before candidate outcomes were reviewed by a study management panel prior to inclusion in a consensus process (68). This study benefits from the methodological strengths of one-to-one interviews, which elicit detail from individual experiences and expectations about recovery, and group workshops, that facilitate efficient discussion and group opinions.
   b. In response to a lack of OMIs demonstrating evidence of validation in the target population, this study developed a novel approach to

identify additional OMIs for consideration. The COSMIN methodology was too rigid, not allowing consideration of OMIs measuring similar constructs to the core outcomes validated in other related areas of healthcare.

The approach described in this study adds value to the field of COS development methodology. Future COS developers may choose to adopt a comparable approach if faced with a similar dearth of measurement instruments validated in the target population when following the COSMIN preferred methodology. This approach is likely to be applicable to COS development studies in other orthopaedic trauma areas where the only suitable candidate PROMS were validated on patients for use in elective orthopaedic procedures, or, in other related health conditions.

7.5 Impact and dissemination

Every effort has been made to facilitate the impact of the OLLF COS from the inception of this project. Intended users of the COS, including key professionals overseeing UK Major Trauma Centers, members of the NIHR National Speciality group for Trauma and Emergency Care and the Orthopaedic Trauma Society, have been engaged from the start of the study. They have contributed to delivering the project, in particular, recruitment to the Delphi survey and raising awareness, which will have built their confidence in the study findings. A crucial target for implementing the OLLF COS for use in routine national outcome collection is the Trauma Audit and Research Network (TARN). This project has received written support from the TARN Research Director and has benefited from the TARN Executive Director's participation in the COMIS consensus meeting.

Adequate dissemination of the OLLF COS is essential to achieving a broader awareness and impact beyond the UK major trauma network. The project was registered on the publicly accessible COMET database. The entry will link to the final COS when it is published. The CO-OLLF study will be submitted to orthopaedic trauma speciality journals to ensure a targeted delivery to a relevant international readership. Findings will also be presented to the Orthopaedic Trauma Society membership, and at the next National Open Fracture Summit, among other meetings.

By gaining widespread awareness and support among UK trauma practitioners, including the involvement of key leaders in UK orthopaedic trauma care and research, the likelihood of COS implementation in future research studies, and the collection of routine PROMs in clinical practice, will be significantly increased.

It has been recognised that failure to achieve COS uptake will itself result in research waste, undermining a principal aim of the COS development movement (293). Implementation of COSs in future research studies is more broadly promoted through the COMET initiative's ongoing work. COMET actively raises awareness and publicises the broad-reaching benefits of COS development and implementation into the medical research landscape (68,76). The search for, and implementation of relevant COS is also promoted by NICE when undertaking systematic reviews to inform clinical guidelines, funding bodies including, the NIHR Health Technology Assessment (HTA) programme, and the Cochrane collaboration among other institutions (see Appendix 10).

A study reviewing NIHR HTA applications, and surveying applicants, demonstrates a positive impact of funder recommendation over COS inclusion in study design

(238). The NIHR HTA Programme is a principal funding target for UK researchers who aim to investigate the clinical effectiveness of new interventions for the care of patients following OLLF. The NIHR Trauma and Emergency Care speciality group is actively supportive of this project.

A recent publication by the COMET initiative, exploring uptake of COSs across different health areas, suggested that significant barriers to uptake include lack of patient, and other key stakeholder involvement in COS development, lack of awareness of the COS and lack of validated instruments (293). This COS development project identified and involved key stakeholder groups while raising widespread awareness among the orthopaedic trauma research community. Unlike this project, most COS studies do not go as far as to make recommendations over which instruments to use when measuring core outcomes (68). While this study does not recommend instruments validated in the target population, it does recommend instruments that are widely used, practical and validated in similar UK patient populations.

7.6 Future research directions

7.6.1 Monitoring CO-OLLF impact

Following this study's publication, the application of the COS for OLLF must be monitored to establish whether uptake is being achieved (293). The DPhil candidate intends to conduct regular screening of clinical trials and systematic reviews on OLLF for COS uptake. This will be achieved by setting up an automated search strategy using the Ovid search engine (Ovid Technologies, Inc 2020, Wolters Kluwer) to search the Medline and Embase databases at predetermined

time points, producing email notifications of newly published studies. If COS uptake is low, promotion strategies discussed above can be revisited. Low uptake may also indicate that the COS has poor relevance, e.g. core outcomes not being used, or trials consistently using a measure not included in the COS. Such a scenario may indicate that a COS update is required.

7.6.2 Development of a composite set of standardised objective clinical outcomes and definitions

Objective clinical outcomes, including deep infection and bone healing, among others, were recognised as important surgical outcomes at the COS consensus meeting. After discussion and voting, consensus was reached that objective clinical outcomes do not need to be reported in every future research study on OLLF, e.g. irrelevant for psychosocial or rehabilitation intervention studies. Several participants at the COS consensus meeting strongly advocated for the inclusion of bone healing and deep infection. Participants also recognised a need to standardise objective clinical outcomes, and their definitions, for future surgical trials during the subsequent discussion. In many cases, funders and ethics committees mandate the collection of objective clinical outcomes representing adverse events, e.g. deep infection and bone union/non-union. The need to standardise important objective clinical outcomes was supported by findings discussed in Chapter 2, where objective clinical outcomes were shown to represent the largest group of outcomes reported in OLLF studies, with little to no continuity over their definitions. It was noted that bone union/healing was the most commonly reported and defined outcome; it was defined in 50 studies with no identical definitions. There was an agreement among participants favouring further

work to create a composite set of standardised objective clinical outcomes and their definitions that could be reported alongside the OLLF COS where required, e.g. in surgical intervention trials. Such work may mirror previous efforts to standardise the assessment of tibial fracture healing through the development of the Radiographic Union Score for Tibial fractures (RUST) (294).

As many objective clinical outcome measures are used synonymously across orthopaedic trauma studies independent of the anatomical area of injury, e.g. bone union and infection, there is a case for a collaborative effort to select essential complication outcomes and agree on how they should be defined and therefore measured. Objective clinical outcomes and their definitions identified in Chapter 2 could be used as an inventory from which further work could be built to achieve consensus for such a set of standardised objective clinical outcomes in orthopaedic trauma. Outcomes and their definitions identified in the published literature on OLLF will likely be widely applicable to other orthopaedic trauma areas as OLLF is an archetypal trauma injury. This is due to its complexity, multiple treatment approaches, and widely recognised complications common to other areas of orthopaedic trauma.

7.6.3 Further work on the Wales Lower Limb Trauma Recovery (WaLLTR) scale and recommendation for a new measure of pain and discomfort.

Assessment of the WaLLTR scale using the COSMIN Risk of Bias Checklist (2,266-268) and methodology for assessing the content validity of PROMs (268) identified issues around the testing of the content validity of the scale; a lack of clarity over whether the scale was based on a reflective or formative model; and a

failure to adequately assess the risk of measurement error when using the scale. Discussion predominately among PROM methodologists and patients over the utility of the WaLLTR scale at the COMIS consensus meeting identified problems with the wording of question items, including double negatives and summary-language. The group felt a lack of clarity was present over how the second-page items (those not counting towards the scale score) should be interpreted, and how they were developed and validated, if at all. The WaLLTR scale came close to achieving ‘consensus in’ for measuring ‘being able to return to life roles’; however, there was concern over how the scale items mapped to this outcome construct.

Many of the issues described above could be addressed by conducting a well-designed cognitive interview study on patients, healthcare professionals and PROM methodologists. In doing so, concerns around the comprehensiveness and comprehensibility of scale items would be addressed, including the wording of questions. Additional work refining question items to map to ‘being able to return to life roles’ would significantly enhance the likelihood of WaLLTR selection for inclusion in the COMIS in a future update. However, addressing shortcomings around the validation of the question items retrospectively would likely result in such significant changes that alpha and beta scale testing would need to be repeated. As such, the creation of a new OMI that reflects the most recent insights into patient’s views over the most important aspects of recovery presented in this body of work may be a more efficient course of action overall.

This study identified a strong theme of struggling to cope with pain or discomfort when recovering from OLLF. There is currently no measure of ‘pain or discomfort’ used in, or validated on the OLLF population that sufficiently captures the granularity, chronicity and variability of the core outcome. Although superficial

changes to the WaLLTR scale to better capture the core outcome of 'return to life roles' may make the OMI more appealing to include in the COMIS at a future update consensus meeting, it would not address fundamental flaws in the validation of the measure as described and it's failure to capture patient's complex experiences of pain following OLLF.

On deeper reflection, given the importance of the patient experience of pain as a fundamental element of recovery, developing a robust and well-validated pain measure for patients following OLLF is warranted. Such a measure, when used in conjunction with a disease/anatomical region-specific (e.g. the LEFS) and general Quality of Life measure (e.g. the EQ-5D-5L), may make an attractive option for a future COMIS for OLLF.

7.6.4 Feasibility trial of COS implementation toward a comprehensive prospective cohort for all patients following OLLF

Trialling the collection of the EQ-5D-5L and LEFS at several Major Trauma Centers utilising established links developed through this study represents the next step along the research ladder, with a view toward the comprehensive collection of core outcomes at all UK MTCs. A feasibly study undertaken jointly with the Trauma Audit and Research Network (TARN), and the Orthopaedic Trauma Society, will help achieve 'buy-in' and address practical concerns from key figures in the orthopaedic trauma community. Methods of outcome collection, e.g. postal survey, telephone or using an online service (app or website link), will need to be explored, taking into account response rates, practicality issues, and additional cost.

A comprehensive collection of meaningful outcomes on patients following OLLF will facilitate investigation into the effect of regional variations in treatment on

patient outcomes. A comprehensive collection of the OLLF COS will also facilitate the ability to efficiently embed RCTs within the MTC network to rapidly investigate the clinical effectiveness of new treatment interventions.

It is of note that there are anticipated limitations that would need to be overcome if the TARN infrastructure is to be utilised for the future comprehensive collection of the COMIS for OLLF. Limitations include addressing the considerable missingness in the TARN data currently collected (117) and likely difficulties of data entry at the data clerk level when entering PROM scores, as well as arrangements to fund the collection and entry of additional data to the TARN database.

7.7 Conceptual considerations of COS development

Reduction and refinement of outcomes identified in the literature, and interpreted from patients in a COS development process, appears to ultimately lead to a position of compromise for each stakeholder group involved. In this study, the granularity and richness of patient experience around emotional functioning and wellbeing identified at the coding level when thematised, could not compete with broader outcome themes like ‘quality of life’ in achieving consensus for inclusion in the COS. As such, patients may feel the COS no longer reflects their emotional journey to the extent that outcome themes presented at the SDGs may have. On the other hand, healthcare professionals may feel resentful that the patient voice was too strong, leading to the exclusion of important objective surgical outcomes such as ‘bone healing’ and ‘deep infection’ during the COS consensus meeting.

These points raise the question: Can a COS ever be all-encompassing?

The answer may be, perhaps not. An all-encompassing COS will likely no longer represent a ‘core set’ of outcomes, and instead, a ‘comprehensive set’ of outcomes. Such a tool would be large, unwieldy and impractical to implement across research studies negating many of the target benefits of COS development.

While individual stakeholder groups may not feel the COS process adequately represents their views, it is hoped that all stakeholders will equally benefit from the positive impact of COS implementation to the research field or area of clinical practice. Such benefits may include, as previously discussed, reduced outcome-reporting bias, promotion of better-quality research studies, as well as the potential to attract more research funding to the field due to improved design of study protocols.

In the broader sense, if COS development projects tend to recommend OMIs that are already widely used and accepted in the field, can the time-consuming nature and expense of conducting such projects be justified? Or is there a more streamlined approach?

It may be argued that the depth and detail of work involved in developing a COS is what gives clinicians and study designers the confidence to implement them in practice and research. Confidence in the rigorous process of COS development may ultimately be the defining feature effecting successful, or unsuccessful uptake of COSs in future studies.

Anecdotally many COS developers may be able to accurately predict the recommended core outcomes and corresponding measurement instruments resulting from their work ahead of time. However, the value of the COS is likely in the detail and rigour of the approach.

Following this logic, demonstration of rigour, transparency and trustworthiness throughout the COS development process are essential in building confidence in the COS recommendations and is, therefore, a crucial element in achieving implementation and impact on future research and clinical practice.

7.8 Relevance of CO-OLLF to patients and healthcare services

Wide dissemination and uptake of a COS for OLLF will realise the following future benefits:

1. Implementation of the COMIS in local and national audit and service evaluation (TARN) to improve trauma care and promote quality assurance initiatives relevant to stakeholders.
2. Inform NICE, the Cochrane Collaboration, research funders, and ethics committees of the COS.
3. Improve patient relevance, consistency of outcome-reporting, research efficiency and appeal to funders, whilst reducing outcome-selection bias in clinical trials.
4. Reduce data heterogeneity in systematic review and promote evidence synthesis addressing important outcomes to all stakeholders.
5. Generate a framework for further COS development in trauma.

7.9 Conclusion

This study used robust consensus methods to identify four outcomes that should be measured on skeletally mature patients following OLLF in all future research studies and audits of clinical practice. The EQ-5D-5L and LEFS are recommended for measuring the core outcomes: ‘quality of life’ and ‘walking, gait and mobility’.

Consensus was not achieved to recommend an outcome measurement for: ‘being able to return to life roles’ or ‘pain or discomfort’.

The WaLLTR scale demonstrated significant inadequacies in its content validity such that it may be more worthwhile developing a new disease/region-specific Quality of Life PROM for OLLF that reflects core outcomes identified in this study, e.g. return to life roles.

This study demonstrates that pain or discomfort is a complex and fundamental component of the patient experience of OLLF that is central to recovery and that there is a dearth of OMIs that comprehensively measure this core outcome in a manner that is acceptable to patients and other stakeholders alike. As such, this study recommends that future work on the development of PROMs for OLLF and lower limb trauma more generally considers the creation of a region-specific measure of pain or discomfort.

The EQ-5D-5L was shown to demonstrate face validity for measuring ‘pain or discomfort’ and ‘being able to return to life roles’ and can be used to measure these two outcomes in addition to any other measurement instruments trial designers may choose to use.

Appendices

8.1 Appendix 1. Research training

During the course of this DPhil project, the candidate has completed the following research training courses:

1. NIHR Academic Clinical Fellow Systematic Review Course, Magdalen College, University of Oxford.
2. Cochrane UK Review Author Training. Oxford

   RA1: Beginning a Systematic Review Protocol

   RA2: The Methods Section of the Protocol.
3. MSc in Health Sciences, University of Warwick. (Graduated with Distinction and received the prize for highest overall mark)
   - Four modules resulting in systematic review assignments
   - One module on Design, Analysis and Interpretation of Epidemiological Research
   - One module on Understanding Research and Critical Appraisal in Research
4. Teaching Certificate in Medical Education, University of Warwick (Graduated with Merit), Fellow of the Higher Education Authority.
5. Core Outcome Measures in Effectiveness Trials (COMET) conference and training workshops. Amsterdam.
6. Clinimetrics: Assessing Measurement Properties of Health Measurement Instruments residential course. COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) course. Department of Epidemiology and Biostatistics, VU Medical Center, Amsterdam.
7. Introduction to Qualitative Research and Conducting Focus Groups 5-day short course. Health Experience Research Group (HERG), University of Oxford.
8. Viva preparation and thesis writing course. NDORMS, University of Oxford.
9. Systematic Reviews Oxford Clinical Trials Research Unit (OCTRU) Workshop. University of Oxford.
10. Attended the Introduction to Stata 2-day short course. Population Health Sciences, University of Bristol.
11. Bone and Joint Journal Reviewers Training Day. London.

8.2 Appendix 2. Publications, presentations and prizes arising from work in this thesis

8.2.1 Prizes resulting from this work

National Institute for Health Research (NIHR) Annual Trainee Meeting, Poster Prize Winner. Development of a tool to improve research on patients sustaining open lower limb fracture. £100 book vouchers (November 2015)

8.2.2 Presentations

8.2.2.1 International

A. Aquilina. European Federation of Orthopaedics and Traumatology (EFFORT). Core outcome sets in trauma and orthopaedic research. Invited speaker for the Bone and Joint Journal session. Vienna (June 2017) **(Oral)**

K Young, **A Aquilina**, TJS Chesser, ML Costa ML, S Hettiaratchy, MB Kelly, CG Moran, I Pallister, M Woodford. **British Association of Plastic Reconstructive and Aesthetic Surgeons (BAPRAS), summer meeting.** Open Tibial Fractures in Major Trauma Centers: A National Update. On behalf of the MTC-22. Helsinki (June 2017) **(Oral)**

8.2.2.2 National

A Aquilina. X Griffin, M Costa, L Tutton, R Fitzpatrick. **3rd National Open Fracture Summit**. Core Outcomes for Open Lower limb Fractures (CO-OLLF). Birmingham (October 2019) **(Oral)**

A Aquilina. X Griffin, M Costa, L Tutton, R Fitzpatrick. **2nd National Open Fracture Summit**. Core Outcomes for Open Lower limb Fractures (CO-OLLF). Newcaste-Upon-Tyne (October 2018) **(Oral)**

A Aquilina, M. Fernandez, X. Griffin, M. Costa. **National Institute for Health Research Annual Trainee Meeting**. The development of a tool to improve research on patients sustaining open lower limb fractures. Leeds (November 2015) **(Poster Prize Winner)**

8.2.2.3 Local

A Aquilina. X Griffin, M Costa, L Tutton, R Fitzpatrick. **Musculoskeletal Research Unit, University of Bristol, Seminar Series**. Core Outcomes for Open Lower limb Fractures (CO-OLLF). Bristol (November 2019) **(Oral)**

A Aquilina. **Oxford Trauma Research Group Away Day**. What have I achieved, learned and will take forwards? Wolfson College, Oxford (December 2018)

A Aquilina. X Griffin, M Costa, L Tutton, R Fitzpatrick. **NDORMS DPhil** Presentation Day. Core Outcomes for research on Open Lower Limb Fractures (CO-OLLF). NDORMS (December 2017) **(Oral)**

8.2.3 Publications

Chan JKK, **Aquilina AL**, Rodrigues JN, Griffin XL, Nanchahal J. Timing and staging of antibiotic administration and surgery for open long bone fractures of the upper and lower limbs. Cochrane Database of Systematic Reviews 2020, Issue 3. Art. No.: CD013555. DOI: 10.1002/14651858.CD013555.

Young K, **Aquilina A**, Chesser TJS, Costa ML, Hettiatratchy S, Kelly MB, Moran CG, Pallister I, Woodford M, MTC-22. Open tibial fractures in major trauma centres: A national prospective cohort study of current practice. Injury. Feb;50(2):497-502 PMID: 30401540

Aquilina A, Keene D, Griffin X. Outcome Measures. In: Nanchahal J. ed. *Standards for the Management of Open Fractures of the Lower Limb*. Accepted by editor (February 2020)

8.3 Appendix 3. Study Management Group

The Study Management Group boasts a wealth of research experience and forms an excellent supervision team for this DPhil project (see Table 8.1). The Study Management Group members were chosen for their specific expertise that helped guide each workstream detailed in this project.

Name (Abbreviation used in this thesis)	**Background**
Prof Xavier Griffin (XG)	Professor of Orthopaedic Trauma with experience delivering trials on clinical effectiveness. XG led a project identifying the COS for fragility hip fracture.
Dr Elizabeth Tutton (ET)	Senior Research Fellow with experience using qualitative research methods to understand lived experiences of injury. ET was a co-applicant on the Wound management of Open Lower Limb Fractures Trial (WOLLF) and led qualitative work exploring the lived experience of recovery.
Prof Ray Fitzpatrick (RF)	Professor of Public Health and Primary Care with a wealth of experience in evaluating health services, the use of patient-reported outcomes to measure health, and the investigation of the patient experience.
Prof Matthew Costa (MC)	Professor of Orthopaedic Trauma with experience leading trials investigating the clinical cost effectiveness of musculoskeletal interventions. MC was Chief Investigator on the WOLLF Trial.
Mr Alexander Aquilina (AA)	DPhil student and previously an Academic Clinical Fellow in Trauma and Orthopaedic surgery. Currently a Trauma and Orthopaedic Specialist Registrar in the Severn Rotation.

Table 8.1. Members of the Study Management Group.

8.4 Appendix 4. Patient and Public Involvement (PPI)

PPI has been integral to the success of this study. Patients and members of the public have been involved in each workstream of this study. Their presence and support at structured discussion groups (SDG), consensus meetings and in the design of the online Delphi survey has been key to delivery of this project.

The CO-OLLF project partnered with Ms Elizabeth Baird (EB) who has acted as PPI partner throughout the entirety of this project.

See Table 8.2 for an overview of where PPI has been used in this project.

PPI Overview	
Stage of Project	**Description of PPI**
Study design	Eight members of the Oxford Trauma PPI Group, including EB, reviewed and provided feedback on the CO-OLLF study protocol. *"A very worthwhile study to conduct"* *"A worthwhile study and the plan to involve patients seems central to it"* Changes to the methodology suggested by the PPI are detailed in the relevant methods sections below. In addition, Ms Heather Bagley, Core Outcome Measures in Effectiveness Trials (COMET) initiative PPI coordinator, has contributed to the design of this study through her help with protocol revisions and previous research grant funding applications.
Study Management	As project PPI partner, EB took on an active management role throughout the project. Key project decisions were discussed with EB, either in person or by email

	correspondence. EB assisted in the ethics application for this project and reviewed all patient-facing documents before they were sent. EB provided help planning and scheduling the two Structured Discussion Group (SDG) meetings and the two consensus meetings. EB played a key role in the design of the Delphi survey. EB attended both SDG meetings and both consensus meeting, where EB actively helped with the facilitation of these meeting due to her familiarity with the project. EB provided continuity between each meeting, helped explain concepts to patients and acted as a patient advocate to ensure their views and opinions were at no point overshadowed.
Research involvement	The patient participants in this project were not recruited as research subjects; rather they became research partners sharing their opinions based on their lived experiences of recovering from open fractures. Patients played key roles in the development of the outcome themes for the Delphi survey and educating healthcare professionals at both consensus meeting on the patient perspective of recovering from an open fracture.
Study Dissemination	EB will review and be acknowledged in published work arising from this thesis.

Table 8.2. Overview of PPI used in CO-OLLF.

All patient participants in this study were provided with travel expenses and compensation for the use of their time (£20 per hour) in line with INVOLVE and departmental guidance. Participants were provided with refreshments at all face to face meetings and lunch at consensus meetings.

8.5 Appendix 5. COMET Study registration

Core Outcomes for research on Open Lower Limb Fractures (CO-OLLF): Development of a core outcome set and core outcome measurement set

Background

An open fracture is a break of a bone where part of the bone sticks out through the skin. Here, the broken bone is at risk of infection. This is a serious injury which may lead to a limb or life-threatening illness and later disability.

Approximately 4,100 people each year in the UK will suffer an open lower limb fracture (OLLF), commonly at the shin bone. Treatment of these devastating injuries is complex such that teams of surgeons are required to repair the bones, muscles, skin and in extreme cases blood vessels and nerves. Despite advances in medical care around 1 in 10 will require amputation of the leg. Treatment is very costly; in the USA the average lifetime cost of an OLLF is $160,000 where the limb is saved and $500,000 where amputation is required (UK cost information unavailable).

Unfortunately, we don't yet know the best way of measuring the results (outcomes) from treatment of these injuries. Researchers have therefore reported outcomes in many ways, making it difficult to compare studies to find out the best way of treating OLLF. Researchers have often used outcomes that are important to them, such as x-ray appearance or amputation rate instead of asking patients what outcomes they think are most important. Outcomes that might be important to patients could include:

- leg appearance
- movement/mobility
- pain

Aims
We aim to develop a 'Core Outcome Set' (COS) that all future research on OLLF should measure and report as a minimum. A COS is a standardised set of outcomes that have been agreed with healthcare professionals and patients. This study also aims to identify how to measure core outcomes (i.e. which scales/measurement instruments are best). This will ensure comparisons can be made between future studies and research can be conducted for maximum patient benefit.

Benefit to patients: A COS for OLLF will:
- support routine use of patient preferred outcomes
- make research more comparable, allow effective testing of new technology and help efficient spending of NHS resources
- help avoid studies only reporting a selection of outcomes that were measured
- inform NICE when developing guidelines and TARN when conducting national audits on patient care of the most important outcomes to use

Contributors
Prof Matt Costa, Professor of Orthopaedic Trauma Surgery, Nuffield Department of Orthopaedics Rheumatology and Musculoskeletal Sciences (NDORMS), University of Oxford – Senior Investigator & supervisor

Mr Xavier Griffin, Associate Professor of Orthopaedic Trauma Surgery, Nuffield Department of Orthopaedics Rheumatology and Musculoskeletal Sciences (NDORMS), University of Oxford – Senior Investigator & supervisor

Dr Liz Tutton, Senior Research Fellow, Universities of Oxford and Warwick – Senior Investigator & supervisor

Prof Ray Fitzpatrick, Professor of Public Health and Primary Care, Nuffield Department of Population health, University of Oxford – Senior Investigator & supervisor

Mr Alex Aquilina. Clinical Research Fellow and DPhil student, University of Oxford – Principle Investigator

Mr Umraz Khan, Consultant Plastic Surgeon, Frenchay Hospital Bristol

Mr Abhilash Jain, Clinical Senior Lecturer Plastic Surgery, University of Oxford

Mr Mike Kelly, Consultant Trauma & Orthopaedic Surgery, North Bristol NHS Trust

Prof Sallie Lamb, Co-Director of the Oxford Clinical Trials Research Unit and Professor of Rehabilitation (University of Oxford)

Mr Iain McFayden, Consultant Trauma & Orthopaedic Surgery, University Hospitals of North Midlands NHS Trust

Dr Rebecca Kearney, Clinical Lecturer , University of Warwick

Prof Fiona Lecky, Director of Research, The Trauma Audit & Research Network

Dr Antoinette Edwards, Director of Operations, The Trauma Audit & Research Network

Further Study Information

Current Stage: Ongoing
Date: October 2015 - October 2020
Funding source(s): Funding to be confirmed

Health Area

Disease Category: Orthopaedics & trauma

Disease Name: Open fracture, Fractures

Target Population

Age Range: 16 - 100

Sex: Either

Nature of Intervention: Surgery, Any

Stakeholders Involved

- Clinical experts
- Consumers (patients)
- Researchers
- Charities
- Consumers (caregivers)
- Ethicists
- Journal editors
- Patient/ support group representatives
- Policy makers
- Service commissioners
- Service providers
- Service users

Study Type

- COS for clinical trials or clinical research
- COS for practice
- Recommendations for outcome measures (measurement/how)

Method(s)

- Consensus meeting
- Interview
- Nominal group technique (NGT)
- Systematic review
- Delphi process
- Focus group(s)

This project will be divided into four workstreams (WS) overseen by a central patient and public involvement group:

WS1. What are the outcome priorities for patients?

Important outcomes identified from qualitative research on patients recovering from OLLF will be fed-back to 10 patients and 10 healthcare professionals in three structured-discussion groups. Participants will work together to develop and map outcome statements onto the WHO's International Classification of Functioning, Disability and Health model (ICF). Using nominal group technique, participants will prioritise outcome statements for inclusion in the COS.

WS2. What outcomes have been reported in the literature and what OMIs have been used to measure them?

A systematic review will be conducted to identify outcomes reported in clinical trials on OLLF, their quality of reporting and what OMIs have been used to measure them.

All outcomes and OMIs identified in WS1-2 will be fed into an inventory of outcomes.

WS3. What is the COS for OLLF?

Inventoried outcomes will be scored by patients and stakeholders by order of importance in an online-Delphi survey. This will be conducted over three-rounds where outcomes reaching consensus for inclusion in the COS will be shortlisted.
A minimum of 30 patients and stakeholders will be invited to an initial consensus meeting where each shortlisted outcome will be discussed before electronic-voting on inclusion in the COS.

WS4. How should the COS be measured?

Upon creation of the COS, inventoried OMIs will be matched to core outcomes. The measurement properties of all matched OMI's will then be assessed for quality using recognised assessment criteria. OMIs reaching an acceptable standard of quality for each core outcome will then be shortlisted.
Participants from consensus meeting one will be re-invited to a second consensus meeting where shortlisted OMIs will be voted on to be included in the COMIS.

Lower limb open fractures occur predominately in a bimodal population of young males sustaining high energy traumatic injuries and older females sustaining low energy fragility open fractures.

Linked Studies

No related studies

Related Links

No related links

8.6 Appendix 6. Ethical Approval for CO-OLLF and documents approved by the Research Ethics Committee (REC)

Ethical approval for this study was granted by the South Central – Oxford B Research Ethics Committee (REC) (REC reference: 18/SC/0051) on the 1st of March 2018. Health Research Authority approval was granted on the 2nd of March 2018.

This study was adopted by the National Institute of Health Research (NIHR) Clinical Research Network (Protocol number: 13257).

See letters confirming ethical approval and approved documents below.

8.6.1 Research Ethics Committee (REC) letter of approval

NHS
Health Research Authority
South Central - Oxford B Research Ethics Committee
Whitefriars
Level 3, Block B
Lewin's Mead
Bristol
BS1 2NT

Telephone: 0207 104 8058

Please note: This is the favourable opinion of the REC only and does not allow you to start your study at NHS sites in England until you receive HRA Approval

01 March 2018

Mr Alexander Aquilina
Kadoorie Centre, John Radcliffe Hospital
Headley Way
Headington, Oxford
OX3 9DU

Dear Mr Aquilina

Study title:	**Core Outcomes for research on Open Lower Limb Fractures (CO-OLLF): Development of a core outcome set and core outcome measurement set**
REC reference:	**18/SC/0051**
Protocol number:	**13257**
IRAS project ID:	**235150**

Thank you for your letter of 21st February 2018 responding to the Proportionate Review Sub-Committee's request for changes to the documentation for the above study.

The revised documentation has been reviewed and approved by the sub-committee.

We plan to publish your research summary wording for the above study on the HRA website, together with your contact details. Publication will be no earlier than three months from the date of this favourable opinion letter. The expectation is that this information will be published for all studies that receive an ethical opinion but should you wish to provide a substitute contact point, wish to make a request to defer, or require further information, please contact please contact hra.studyregistration@nhs.net outlining the reasons for your request.

Under very limited circumstances (e.g. for student research which has received an unfavourable opinion), it may be possible to grant an exemption to the publication of the study.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised.

Conditions of the favourable opinion

The REC favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements. Each NHS organisation must confirm through the signing of agreements and/or other documents that it has given permission for the research to proceed (except where explicitly specified otherwise).

Guidance on applying for HRA Approval (England)/ NHS permission for research is available in the Integrated Research Application System, www.hra.nhs.uk or at http://www.rdforum.nhs.uk.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of management permissions from host organisations.

Registration of Clinical Trials

All clinical trials (defined as the first four categories on the IRAS filter page) must be registered on a publically accessible database. This should be before the first participant is recruited but no later than 6 weeks after recruitment of the first participant.

There is no requirement to separately notify the REC but you should do so at the earliest opportunity e.g. when submitting an amendment. We will audit the registration details as part of the annual progress reporting process.

To ensure transparency in research, we strongly recommend that all research is registered but for non-clinical trials this is not currently mandatory.

If a sponsor wishes to request a deferral for study registration within the required timeframe, they should contact hra.studyregistration@nhs.net. The expectation is that all clinical trials will be registered, however, in exceptional circumstances non registration may be permissible with

prior agreement from the HRA. Guidance on where to register is provided on the HRA website.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" above).

Approved documents

The documents reviewed and approved by the Committee are:

Document	*Version*	*Date*
Copies of advertisement materials for research participants [AA CO-OLLF poster version 1.3 29Nov2017]	1.3	29 November 2017
Copies of advertisement materials for research participants [AA CO-OLLF poster version 1.3 29Nov2017]	1.4	13 February 2018
Evidence of Sponsor insurance or indemnity (non NHS Sponsors only) [01082017 OU insurance policy schedule & certificate.pdf]		01 August 2017
IRAS Application Form [IRAS_Form_14012018]		14 January 2018
IRAS Application Form XML file [IRAS_Form_14012018]		14 January 2018
IRAS Checklist XML [Checklist_21022018]		21 February 2018
Letter from funder [Alexander Aquilina LETTER.pdf]		24 October 2017
Letter from sponsor [80103 A AQUILINA PID 13257 signed sponsor letter KM]		03 January 2018
Other [Evidence of external review]		12 January 2017
Other [Professional participant consent form]	1.3	21 December 2017
Other [Professional information leaflet]	1.3	21 December 2017
Other [Supervisor CV. Prof Matt Costa]		09 January 2018
Other [Dr Elizabeth Tutton summarised CV]		09 January 2018
Other [Prof Ray Fitzpatrick summarised CV]		09 January 2018
Other [Prof Xavier Griffin summarised CV]		09 January 2018
Other [Example outcome statements and Delphi survey]	1.0	12 January 2018
Other [DelphiManager brochure]	1.0	12 January 2018
Other [Professional information leaflet]	1.3	13 February 2018
Other [Cover letter replying to provisional opinion.]	1.1	13 February 2018
Other [CO-OLLF study participant reply slip]	1.0	13 February 2018
Other [example CO-OLLF participant spreadsheet]	1.0	13 February 2018
Participant consent form [Patient consent form]	1.3	21 December 2017
Participant information sheet (PIS) [Patient information leaflet]	1.3	21 December 2017
Participant information sheet (PIS) [Patient information leaflet]	1.4	13 February 2018
Research protocol or project proposal [CO-OLLF protocol	1.6	21 December 2017

21Dec2017 v1.6]		
Summary CV for Chief Investigator (CI) [Alex Aquilina CV December 2017]		

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Reporting requirements

The attached document "After ethical review – guidance for researchers" gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study

The HRA website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

Feedback

You are invited to give your view of the service that you have received from the Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the HRA website:
http://www.hra.nhs.uk/about-the-hra/governance/quality-assurance

We are pleased to welcome researchers and R & D staff at our RES Committee members' training days – see details at http://www.hra.nhs.uk/hra-training/

18/SC/0051	**Please quote this number on all correspondence**

With the Committee's best wishes for the success of this project.

Yours sincerely

Pp Bywater

Mr Chris Foy
Chair

Email: nrescommittee.southcentral-oxfordb@nhs.net

8.6.2 Letter of Health Research Authority (HRA) approval

NHS
Health Research Authority

Mr Alexander Aquilina
Kadoorie Centre, John Radcliffe Hospital
Headley Way
Headington, Oxford
OX3 9DU

Email: hra.approval@nhs.net

02 March 2018

Dear Mr Aquilina

Letter of HRA Approval

Study title:	**Core Outcomes for research on Open Lower Limb Fractures (CO-OLLF): Development of a core outcome set and core outcome measurement set**
IRAS project ID:	**235150**
Protocol number:	**13257**
REC reference:	**18/SC/0051**
Sponsor:	**University of Oxford**

I am pleased to confirm that **HRA Approval** has been given for the above referenced study, on the basis described in the application form, protocol, supporting documentation and any clarifications noted in this letter.

Participation of NHS Organisations in England
The sponsor should now provide a copy of this letter to all participating NHS organisations in England.

Appendix B provides important information for sponsors and participating NHS organisations in England for arranging and confirming capacity and capability. **Please read *Appendix B* carefully**, in particular the following sections:

- *Participating NHS organisations in England* – this clarifies the types of participating organisations in the study and whether or not all organisations will be undertaking the same activities
- *Confirmation of capacity and capability* - this confirms whether or not each type of participating NHS organisation in England is expected to give formal confirmation of capacity and capability. Where formal confirmation is not expected, the section also provides details on the time limit given to participating organisations to opt out of the study, or request additional time, before their participation is assumed.
- *Allocation of responsibilities and rights are agreed and documented (4.1 of HRA assessment criteria)* - this provides detail on the form of agreement to be used in the study to confirm capacity and capability, where applicable.

Further information on funding, HR processes, and compliance with HRA criteria and standards is also provided.

It is critical that you involve both the research management function (e.g. R&D office) supporting each organisation and the local research team (where there is one) in setting up your study. Contact details and further information about working with the research management function for each organisation can be accessed from the HRA website.

Appendices
The HRA Approval letter contains the following appendices:

- A – List of documents reviewed during HRA assessment
- B – Summary of HRA assessment

IRAS project ID	235150

After HRA Approval
The document *"After Ethical Review – guidance for sponsors and investigators"*, issued with your REC favourable opinion, gives detailed guidance on reporting expectations for studies, including:

- Registration of research
- Notifying amendments
- Notifying the end of the study

The HRA website also provides guidance on these topics, and is updated in the light of changes in reporting expectations or procedures.

In addition to the guidance in the above, please note the following:

- HRA Approval applies for the duration of your REC favourable opinion, unless otherwise notified in writing by the HRA.
- Substantial amendments should be submitted directly to the Research Ethics Committee, as detailed in the *After Ethical Review* document. Non-substantial amendments should be submitted for review by the HRA using the form provided on the HRA website, and emailed to hra.amendments@nhs.net.
- The HRA will categorise amendments (substantial and non-substantial) and issue confirmation of continued HRA Approval. Further details can be found on the HRA website.

Scope
HRA Approval provides an approval for research involving patients or staff in NHS organisations in England.

If your study involves NHS organisations in other countries in the UK, please contact the relevant national coordinating functions for support and advice. Further information can be found through IRAS.

If there are participating non-NHS organisations, local agreement should be obtained in accordance with the procedures of the local participating non-NHS organisation.

User Feedback
The Health Research Authority is continually striving to provide a high quality service to all applicants and sponsors. You are invited to give your view of the service you have received and the application procedure. If you wish to make your views known please use the feedback form available on the HRA website.

HRA Training
We are pleased to welcome researchers and research management staff at our training days – see details on the HRA website.

Your IRAS project ID is **235150**. Please quote this on all correspondence.

Yours sincerely

Michael Higgs
Assessor

Copy to: *Ms Heather House, University of Oxford (Sponsor)*
Ms Victoria Rush, Oxford Health NHS Foundation Trust (Lead NHS R&D office)

IRAS project ID	235150

Appendix A – List of Documents

The final document set assessed and approved by HRA Approval is listed below.

Document	Version	Date
Copies of advertisement materials for research participants [Poster]	1.4	13 February 2018
Evidence of Sponsor insurance or indemnity (non-NHS Sponsors only)		01 August 2017
HRA Schedule of Events	1	14 February 2018
HRA Statement of Activities	1	14 February 2018
IRAS Application Form [IRAS_Form_14012018]		14 January 2018
Letter from funder		24 October 2017
Letter from sponsor		03 January 2018
Other [DelphiManager brochure]	1.0	12 January 2018
Other [Example outcome statements and Delphi survey]	1.0	12 January 2018
Other [Example participant spreadsheet]	1.0	13 February 2018
Other [Participant reply slip]	1.0	13 February 2018
Participant consent form [Patient]	1.3	21 December 2017
Participant consent form [Professional]	1.3	21 December 2017
Participant information sheet (PIS) [Patient]	1.4	13 February 2018
Participant information sheet (PIS) [Professional]	1.3	13 February 2018
Referee's report or other scientific critique report		12 January 2017
Research protocol or project proposal	1.6	21 December 2017
Response to Request for Further Information		13 February 2018
Summary CV for Chief Investigator (CI) [Alex Aquilina]		
Summary CV for supervisor (student research) [Elizabeth Tutton]		
Summary CV for supervisor (student research) [Matthew Costa]		
Summary CV for supervisor (student research) [Ray Fitzpatrick]		
Summary CV for supervisor (student research) [Xavier Griffin]		

IRAS project ID	235150

Appendix B – Summary of HRA Assessment

This appendix provides assurance to you, the sponsor and the NHS in England that the study, as reviewed for HRA Approval, is compliant with relevant standards. It also provides information and clarification, where appropriate, to participating NHS organisations in England to assist in assessing and arranging capacity and capability.

For information on how the sponsor should be working with participating NHS organisations in England, please refer to the, *participating NHS organisations*, *capacity and capability* and *Allocation of responsibilities and rights are agreed and documented (4.1 of HRA assessment criteria)* sections in this appendix.

The following person is the sponsor contact for the purpose of addressing participating organisation questions relating to the study:

Name: Mr Alexander Aquilina
Tel: 01865227902
Email: alexander.aquilina@ndorms.ox.ac.uk

HRA assessment criteria

Section	HRA Assessment Criteria	Compliant with Standards?	Comments
1.1	IRAS application completed correctly	Yes	No comments
2.1	Participant information/ consent documents and consent process	Yes	No comments
3.1	Protocol assessment	Yes	No comments
4.1	Allocation of responsibilities and rights are agreed and documented	Yes	A Statement of Activities and Schedule of Events have been provided for use with participating NHS organisations in England. Exchange of the SoA will confirm capacity and capability of an NHS organisation to host the research.
4.2	Insurance/ indemnity arrangements assessed	Yes	Insurance for the management, design and conduct of the study (at non-NHS sites) will be provided by the sponsor. Indemnity for the conduct of the study in the NHS will be provided by NHS schemes.
4.3	Financial arrangements assessed	Yes	External study funding has been secured from AOUK Trauma. The sponsor does not intend to make funds available to participating NHS organisations.

IRAS project ID	235150

Section	HRA Assessment Criteria	Compliant with Standards?	Comments
5.1	Compliance with the Data Protection Act and data security issues assessed	Yes	No comments
5.2	CTIMPS – Arrangements for compliance with the Clinical Trials Regulations assessed	Not Applicable	No comments
5.3	Compliance with any applicable laws or regulations	Yes	No comments
6.1	NHS Research Ethics Committee favourable opinion received for applicable studies	Yes	The study has a favourable ethical opinion from the South Central - Oxford B Research Ethics Committee.
6.2	CTIMPS – Clinical Trials Authorisation (CTA) letter received	Not Applicable	No comments
6.3	Devices – MHRA notice of no objection received	Not Applicable	No comments
6.4	Other regulatory approvals and authorisations received	Not Applicable	No comments

Participating NHS Organisations in England

This provides detail on the types of participating NHS organisations in the study and a statement as to whether the activities at all organisations are the same or different.

There is a single type of participating NHS organisation in England, i.e. the research activities at all organisations are the same. At participating NHS organisations, members of patients' direct care team will identify and discuss the study with potential participants and, if there is interest, pass on contact details to the research team. Healthcare professionals may also be recruited as participants but this will not be done by virtue of their NHS employer but through other channels.

The Chief Investigator or sponsor should share relevant study documents with participating NHS organisations in England in order to put arrangements in place to deliver the study. The documents should be sent to both the local study team, where applicable, and the office providing the research management function at the participating organisation. For NIHR CRN Portfolio studies, the Local LCRN contact should also be copied into this correspondence. For further guidance on working with participating NHS organisations please see the HRA website.

If Chief Investigators, sponsors or Principal Investigators are asked to complete site level forms for participating NHS organisations in England which are not provided in IRAS or on the HRA website, the Chief Investigator, sponsor or Principal Investigator should notify the HRA immediately at hra.approval@nhs.net. The HRA will work with these organisations to achieve a consistent approach to information provision.

IRAS project ID	235150

Confirmation of Capacity and Capability

This describes whether formal confirmation of capacity and capability is expected from participating NHS organisations in England.

Participating NHS organisations in England **will be expected to formally confirm their capacity and capability** to host this research.

- The sponsor should ensure that participating NHS organisations are provided with a copy of this letter and all relevant study documentation, and work jointly with NHS organisations to arrange capacity and capability whilst the HRA assessment is ongoing.
- Further detail on how capacity and capability will be confirmed by participating NHS organisations, following issue of the Letter of HRA Approval, is provided in the *Participating NHS Organisations* and *Allocation of responsibilities and rights are agreed and documented (4.1 of HRA assessment criteria)* sections of this appendix.
- The Assessing, Arranging, and Confirming document on the HRA website provides further information for the sponsor and NHS organisations on assessing, arranging and confirming capacity and capability.

Principal Investigator Suitability

This confirms whether the sponsor's position on whether a PI, LC or neither should be in place is correct for each type of participating NHS organisation in England, and the minimum expectations for education, training and experience that PIs should meet (where applicable).

A Principal Investigator should be in place at each participating NHS organisation in England. The Chief Investigator holds appropriate contractual arrangements at each site listed in Part C of the IRAS form to also take on this role.

The study team will provide training on the protocol to staff involved in the study at participating NHS organisations. GCP training is not a generic training expectation, in line with the HRA/MHRA statement on training expectations.

HR Good Practice Resource Pack Expectations

This confirms the HR Good Practice Resource Pack expectations for the study and the pre-engagement checks that should and should not be undertaken.

Where arrangements are not already in place and external researchers are conducting research activity with patients at NHS organisations (for example the focus groups), a Letter of Access on the basis of a standard DBS check and occupational health clearance should be in place.

Other Information to Aid Study Set-up

This details any other information that may be helpful to sponsors and participating NHS organisations in England in study set-up.

The applicant has indicated that they intend to apply for inclusion on the NIHR CRN Portfolio.

8.6.3 Study sponsorship letter

RESEARCH SERVICES
Clinical Trials and Research Governance
Joint Research Office
Block 60
Churchill Hospital
Headington
Oxford
OX3 7LE

To whom it may concern

Date: 03/01/2018

Dear Sir/Madam,

Title: Core Outcomes for research on Open Lower Limb Fractures (CO-OLLF): Development of a core outcome set and core outcome measurement set

PID: 13257

Protocol Date/Version: 21.12.2017 Version 1.6

The above study has been designed by Mr Alexander Aquilina and colleagues at the University of Oxford and funded by the NIHR Oxford Biomedical Research Centre. I confirm that the University will accept the role of Research Sponsor of this Study and will comply with the requirements of the Department of Health Research Governance Framework for Health and Social Care 2005, in so far as these apply in the United Kingdom.

Insurance-provided indemnity arrangements are in place for the project:
Newline Underwriting Management Ltd., at Lloyd's of London.

Sponsorship is confirmed subject to the condition that the following are sent to Clinical Trials and Research Governance for review prior to submission to the Research Ethics Committee. Failure to do so may compromise insurance cover for the project.

- Any minor or substantial amendments
- Any extension to the study end date
- Addition of any new research site or patient identification centre

In addition, annual progress reports, the end of study notification and final report must be copied to Clinical Trials and Research Governance.

Lastly, where they exist, University Core SOPs must be followed by default for all clinical research sponsored by the University. Further information can be found here: https://www.admin.ox.ac.uk/researchsupport/ctrg/resources/

Any communications relating to Research Sponsorship should be directed to the undersigned, whose contact details are given in this letter.

Yours faithfully

Dr Karen Melham
Clinical Trials and Research Governance

Tel: +44 (0)1865 572221 · Fax: +44 (0)1865 572228 · Web: www.admin.ox.ac.uk/researchsupport/ctrg/
Email: Heather.house@admin.ox.ac.uk or Elaine.Chick@admin.ox.ac.uk

8.6.4 CO-OLLF study advertisement poster

NDORMS
NUFFIELD DEPARTMENT OF ORTHOPAEDICS, RHEUMATOLOGY AND MUSCULOSKELETAL SCIENCES
UNIVERSITY OF OXFORD
Oxford Trauma
NHS National Institute for Health Research

We need your views to help future research.

What is important to patients recovering from open breaks in the leg bones?

My name is Alex Aquilina. I am a PhD student working with doctors, surgeons and researchers at the University of Oxford. We want to improve the care for patients who have had traumatic injuries (an injury resulting from physical force to the body requiring immediate medical attention).

What we are studying? We want to hear from patients who have had 'open leg breaks' (broken a bone where part of the bone sticks out through the skin). We want to know what patients think are the most important areas when recovering from these injuries.

Why are we doing this? At the moment, doctors treating these injuries do not know what the most important factors are to patients recovering from open breaks. The more doctors can learn from patients, the better they can help them. We will use what you tell us to help researchers and doctors improve research and treatment in the future.

Can you help? If you have had an injury like this (a break in a lower leg bone that has also torn the skin), we would like you to help us. This is your chance to tell us what was important in your recovery from injury.

What is involved? You can choose how you would like to help. For example, you can join discussion groups, do online surveys, or join in with meetings.

Want to learn more? Contact us:
Email: alexander.aquilina@ndorms.ox.ac.uk | Phone: 01865 227902
Please quote 'CO-OLLF Study' when you phone / email.
We value your help very much but please we will only be able offer travel expenses.
We look forward to hearing from you

Poster REC Ref: 18/SC/0051 IRAS ID: 235150 Version 1.4, 13Feb2018

Alex Aquilina 01865 223898 Research Study

Alex Aquilina 01865 223898 Research Study
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Alex Aquilina 01865 223898 Research Study

8.6.5 CO-OLLF research study participant reply slip

CO-OLLF

(Core Outcomes for research on Open Lower Limb Fractures)

Research Study Participant Reply Slip

Thank you for reading the study information sheet

- If you are interested in taking part in this study, please indicate which of the three separate parts you would like to participate in by ticking the relevant box below and providing your contact details:

Tick box	Description of study components
	A discussion group (we need up to 10 people for this, both patients and healthcare professionals- although please note the groups will be separate) This is a chance to tell us your views about statements that we believe summarise important outcomes to patients recovering from an open lower limb fracture (OLLF). You will need to be able to attend a half-day meeting. We will ask your permission to make an audio recording of this meeting (this is for research purposes only).
	An online survey (we need a minimum of 30 people for this) We will invite you to do a survey online. We will ask you to rate on a scale of 1-9 how important you feel different outcomes are when recovering from an OLLF, based on your own experience. The survey consists of 3 rounds, each of which will take a maximum of 30 minutes to complete.
	Two consensus meetings (we need a minimum of 10 patients for this) We will invite you to come to one or two all-day meetings. Other patients, healthcare professionals including surgeons, doctors, nurses and physiotherapists, and researchers, will be there, too. At the first meeting, we will discuss the outcomes which people have told us are important in the online survey. After discussion, we will decide which outcomes we all think must be used in future research studies. We will vote on these. At the second meeting, we will discuss measuring outcomes. We will explain some of the possible ways to measure these. We will then invite you to help choose how we should measure the outcomes which we decided (at meeting 1) are important. We will ask your permission to make an audio-visual recording of these meetings (for research purposes only).

Contact Details

Name	.....
Date of Birth	.....
Participant type	Patient ☐ Healthcare Professional ☐ Researcher ☐
Email address	.....
Phone number	.....
Postal address	....
Type or description of lower leg injury (patient)	....
Months since injury (patient)	....
Job title or employment status	....

Please return this form to:
CO-OLLF Study
FAO Rachel Foxhall
Kadoorie Centre,
John Radcliffe Hospital,
Headley Way,
Headington,
Oxford OX3 9DU

Or alternatively email alexander.aquilina@ndorms.ox.ac.uk with which parts of the study you would like to participate along with the detail requested in the above table.

If preferred, you may also call 01865 223898.

Thank you for taking the time to complete this form.

8.6.6 Patient information leaflet

CO-OLLF

(Core Outcomes for research on Open Lower Limb Fractures)

Research Study:

Information Leaflet for people taking part in the study

- We would like to invite you to take part in the 'CO-OLLF' research study. We are looking for people who have had a traumatic injury involving an 'open' broken bone in their leg (open lower limb fracture, or 'OLLF'), ('Open' here means when the bone sticks out through the skin. A traumatic injury is an injury resulting from physical force to the body requiring immediate medical attention).
- We want to make research, and treatment, more patient-focussed. For this reason, we need to find out what is most important for patients who are recovering from an OLLF. This may help us to improve how we treat patients in the future. It may also help us to improve how we do research.
- Ideally we would like to involve people from a wide range of age and background. We want to include people who've had anything from a less serious injury up to those with a much more serious one.
- Before you decide to take part, it is important that you understand why we are doing this research and what it will involve. Please take time to read the following information and talk to others about the study if you wish.

  If anything is unclear or if you would like more information please contact the Chief Investigator, Alex Aquilina:

  Email: alexander.aquilina@ndorms.ox.ac.uk | Phone: 01865 223898.

  Please quote 'CO-OLLF Study' when you phone / email.

Why are we doing this study?

- Unfortunately, we don't yet know the best way of measuring the results (outcomes) from treatment of these injuries. Until now, studies have been done in many different ways. This makes it difficult to compare them. We need to be able to compare studies so we can find the best way of treating OLLF.
- We aim to develop a list of key outcomes of treatment (known as a 'Core Outcome Set' or COS) that all future research on OLLF should measure. It is important that this COS is agreed with **patients**.

What does taking part in the study involve?

- You can get involved in any of three separate parts of this study, which include:
    - **A discussion group** (we need up to 10 people for this, both patients and healthcare professionals- although please note the groups will be separate)
      This is a chance to tell us your views about statements that we believe summarise important outcomes to patients recovering from an OLLF.
      You will need to be able to attend a half-day meeting.
      We will ask your permission to make an audio recording of this meeting (this is for research purposes only).
    - **An online survey** (we need a minimum of 30 people for this)
      We will invite you to do a survey online. We will ask you to rate on a scale of 1-9 how important you feel different outcomes are when recovering from an OLLF, based on your own experience.
      The survey consists of 3 rounds, each of which will take a maximum of 30 minutes to complete.
    - **Two consensus meetings** (we need a minimum of 10 patients for this)
      We will invite you to come to one or two all-day meetings. Other patients, healthcare professionals including surgeons, doctors, nurses and physiotherapists, and researchers, will be there, too.

      At the first meeting, we will discuss the outcomes which people have told us are important in the online survey.
      After discussion, we will decide which outcomes we all think must be used in future research studies. We will vote on these.

      At the second meeting, we will discuss measuring outcomes. We will explain some of the possible ways to measure these.
      We will then invite you to help choose how we should measure the outcomes which we decided (at meeting 1) are important.

      We will ask your permission to make an audio-visual recording of these meetings (for research purposes only).

What are the possible benefits of taking part?
There are no direct benefits of agreeing to take part in this study. Your contribution will be likely to help how we do future research, and to help make it more patient-focussed.

What are the possible disadvantages and risks of taking part?
Agreeing to help will take some of your time. We will send you documents to read before you come to the consensus meetings. These documents may take up to 30 minutes to read.

For people who come to any face-to-face meeting, we will be able to pay your travel expenses for car mileage, standard class rail travel and parking charges.

If you agree to take part, we will need to record some basic personal information. This is so that we can contact you to invite you to join in with different parts of the study and give feedback about the study results. Data protection laws will guide the handling of all personal data. Personal information will not be shared with researchers outside of the University of Oxford. We may use your information to contact you again to invite you to participate in future research studies. Direct quotations may be published but will be anonymised.

All research data from you will be anonymised (kept without your name on it) and stored on secure University of Oxford servers.

Do I have to take part?
No. You decide whether or not you want to take part in this study. You are welcome to keep this leaflet and use it to help you make your decision.

If you would like to take part then we will ask you to sign a consent form on the day if you come to a meeting. If you are taking part in the online surveys then all responses will be anonymous and by sending the survey in you are giving your agreement to its use in this research.

You are free to leave the study at any point without giving a reason and without any adverse consequences. If you decide to take part and then withdraw we will still want to use your data unless you specifically tell us otherwise. Please note that it is not possible to withdraw what you have said from recordings of the focus groups because it is an integral part of the 'story' of the group and skipping it would leave things out of context.

Who is organising and funding this study?

- This study is being organised by the Oxford Orthopaedic Trauma Research Group based in the Kadoorie Cetntre within the John Radcliffe Hospital. https://www.ndorms.ox.ac.uk/research-groups/oxford-trauma
- The Chief Investigator Alexander Aquilina is a qualified medical doctor
- This study is being funded by AOUK http://www.aouk.org/01_home.html

What will happen to the results of this study?

- The results of this study will be used as part of a PhD project and are intended to be published and presented at conferences. Participants will not be identifiable in any publications, reports or presentations resulting from this work.
- All participants will be provided with a summary of the findings of this research study at the end of this project.

Who has approved this study?

- A group of expert researchers and patient representatives has approved this study.
- All research in the NHS is looked at by an independent group of people, called a Research Ethics Committee, to protect participants' interests. This

study has been reviewed and given favourable opinion by South Central – Oxford B Research Ethics Committee. (REC Reference 18/SC/0051).

What if I have concerns?

- If you have any concerns or complaints about any aspect of the study, please contact the CO-OLLF research team:
  Email: alexander.aquilina@ndorms.ox.ac.uk | Phone: 01865 223898.
  You can also contact the University of Oxford Clinical Trials and Research Governance office:
  Email: ctrg@admin.ox.ac.uk | Phone: 01865 572224.

- If you would prefer to speak with someone who is not involved in research, then please contact the Patient Advice and Liaison Service (PALS). PALS is a confidential NHS service that can provide you with support for any complaints or queries you have regarding the care you receive as an NHS patient. However, PALS cannot provide information about this research study.
  Email: PALS@ouh.nhs.uk | Phone: 01865 221473.

What if I need support?

- If you feel you would like support relating to your injury or the study, please feel free to contact:
  - **The Oxford Trauma Group**
    oxfordtrauma@ndorms.ox.ac.uk
    01865 (2)23114

- The University of Oxford, as Sponsor, has appropriate insurance in place in the unlikely event that you suffer any harm as a direct consequence of your participation in this study.
- If you would like to be involved in further research we will ask your permission to keep your contact details to invite you to future studies.

THANK YOU FOR READING THIS INFORMATION LEAFLET

AND THINKING ABOUT TAKING PART

IF YOU WOULD LIKE TO TAKE PART PLEASE COMPLETE THE ATTACHED PARTICIPANT REPLY SLIP AND CONTACT ALEXANDER AQUILINA:

Email: alexander.aquilina@ndorms.ox.ac.uk

Phone: 01865 223898.

If you are interested in taking part in this study and provide us with your contact details you give your consent for us to hold your personal information for the purposes of this study alone. Personal information required will include your name, date of birth, preferred contact details, type or description of lower leg injury and months since injury.

8.6.7 Patient consent form

Oxford Orthopaedic Trauma Research Group,
Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences,
University of Oxford, Kadoorie Centre for Critical Care Research and Education
Level 3, John Radcliffe Hospital
Headley Way
Headington
Oxford OX3 9DU
UK
Chief Investigator: Mr Alex Aquilina

Study Code: *Site ID Code:* *Participant identification number:*

PATIENT CONSENT FORM

Study Title: Core Outcomes for Open Lower Limb Fractures (CO-OLLF)

Name of Researcher:

.....

If you agree, please initial box

1. I confirm that I have read the information sheet dated 07 Dec 2017 (version 1.3) for this study. I have had the opportunity to consider the information and ask questions. My questions (if any) have been answered and I am satisfied with the answers.	
2. I understand that I do not have to take part in this study. I know that I am free to leave at any time without giving any reason. If I leave it before the end, my medical care and my legal rights will not be affected.	
3. I understand that you may collect some information about me during this study. I understand that doctors, nurses, other medical specialists / researchers from the University of Oxford may look at this information. They will do this only where it is relevant to my taking part in this research. Members from regulatory authorities and from the NHS Trusts may also, on occasion, see this material.	

I give permission for these individuals to have access to my records.		
4. I agree to audio/video recording of meetings. I also agree that you may use anonymised quotes (i.e., without my name on them) in research reports and publications.		
5. I understand that the information collected about me may be used in an anonymous form to support other research in the future. It will not be possible for me to be identified by it.		
6. I agree to take part in this study.		
Additional:		
7. I agree to be contacted about ethically approved research studies for which I may be suitable. I understand that agreeing to be contacted does not oblige me to participate in any further studies.	Yes	No

Name of Participant	*Date*	*Signature*
Name of Person taking Consent	*Date*	*Signature*

**1 copy for participant; 1 copy for researcher site file; 1 (original) to be kept in medical notes* (if participant is a patient).

8.6.8 Professional information leaflet

CO-OLLF
(Core Outcomes for research on Open Lower Limb Fractures)
Research Study:

Information Leaflet for professionals taking part in the study

- We would like to invite you to take part in the 'CO-OLLF' research study. We are looking for health care professionals and research methodologists involved in looking after patients following open lower limb fracture (OLLF). In addition we would also like to invite clinical researchers who have had experience undertaking research on patients following musculoskeletal injury.
- We want to make research, and treatment, more patient-focussed and gain consensus over the most important outcomes to collect on patients following OLLF. For this reason, we need to find out what are the most important outcomes for patients who are recovering from an OLLF and for professionals treating and conducting research on them. This may help us to improve how we treat patients in the future. It may also help us to improve how we do research.
- Ideally we would like to involve healthcare professionals and researchers from a wide range of backgrounds and disciplines.
- Before you decide to take part, it is important that you understand why we are doing this research and what it will involve. Please take time to read the following information and talk to others about the study if you wish.

  If anything is unclear or if you would like more information please contact the Chief Investigator, Alexander Aquilina:

  Email: alexander.aquilina@ndorms.ox.ac.uk | Phone: 01865 223898.

  Please quote 'CO-OLLF Study' when you phone / email.

Why are we doing this study?

- Unfortunately, we don't yet know the best way of measuring the results (outcomes) from treatment of these OLLF. Until now, studies have been done in many different ways. This makes it difficult to compare them. We need to be able to compare studies so we can find the best way of treating OLLF.
- We aim to develop a list of key outcomes of treatment (known as a 'Core Outcome Set' or COS) that all future research on OLLF should measure. It is important that this COS is agreed with **patients**.

What does taking part in the study involve?

- You can get involved in any of three separate parts of this study, which include:
    - **A discussion group** (we need up to 10 people for this, both patients and healthcare professionals- although please note the groups will be separate)
      This is a chance to tell us your views about statements that we believe summarise important outcomes to patients recovering from an OLLF.
      You will need to be able to attend a half-day meeting.
      We will ask your permission to make an audio recording of this meeting (this is for research purposes only).
    - **An online survey** (we need a minimum of 30 healthcare professionals and 30 research methodologists for this)
      We will invite you to do a survey online. We will ask you to rate on a scale of 1-9 how important you feel different outcomes are when recovering from an OLLF, based on your own experience.
      The survey consists of 3 rounds, each of which will take a maximum of 30 minutes to complete.
    - **Two consensus meetings** (we need a minimum of 10 healthcare professionals and 10 research methodologists for each meeting)
      We will invite you to come to one or two all-day meetings. Patients, other healthcare professionals including surgeons, doctors, nurses and physiotherapists, and researchers, will be there, too.

      At the first meeting, we will discuss the outcomes which people have told us are important in the online survey.
      After discussion, we will decide which outcomes we all think must be used in future research studies. We will vote on these.

      At the second meeting, we will discuss measuring outcomes. We will explain some of the possible ways to measure these.
      We will then invite you to help choose how we should measure the outcomes which we decided (at meeting 1) are important.

      We will ask your permission to make an audio-visual recording of these meetings (for research purposes only).

All meetings will take place in Oxford on either university or hospital grounds (depending on availability).

What are the possible benefits of taking part?

There are no direct benefits of agreeing to take part in this study. Your contribution will be likely to help how we do future research, and to help make it more patient-focussed.

What are the possible disadvantages and risks of taking part?
Agreeing to help will take some of your time.

For people who come to any face-to-face meeting, we will be able to pay your travel expenses for car mileage, standard class rail travel and parking charges.

If you agree to take part, we will need to record some basic personal information. This is so that we can contact you to invite you to join in with different parts of the study and give feedback about the study results. Data protection laws will guide the handling of all personal data. Personal information will not be shared with researchers outside of the University of Oxford. We may use your information to contact you again to invite you to participate in future research studies. Direct quotations may be published but will be anonymised.

All research data from you will be anonymised (kept without your name on it) and stored on secure University of Oxford servers.

Do I have to take part?
No. You decide whether or not you want to take part in this study. You are welcome to keep this leaflet and use it to help you make your decision.

If you would like to take part then we will ask you to sign a consent form on the day if you come to a meeting. If you are taking part in the online surveys then all responses will be anonymous and by sending the survey in you are giving your agreement to its use in this research.

You are free to leave the study at any point without giving a reason and without any adverse consequences. If you decide to take part and then withdraw we will still want to use your data unless you specifically tell us otherwise. Please note that it is not possible to withdraw what you have said from recordings of the focus groups because it is an integral part of the 'story' of the group and skipping it would leave things out of context.

Who is organising and funding this study?

- This study is being organised by the Oxford Orthopaedic Trauma Research Group based in the Kadoorie Cetntre within the John Radcliffe Hospital. https://www.ndorms.ox.ac.uk/research-groups/oxford-trauma
- The Chief Investigator Alexander Aquilina is a qualified medical doctor
- This study is being funded by AOUK http://www.aouk.org/01_home.html

What will happen to the results of this study?

- The results of this study will be used as part of a PhD project and are intend to be published and presented at conferences. Participants will not be identifiable in any publications, reports or presentations resulting from this work.
- All participants will be provided with a summary of the findings of this research study at the end of this project.

Who has approved this study?

- A group of expert researchers from the University of Oxford and patient representatives has approved this study.
- All research in the NHS is looked at by an independent group of people, called a Research Ethics Committee, to protect participants' interests. This study has been reviewed and given favourable opinion by South Central – Oxford B Research Ethics Committee. (REC Reference18/SC/0051).

What if I have concerns or there is a problem?

- If you wish to complain about any aspect of the way in which you have been approached or treated during the course of this study, you should contact Alexander Aquilina
- Email: alexander.aquilina@ndorms.ox.ac.uk | Phone: 01865 223898.
- Or you may contact the University of Oxford Clinical Trials and Research Governance office:
- Email: ctrg@admin.ox.ac.uk | Phone: 01865 572224.
- If you would prefer to speak with someone who is not involved in research, then please contact the Patient Advice and Liaison Service (PALS). PALS is a confidential NHS service that can provide you with support for any complaints or queries you have regarding the care you receive as an NHS patient. However, PALS cannot provide information about this research study.
- Email: PALS@ouh.nhs.uk | Phone: 01865 221473.

What if I need support?

- If you feel you would like support relating to the study, please feel free to contact:
  - **The Oxford Trauma Group**
    oxfordtrauma@ndorms.ox.ac.uk
    01865 (2)23114
- The University of Oxford, as Sponsor, has appropriate insurance in place in the unlikely event that you suffer any harm as a direct consequence of your participation in this study.
- If you would like to be involved in further research we will ask your permission to keep your contact details to invite you to future studies. Personal information required will include your name, date of birth, preferred contact details and job title.

THANK YOU FOR READING THIS INFORMATION LEAFLET AND THINKING ABOUT TAKING PART
IF YOU WOULD LIKE TO TAKE PART PLEASE COMPLETE THE ATTACHED PARTICIPANT REPLY SLIP AND CONTACT ALEXANDER AQUILINA:

Email: alexander.aquilina@ndorms.ox.ac.uk
Phone: 01865 223898

8.6.9 Professional consent form

Oxford Orthopaedic Trauma Research Group,
Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Kadoorie Centre for Critical Care Research and Education
Level 3, John Radcliffe Hospital
Headley Way
Headington
Oxford OX3 9DU
UK
Chief Investigator: Mr Alex Aquilina

Study Code: *Site ID Code:* *Participant identification number:*

Health Care Professional and Research Methodologist consent form.

Study Title: Core Outcomes for Open Lower Limb Fractures (CO-OLLF)

Name of Researcher: ……..If you agree, please initial box

1. I confirm that I have read the information sheet dated 07Dec2017 (version 1.1) for this study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.		
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my employment or legal rights being affected.		
3. I agree to audio/video recording and the use of anonymised quotes in research reports and publications.		
4. I understand that the information collected about me may be used in an anonymous form to support other research in the future. It will not be possible for me to be identified by it.		
5. I understand that relevant sections of the data collected during the study may be looked at by individuals from University of Oxford and from the NHS Trust, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records.		
6. I agree to take part in this study.		
Additional:		
7. *I agree to be contacted about ethically approved research studies for which I may be suitable. I understand that agreeing to be contacted does not oblige me to participate in any further studies.*	Yes	No

_____	_____	_____
Name of Participant	*Date*	*Signature*
_____	_____	_____
Name of Person taking Consent	*Date*	*Signature*

**1 copy for participant; 1 copy for researcher site file*

8.7 Appendix 7. Research funding

The overall project salary costs for the first three years were supported by the NIHR Oxford Biomedical Research Centre.

Project costs were additionally supported by the award of the AOUK Major research grant. £10 000 (November 2017). See the letter below.

Salary costs for the fourth year of this project were supported by:

Advanced Hip Research Fellowship. North Bristol NHS Trust. Funded by Depuy Synthes, Johnson & Johnson. £40 000 (August 2019)

Health Education England South West Simulation Network: Simulation Fellowship project funding. £21,000 (January 2020)

University and College fees were supported by the University of Oxford, Clarendon Fund, following the award of a Clarendon Scholarship. (October 2016)

AO UK

WE/VMC
24 October 2017

Mr Alexander L Aquilina
Clinical Research Fellow & Dhil Student
Kadoorie Centre
Level 3
John Radcliffe Hospital
Oxford
OX3 9DU

Dear Mr Aquilina

Many thanks for taking the time to submit your work:

Developing core outcomes for research on open lower limb fractures.

I read your proposal with interest. The study of considerable lower limb trauma is rightly growing in importance and studies such as these in which meaningful outcomes are distilled working alongside patients, are of immense value.

I am delighted, on behalf of AOUK, to be able to support your work with the Major Grant Funding of £10,000. There were six applications for the single Major Grant funding opportunity this year. All, like yours were high-quality applications of a mixture of basic science and 'closer to patient' topics and all with considerable support from teams with a proven track record. The work proposed by your group in terms of the importance of the topic, its generalisability to many centres internationally and most importantly its use of patients to derive outcome was the key facets that I used to award your funding.

I wish you and the team at Oxford all success in continuing this work in the future and I look forward to reading the published results.

With best wishes

Mr W Eardley - GMC No: 4499792
MD, MSc, PgCertMedEd, DipSEM(UK&I),FRCSEd(Tr&Orth)
Consultant Orthopaedic Surgeon
Chairman AOUK Research and Professional Development

AO UK
Marlborough House, York Business Park, Nether Poppleton, York, YO26 6RW
Phone:+44 1904 787767 Fax:+44 1904 781537
aouki1@btconnect.com

8.8 Appendix 8. PROSPERO registration on the NIHR International prospective register of systematic reviews

NIHR | National Institute for Health Research

PROSPERO
International prospective register of systematic reviews

Core outcomes in open lower limb fractures: a systematic review to determine what outcomes have been reported and how they have been measured

Alexander Aquilina, Matthew Costa, Xavier Griffin, Elizabeth Tutton, Ray Fitzpatrick

Citation

Alexander Aquilina, Matthew Costa, Xavier Griffin, Elizabeth Tutton, Ray Fitzpatrick. Core outcomes in open lower limb fractures: a systematic review to determine what outcomes have been reported and how they have been measured. PROSPERO 2015 CRD42015024219 Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42015024219

Review question

What outcome measures have been reported in studies investigating open lower limb fractures?
How have these outcomes been measured?

Searches

Databases to be searched:
• Cochrane Bone, Joint and Muscle Trauma Group Specialised Register
• Cochrane Central Register of Controlled Trials (CENTRAL)
• MEDLINE
• EMBASE
• AMED
• PsycINFO
• CINAHL
• WHO International Clinical Trials Registry Platform

Types of study to be included

All clinical studies excluding case reports.

Condition or domain being studied

An open fracture is a break of a bone where part of the bone sticks out through the skin. Here, the broken bone is at risk of infection. This is a serious injury which may lead to a limb or life-threatening illness and later disability.
Approximately 4,100 people each year in the UK will suffer an open lower limb fracture (OLLF) of which 370 will require an amputation. The life-time projected cost of an OLLF has been estimated to be between $160,000 and $500,000 where the leg is reconstructed or amputated respectively (UK cost-estimate unavailable). All major trauma centres submit data to the Trauma Audit and Research Network (TARN). However, currently outcomes reported are measures of process and not patient-centred measures such as Patient Reported Outcome Measures (PROMs). To improve the patient experience of recovery and investigate new treatments for these devastating injures it is essential that consensus is gained over the collection of outcomes meaningful to patients and stakeholders.

Participants/population

Studies reporting any outcomes on adult participants with open lower limb fractures.
Studies excluded: animal studies, case-reports, and review articles.

Intervention(s), exposure(s)

Studies reporting any outcomes on adult participants with open lower limb fractures.
Studies excluded: animal studies, case-reports, and review articles.

Comparator(s)/control

n/a

Main outcome(s)

All outcomes reported in studies on open lower limb fractures will be analysed and data extracted will

include:
• the named outcome
• whether the outcome was defined
• outcome definition
• method of measurement (i.e. outcome measurement instrument used)
• time points of measurement
• study population
• study design

* Measures of effect

n/a

Additional outcome(s)

none

* Measures of effect

n/a

Data extraction (selection and coding)

Eligibility of studies and data extraction will be assessed by the lead reviewer. The reliability will be independently checked in a sub-sample by a second reviewer and any disagreements resolved by a third reviewer.

Risk of bias (quality) assessment

Studies will be assess following COMET and COSMIN guidance.

Strategy for data synthesis

A narrative synthesis will be conducted on outcomes reported in studies on open lower limb fractures, this will include analysis on the variability of outcomes reported, definitions of outcomes, method of outcome measurement and time point of outcome measurement. Analysis will also be made on the study population and type of studies in which outcomes were reported. Where possible summary statistics will be generated and a quantitative analysis will be conducted.

Analysis of subgroups or subsets

Outcome statements for each type of outcome reported will be generated. Outcome statements will be grouped by mapping to the WHO's International Classification of Functioning, Disability and Health model (ICF).

Contact details for further information

Mr Aquilina
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Type and method of review

Systematic review

Anticipated or actual start date

16 January 2017

Anticipated completion date
02 August 2017

Funding sources/sponsors
NIHR Oxford BRC

AO Major Trauma Grant

Conflicts of interest
None known

Language
English

Country
England

Stage of review
Review Ongoing

Subject index terms status
Subject indexing assigned by CRD

Subject index terms
Fractures, Open; Humans

Date of registration in PROSPERO
07 July 2015

Date of first submission
25 July 2019

Stage of review at time of this submission

Stage	Started	Completed
Preliminary searches	Yes	Yes
Piloting of the study selection process	Yes	Yes
Formal screening of search results against eligibility criteria	Yes	Yes
Data extraction	Yes	Yes
Risk of bias (quality) assessment	Yes	Yes
Data analysis	Yes	No

Revision note
Progress update

The record owner confirms that the information they have supplied for this submission is accurate and complete and they understand that deliberate provision of inaccurate information or omission of data may be construed as scientific misconduct.

The record owner confirms that they will update the status of the review when it is completed and will add

publication details in due course.

Versions

07 July 2015
07 July 2015
12 April 2017
25 July 2019

PROSPERO
This information has been provided by the named contact for this review. CRD has accepted this information in good faith and registered the review in PROSPERO. The registrant confirms that the information supplied for this submission is accurate and complete. CRD bears no responsibility or liability for the content of this registration record, any associated files or external websites.

8.9 Appendix 9. Description and reference to the Core Outcome Measures for effectiveness Trials (COMET) initiative guidance, standards and checklists.

COMET guidance document (year of publication)	Description
The Core Outcome Set-STAndards for Reporting (COS-STAR) Statement (2016) (72)**.**	From annual systematic reviews of COS projects undertaken by COMET, it was identified that the clarity of publications on COS projects was variable and, in many cases, suboptimal. In order to address these issues, an international group that included experienced COS developers, methodologists, journal editors, potential users of COS (clinical trialists, systematic reviewers, and clinical guideline developers), and patient representatives developed the COS-STAR Statement as a reporting guideline for COS studies. The developmental process consisted of an initial reporting item generation stage and a two-round Delphi survey of participants representing key stakeholder groups, followed by a consensus meeting. Consensus was found for an 18-item checklist considered essential for transparent and complete reporting in all COS studies. The checklist items focus on the introduction, methods, results, and discussion section of a manuscript describing the development of a particular COS (72).
The COMET Handbook: version 1.0 (2017) (70)**.**	Accumulating work in the area of COS development has necessitated the need to produce methodological guidance to ensure researchers have a resource to access when planning COS development projects. COMET published a handbook to bring together the initiative's current research-backed methodological guidance. The handbook will be periodically updated as advances continue to be made in COS methodology (70).
The Core Outcome Set-STAndards for Development (COS-STAD) identifies minimum	The Core Outcome Set-STAndards for Development (COS-STAD) project aims to identify minimum standards for the design of a COS study. An international group of experienced COS developers, methodologists, journal

standards for the design of a COS study (2017) (71)**.**	editors, potential users of COS (clinical trialists, systematic reviewers, and clinical guideline developers), and patient representatives produced the COS-STAD recommendations to help improve the quality of COS development and support the assessment of whether a COS had been developed using a reasonable approach. An open survey of experts generated an initial list of items, which was refined by a 2-round Delphi survey and fed into a consensus meeting. Consensus was found for an 11-item list of minimum design recommendations for all COS development projects. The recommendations focus on three key domains: the scope, the stakeholders, and the consensus process. The COS-STAD minimum standards aim to be used to aid COS developers in planning projects and by users wishing to critically appraise COS projects (71).
A new taxonomy for outcome classification (2018) (12)**.**	Recognition that a lack of a standardised classification system for outcomes in clinical trials results in inconsistencies due to ambiguity and variation in how outcomes are described across different studies led to work to identify a suitable taxonomy of outcomes for use in COS development. Following a literature review identifying existing outcome frameworks, Dodd *et al.* 2018 determined that no current outcome framework was sufficiently comprehensive or granular for classification of all potential outcomes from clinical trials (12). A new outcome taxonomy designed for COS development studies and annotations of outcomes in COS contained in the COMET database was created. The COMET taxonomy of outcomes will also facilitate searching for clinical trials using outcomes reported as a search field on trial registries and literature databases.
The Core Outcome Set-STAndardised Protocol Items (COS-STAP) Statement consists of a checklist of items considered essential in a COS protocol (2019) (73)**.**	The COS-STAP statement was developed following the EQUATOR guideline development framework. After an item generation stage, a two-round Delphi Survey was conducted, followed by a consensus meeting where an agreement was met for the 13 item Statement. The COS-STAP Statement consists of a checklist of 13 items considered essential for documentation in a protocol, outlining the scope of the COS, stakeholder

	involvement, COS development plans and consensus processes (73).

8.10 Appendix 10. Key research groups and organisations actively endorsing COS uptake, COMET and the COMET database as published on the COMET Website (69).

Trial methodology groups
• University of Birmingham PROs in Trials (https://www.birmingham.ac.uk/research/applied-health/research/prolearn/trials.aspx) • SPIRIT Statement, Checklist, Methods, Participants, Interventions, Outcomes (https://www.spirit-statement.org/outcomes-2/)
Trial Funders
• NIHR, HTA Programme (http://www.ct-toolkit.ac.uk/routemap/protocol-development/) • Deutsche Forschungsgemeinschaft, German Research Foundation (https://www.dfg.de/formulare/17_02/17_02_en.pdf) • Health Research Board, Ireland (https://www.hrb.ie/funding/funding-schemes/before-you-apply/useful-links) • European Commission, Horizon 2020 (https://ec.europa.eu/research/participants/docs/h2020-funding-guide/index_en.htm) • Belgian healthcare Knowledge Centre (https://www.kce.fgov.be/en/resources-for-investigators)

- The Netherlands Organisation for Health Research and Development (https://www.zonmw.nl/en/)
- Versus Arthritis (https://www.versusarthritis.org)

Trial Registries

- WHO ISRCTN (https://www.isrctn.com/page/definitions#primaryOutcomeMeasures)

Regulatory Authorities

- European Medicines Agency (http://www.ema.europa.eu/docs/en_GB/document_library/Scientific_guideline/2015/12/WC500198877.pdf)
- UK, Health Research Authority (https://www.hra.nhs.uk/planning-and-improving-research/best-practice/outcome-measures/)
- Swedish Agency for Health Technology Assessment and Assessment of Social Services (https://www.sbu.se/en/collaboration/cos/)

Systematic Review Groups

- Cochrane Collaboration
    - Defining and grouping outcomes for synthesis (Chapter 3, section 3.2.4.3, Table 3.2.c)
    - A framework for assessing risk of bias due to missing results in a synthesis (Chapter 13, section 13.3.3)
    - PICO and complexity (Chapter 17, section 17.2.3)
    - Selecting from multiple PROMS (Chapter 18, section 18.4.1)

    (Links embedded)

Clinical Guideline Developers

• Evidence Standards Framework for Digital Health Technologies (https://www.nice.org.uk/about/what-we-do/our-programmes/evidence-standards-framework-for-digital-health-technologies) • NICE, Developing NICE Guidelines: the manual (https://www.nice.org.uk/process/pmg20/chapter/developing-review-questions-and-planning-the-evidence-review)
Journal Editors
• Core Outcomes in Women's and Newborn Health (http://www.crown-initiative.org/)

8.11 Appendix 11. A list and description of COSMIN tools for the selection of OMIs for research and clinical practice (91)

A list and description of COSMIN tools for the selection of OMIs for research and clinical practice	
COSMIN Tool	**Description**
COSMIN Taxonomy of Measurement Properties (269)	The COSMIN initiative identified and further defined quality criteria for measurement properties of health status questionnaire in 2007 (295). Later, an international Delphi study consisting of four written rounds was held among 43 expert participants where consensus on taxonomy, terminology, and definitions of measurement properties was found (269).
COSMIN Database of Systematic Reviews (276)	The COSMIN group recognise that selection of measurement tools for research is a complex and often difficult process. The database for systematic reviews was established to aid researchers in the appropriate selection of OMIs and identify gaps in the knowledge on the quality of OMIs. In a systematic review of OMIs, the quality of the OMIs is critically appraised and compared. An overview is given on the feasibility aspects and interpretability of each included instrument. Systematic reviews of OMIs are useful tools for selecting a measurement instrument for a particular purpose. Also, they are useful tools to identify OMIs that need further validation. COSMIN undertakes regular systematic searches to ensure the database remains comprehensive. There are currently over 1000 reviews detailed (276).
COSMIN checklists for Assessing Study Qualities (91)	The COSMIN initiative has developed several checklists for assessment of the methodological quality of studies on measurement properties of OMIs. The first checklist by the COSMIN Group was published in 2010 following an international Delphi study (296), which has now been superseded by two more recently published checklists and one currently in development:

	1. The COSMIN Study Design Checklist: for use when designing or appraising studies on the measurement properties of Patient-Reported Outcome Measures (PROMs) (266). 2. The COSMIN Risk of Bias Checklist: substitutes the original COSMIN checklist (296). It was exclusively developed for assessing the methodological quality of single studies included in systematic reviews of PROMs. The checklist contains standards referring to design requirements and preferred statistical methods of studies on measurement properties. For each measurement property, a COSMIN Risk of Bias box was developed containing all standards needed to assess the quality of a study on that specific measurement property. Both preferred statistical methods based on Classical Test Theory (CTT) and Item Response Theory (IRT) or Rasch analyses are included in the standards (91,266). 3. COSMIN Reporting checklist: for studies on measurement properties of PROMs: COSMIN is currently collaborating with the University of Michigan and is receiving funding from the Patient-Centered Outcomes Research Institute (PCORI). It is hoped this checklist will improve the written information in studies on measurement properties and ultimately to improve the ability of researchers and clinicians to select the most suitable OMIs for their research (91).
§1	To address problems with poor indexing and significant variation in reporting, the COSMIN initiative has developed a search filter to identify all relevant studies in PubMed and Embase on measurement properties effectively (271). Use of the COSMIN search filter will be discussed later in this thesis.
COSMIN Guideline for Systematic Reviews of Outcome Measurement	COSMIN has developed a 10-step procedure to help prepare, select, evaluate, interpret and report on studies in a systematic review of PROMs. Steps 1–4 concern preparing and performing the literature search and selecting relevant studies. Steps 5–8 concern the evaluation of the quality of the eligible studies, the measurement properties, and the interpretability and feasibility

Instruments (91,267,268)	aspects. Steps 9 and 10 concern formulating recommendations and reporting the systematic review (91,267,268). The 10-steps are detailed in a schematic diagram and a comprehensive user manual available from the COSMIN website (91,267,268). The guideline aims to aid reviewers to draw transparent conclusions and make evidence-based recommendations on the quality of PROMs. The guideline also supports the evidence-based selection of PROMs for use in research and clinical practice (91,267,268).
COSMIN Guideline for Selecting Instruments for a Core Outcome Set (2,91)	The COSMIN and COMET initiatives have systematically developed a joint consensus-based guideline to improve the selection of OMIs when developing a COMIS. The COSMIN initiative has developed a preferred approach for the selection of OMIs for core outcomes. This approach consists of four steps: 1. Conceptual considerations: the outcome to be measured and the population it will be measured in. 2. Identifying existing OMIs: accessing systematic reviews of OMIs and undertaking a literature search. 3. Quality assessment of outcome measurement instruments: evaluation of the measurement properties and the feasibility aspects of each OMI. Evidence of the measurement properties should be available in the target population. 4. Generic recommendations on the selection of OMIs for a COS: the selection of only one OMI for each core outcome, evidence that the OMI has good content validity and internal consistency, and that the OMI is feasible to use. A consensus process involving relevant stakeholders, including patients, should be undertaken to agree on the OMI selected for each core outcome is also recommended (2).

8.12 Appendix 12. Key guidance for the design, conduct, reporting and grading of evidence from clinical trials, systematic reviews and meta-analyses.

Research Guidelines	Description
EQUATOR Network (35,297)	The EQUATOR Network grew out of work on the CONSORT statement as well as other advisory groups. The project started in March 2006 and held its first meeting in Oxford that year before being formally launched in 2008. It has since grown into an international organisation with multinational backing. EQUATOR continues to work towards increasing the useability and value of published research. (https://www.equator-network.org)
Consolidated Standards of Reporting Trials (CONSORT) Statement (298,299)	International recognition of inadequate reporting of RCTs fueled the development of the original CONSORT Statement in 1996 and its revision five years later. The CONSORT statement aims to address lucid and incomplete reporting of critical information in trials to help drive improvements in research methodology and conduct. The CONSORT Statement represents a continually evolving guideline; currently, the revised 2010 Statement consists of a 25-item checklist that provides guidance for reporting of all RCTs with a focus on individually randomised, two

	group, parallel trials. There are currently 28 published extensions to the 2010 CONSORT Statement that provide additional guidance specific to a variety of trial designs (297). (https://www.equator-network.org/reporting-guidelines/consort/)
Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) Statement (262,263)	The SPIRIT initiative was launched in 2007 to direct an international project aiming to improve the completeness of trial protocols by producing evidence-based recommendations for a minimum set of items to be addressed in trial protocols. The 2013 SPIRIT Statement includes a 33-item checklist and a template of recommended content for the schedule of enrolment, interventions, and assessments. The SPIRIT Statement focusses on RCT protocols but can be used for any type of trial. (https://www.equator-network.org/reporting-guidelines/spirit-2013-statement-defining-standard-protocol-items-for-clinical-trials/)
The Preferred Reporting Items for Systematic Reviews and Meta-Analyses	To address the suboptimal reporting of meta-analyses, an international group developed guidance called the QUality Of Reporting Of Meta-analyses (QUOROM) Statement in 1996, which focused on the reporting of meta-analyses of randomised controlled trials (300). The PRISMA Statement updates the QUOROM

(PRISMA) Statement (195)	Statement to address several conceptual and practical advances in the science of systematic reviews. The PRISMA Statement was created following a three-day meeting of 49 participants held in Ottawa, Canada, in June 2005 and consists of a 27-item checklist to help authors improve reporting of systematic reviews and meta-analyses. The PRISMA Statement focuses on systematic reviews of RCTs, but can also be used as a basis for reporting of other types of research, particularly evaluations of interventions. (https://www.equator-network.org/reporting-guidelines/prisma/)
Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group (36)	The GRADE Working Group was established in 2000 to address an increasingly apparent deficit in the grading systems for healthcare. The GRADE Working Group have developed an international consensus for the sensible and transparent rating of evidence in healthcare research and the strength of recommendation that can be made upon it. (38). The GRADE Working group have developed a comprehensive handbook (272) and associated online software GRADEPro GDT (301) for rating the quality of the best available evidence and developing health care recommendations. GRADE discuss methods for

	considering the relative importance of outcomes which will be discussed later in this thesis (246,272). (https://gdt.gradepro.org/app/handbook/handbook.html#h.pq7g5y80zfhj)
Cochrane handbook (39)	The Cochrane collaboration was named after the physician-epidemiologist Archie Cochrane, who called for up-to-date, systematic reviews of all relevant randomised controlled trials in healthcare research. The collaboration was founded following a meeting of around 80 participants held in Oxford, UK, in 1993. The original goals were to produce high-quality systematic reviews (where possible, meta-analyses) of trials of every sort of health care intervention, to ensure that these are subjected to rigorous peer review and, when necessary, updating, and to disseminate these systematic reviews electronically (302). The Cochrane 2020 strategy aims to put Cochrane evidence at the heart of health decision-making all over the world (303). The Cochrane handbook for Systematic Reviews of Interventions is the official guide that describes in detail the process of preparing and maintaining Cochrane systematic reviews on the effects of healthcare interventions (39). This handbook is used by many as a guide for the good methodological conduct of systematic reviews in any field of healthcare and not

	just limited to those produced for Cochrane. Reference is made to the Cochrane handbook in systematic review work discussed in this thesis below. (https://training.cochrane.org/handbook)
Outcome-Reporting Bias in Trials (ORBIT) (304)	Outcome-reporting bias (ORB) has been recognised as a major problem in medical research and has been an area of research focus for over a decade (304). The ORBIT group led by researchers at the University of Liverpool, working in close proximity to the COMET initiative and funded by the MRC, have undertaken a series of research projects investigating ORB. These projects include the assessment and provision of empirical evidence of ORB (31,305-307), methodological systems for the classification and detection of ORB (31,308), qualitative research into ORB (309,310), ORB adjustment methods and their application (311-315). In addition, the ORBIT Group have developed several tools to aid the assessment of and adjustment for ORB, which have had a wide uptake, particularly in Cochrane reviews (304). (http://outcome-reporting-bias.org/About)

8.13 Appendix 13. Outcome classification systems identified by Dodd *et al.* 2017 described and discussed for suitability for use in CO-OLLF.

Outcome classification systems identified by Dodd *et al.* 2017 described and discussed for suitability for use in CO-OLLF		
Outcome classification system	**Description**	**Critique**
The Wilson and Cleary Model of Health-Related Quality of Life (15)	In 1995 Wilson and Cleary proposed a taxonomy or classification system modelling health-related quality of life. They identified that other models of health fail to recognise how outcomes may interrelate. Outcomes are divided into five related levels, biological and physical variables, symptom status, functioning status, general health perceptions and overall quality of life. Wilson and Cleary believe that there are specific causal relationships between their five levels of outcomes that link traditional clinical outcomes to health-related quality of life. The model was revised in 2005 to enhance the characterisation of the relationships between the five outcome levels (16).	This is a conceptual model of health and does not provide a hierarchical outcome taxonomy structure. It excludes outcomes including adverse events, which is of particular importance to surgical research trials.
The WHO International Classification of Functioning, Disability and Health (ICF) (17)	In 1995 Wilson and Cleary proposed a taxonomy or classification system modelling health-related quality of life. They identified that other models of health fail to recognise how outcomes may interrelate. Outcomes are divided into five	The ICF has been used to categorise outcomes in other COS projects, a good example of which is a systematic review of the outcomes reported in cardiac arrest clinical trials by Whitehead *et al.* 2015 (316).

	related levels, biological and physical variables, symptom status, functioning status, general health perceptions and overall quality of life. Wilson and Cleary believe that there are specific causal relationships between their five levels of outcomes that link traditional clinical outcomes to health-related quality of life. The model was revised in 2005 to enhance characterisation of the relationships between the five outcome levels (16).	The ICF can be used to provide an external structure for 'understanding' what outcomes are measured in clinical studies identified in the literature and for promoting consistency of language in reporting of outcomes (18). However, the ICF focuses on patient and contextual factors rather than an explicit classification of outcomes (12).
Disease-specific outcome classification taxonomies	There are a number of different disease-specific outcome classification taxonomies detailed on the USA National Institutes of Health, HealthMeasures website (317). These include the National Institute of Health Toolbox for assessment of neuro-behavioral function (318), the Quality of Life in Neurological Disorders (Neuro-QoL) for the measurement of the physical, mental and social effects of living with neurological conditions (319), and the Adult Sickle Cell Quality of Life Measurement Information System (ASCQ-Me) (320).	There is no disease-specific outcome classification system for lower limb trauma. Using other named disease classification systems would not provide a comprehensive classification of all anticipated outcomes for OLLF.
The OMERACT Filter 2.0 (3)	Following a review of existing health frameworks in 2014, the OMERACT group developed a bespoke framework designed to facilitate Core Outcome Set development in rheumatology (13). The OMERACT Filter 2.0 is	The OMERACT 'core areas' and domain examples provide a broad structure that can be used for classifying outcomes. However, this system is not sufficiently detailed to facilitate efficient hierarchical

	a framework for the measurement of rheumatological health conditions in the setting of interventions over three core areas, death, life impact and pathophysiologic manifestations, with a recommendation to measure resource use (3).	classification of all outcome themes and sub-themes for OLLF.
PROMIS (19)	The PROMIS framework was developed to measure health in adults and children by expanding on the three overarching concepts in the WHO definition of health. Concepts are arranged into a hierarchy where self-reported health is at the top (13). The PROMIS initiative was started by a cooperative of researchers in 2004 with funding from the USA Institutes of Health, aiming to transform the way patient-reported outcomes are chosen and used in research and clinical practice (13,20). The PROMIS initiative now offers over 300 measures of physical, mental and social health, they are free to access and can be delivered in a variety of ways, including short forms, computer adapted tests, and profiles (a fixed collection of short forms covering multiple areas of health) (21).	PROMIS provides a structure for classification of the PROMS and would not sufficiently direct the classification of outcome themes related to objective clinical measures commonly collected in studies on OLLF, e.g. bone union and deep infection.
The Nursing Outcome Classification (NOC) (321)	The NOC provides a standardised classification system of patient outcomes for evaluating the effects of nursing interventions. NOC outcomes are	The NOC facilitates the classification of outcomes relevant to nursing and does not have the structure to classify outcomes of broader

	grouped hierarchically into 34 classes within seven domains: 1. Functional Health 2. Physiologic Health 3. Psychosocial Health 4. Health Knowledge & Behaviour 5. Perceived Health 6. Family Health 7. Community Health	relevance to OLLF, e.g. adverse events.
Data-driven approaches	In a data-driven approach, researchers use the outcomes gathered from the literature or patients to create outcome categories from which to classify outcomes. Good examples of this approach are provided by Davey *et al.* 2011 and Smith *et al.* 2015, where outcomes from Cochrane reviews drove the creation of 11 and 15 outcome categories, respectfully (97,322).	Using an outcome classification system created using a data-driven approach in study areas, not including OLLF would not provide a fully comprehensive system for use in hierarchically classifying all theoretical outcomes in OLLF.

8.14 Appendix 14. COMET Taxonomy of Outcomes. Explanation of how to categorise and map outcomes with examples of categories outcomes. Adapted from Dodd *et al.* 2017 supplemental material (12).

Outcome area	Outcome domain	Explanation
Death	1. Mortality/survival	Includes overall (all-cause) survival/mortality and cause-specific survival/mortality, as well as composite survival outcomes that include death (e.g. disease-free survival, progression-free survival, amputation-free survival)
Physiological / clinical	**Physiological/clinical** 2. Blood and lymphatic system outcomes 3. Cardiac outcomes 4. Congenital, familial and genetic outcomes 5. Endocrine outcomes 6. Ear and labyrinth outcomes 7. Eye outcomes 8. Gastrointestinal outcomes 9. General outcomes 10. Hepatobiliary outcomes 11. Immune system outcomes 12. Infection and infestation outcomes 13. Injury and poisoning outcomes 14. Metabolism and nutrition outcomes 15. Musculoskeletal and connective tissue outcomes 16. Outcomes relating to neoplasms: benign, malignant and unspecified (including cysts and polyps) 17. Nervous system outcomes 18. Pregnancy, puerperium and perinatal outcomes 19. Renal and urinary outcomes 20. Reproductive system and breast outcomes 21. Psychiatric outcomes 22. Respiratory, thoracic and mediastinal outcomes 23. Skin and subcutaneous tissue outcomes 24. Vascular outcomes	Physiological/clinical outcomes include measures of physiological function, signs and and symptoms, as well as laboratory (and other scientific) measures relating to physiology, and are categorised according to the underlying cause/body system. "General disorders" includes those affecting the whole body and cannot be attributed to a certain body system e.g. fatigue, chills, flu like symptoms, malaise, anorexia, pain (unspecified, not associated with a particular body system), fever (not attributable to infection), anthropometric measures (e.g. weight), "global" measures, "symptoms" (not associated with a particular body system), "physical health", fitness. Pain outcomes are categorised according to underlying cause or body system or within the "General symptoms" category (if non-specific). Laboratory parameters (for example, from blood samples) and scientific measures (for example, pharmacokinetic outcomes) should be classified within the physiological domain that captures the reason for the assessment (rather than within the "blood and lymphatic system" category, for example). Psychiatric outcomes include all those relating to mental health conditions and associated behaviours (e.g. addictions and behavioural problems). Pregnancy, puerperium and perinatal domain extends to outcomes relating to breastfeeding and weaning. Outcomes relating to neoplasms include those related to non-solid and solid tumours.

Outcome area	Outcome domain	Explanation
Life impact	**Functioning** 25. Physical functioning 26. Social functioning 27. Role functioning 28. Emotional functioning/wellbeing 29. Cognitive functioning	**Impact outcomes** Physical functioning: impact of disease/condition on physical activities of daily living (for example, ability to walk, independence, self-care, performance status, disability index, measures relating to sleep, motor skills, sexual dysfunction. health behaviour and management) Social functioning: impact of disease/condition on social functioning (e.g. ability to socialise, behaviour within society, communication, companionship, psychosocial development, aggression, recidivism, participation) Role functioning: impact of disease/condition on role (e.g. ability to care for children, work status) Emotional functioning/wellbeing: impact of disease/condition on emotions or overall wellbeing (e.g. ability to cope, worry, frustration, confidence, perceptions regarding body image and appearance, psychological status, stigma, life satisfaction, meaning and purpose, positive affect, self-esteem, self-perception and self-efficacy) Cognitive functioning: impact of disease/condition on cognitive function (e.g. memory lapse, lack of concentration, attention); outcomes relating to knowledge, attitudes and beliefs (e.g. learning and applying knowledge, spiritual beliefs, health beliefs/knowledge)
	30. Global quality of life	Includes only implicit composite outcomes measuring global quality of life
	31. Perceived health status	Subjective ratings by the affected individual of their relative level of health
	32. Delivery of care	Includes outcomes relating to the delivery of care, including • adherence/compliance • patient preference • tolerability/acceptability of intervention • withdrawal from intervention (e.g. time to treatment failure, reason for stopping therapy) • appropriateness of intervention • accessibility, quality and adequacy of intervention • patient/carer satisfaction (emotional rather than financial burden) • process, implementation and service outcomes (e.g. overall health system performance and the impact of service provision on the users of services)
	33. Personal circumstances	Outcomes relating to patient's finances, home and environment
Resource use	**Resource use** 34. Economic 35. Hospital 36. Need for intervention 37. Societal/carer burden	Economic: general outcomes (e.g. cost, resource use) not captured within other specific resource use domains Hospital: outcomes relating to inpatient or day case hospital care (e.g. duration of hospital stay, admission to ICU) Need for intervention: outcomes relating to medication (e.g. concomitant medications, pain relief), surgery (e.g.

Outcome area	Outcome domain	Explanation
		caesarean delivery, time to transplantation) and other procedures (e.g. dialysis-free survival, mode of delivery) Societal/carer burden: outcomes relating to financial or time implications on carer or society as a whole (e.g. need for home help, entry to institutional care, effect on family income)
Adverse events	38. Adverse events/effects	Includes outcomes broadly labelled as some form of unintended consequence (e.g. adverse events/effects, adverse reactions, safety, harm, negative effects, toxicity, complications, sequelae). Specifically named adverse events should be classified within the appropriate taxonomy domain above with an additional level of categorisation which identifies that this outcome is being considered as an adverse event.

8.15 Appendix 15. Citation list for Dodd *et al.* 2017

Search ordered by date of publication using the PubMed Central citation search function (search undertaken of the 20th of October 2020).

Detail of how the COMET Taxonomy of Outcomes was used in the article given underneath in bold.
1: Ramsey I, Eckert M, Hutchinson AD, Marker J, Corsini N. Core outcome sets in cancer and their approaches to identifying and selecting patient-reported outcome measures: a systematic review. J Patient Rep Outcomes. 2020 Sep 15;4(1):77. doi: 10.1186/s41687-020-00244-3. PMID: 32930891; PMCID: PMC7492323.
Systematic review using the COMET Taxonomy of Outcomes
2: D'Souza R, Villani L, Hall C, Seyoum M, Kingdom J, Krznaric M, Donnolley N, Javid N. Core outcome set for studies on pregnant women with vasa previa (COVasP): a study protocol. BMJ Open. 2020 Jul 19;10(7):e034018. doi: 10.1136/bmjopen-2019-034018. PMID: 32690497; PMCID: PMC7371138.
COS study protocol citing intension of using the COMET Taxonomy of Outcomes
3: King A, D'Souza R, Teshler L, Shehata N, Malinowski AK. Development of a core outcome set for studies on prevention and management of pregnancy-associated venous thromboembolism (COSPVenTE): a study protocol. BMJ Open. 2020 Jul 19;10(7):e034017. doi: 10.1136/bmjopen-2019-034017. PMID: 32690496; PMCID: PMC7371150.
COS study protocol citing intension of using the COMET Taxonomy of Outcomes
4: van Raath MI, Chohan S, Wolkerstorfer A, van der Horst CMAM, Limpens J, Huang X, Ding B, Storm G, van der Hulst RRWJ, Heger M. Clinical outcome measures and scoring systems used in prospective studies of port wine stains: A systematic review. PLoS One. 2020 Jul 2;15(7):e0235657. doi: 10.1371/journal.pone.0235657. PMID: 32614899; PMCID: PMC7332045.
Systematic review using the COMET Taxonomy of Outcomes
5: Fransen F, Spuls P, Alam M, Badawi A, Boixeda P, Haedersdal M, Hamzavi I, Hedelund L, Kelly KM, Kono T, Laubach HJ, Manuskiatti W, Marini L, Nouri K, Paasch U, Passeron T, Prinsen CACS, Verner I, Wolkerstorfer A. Generic outcome set for the international registry on Laser trEAtments in Dermatology (LEAD): a protocol for a Delphi study to achieve consensus on what to measure. BMJ Open. 2020 Jun 28;10(6):e038145. doi: 10.1136/bmjopen-2020-038145. PMID: 32595165; PMCID: PMC7322331.
COS study protocol citing intension of using the COMET Taxonomy of Outcomes

6: Wason J, McMenamin M, Dodd S. Analysis of responder-based endpoints: improving power through utilising continuous components. Trials. 2020 May 25;21(1):427. doi: 10.1186/s13063-020-04353-8. PMID: 32450909; PMCID: PMC7249409.
Systematic review using the COMET Taxonomy of Outcomes
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COS study protocol citing intension of using the COMET Taxonomy of Outcomes
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Systematic review using the COMET Taxonomy of Outcomes

8.16 Appendix 16. Search strategies used in Chapter 2

8.16.1 Primary searches

	Medline (Ovid MEDLINE® Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®) 1946 to the 20th of July 2017	
	Searches	**Results**
1	Fractures, Open/	5041
2	((open or compound or severe* or mangle*) adj3 (fracture* or break*)).ti,ab.	10342
3	1 or 2	12576
4	exp lower extremity/ or exp buttocks/ or exp foot/ or exp hip/ or exp knee/ or exp leg/ or exp thigh/	153269
5	"lower extremit*".ti,ab.	46287
6	"lower limb*".ti,ab.	40713
7	(leg or legs).ti,ab.	99855
8	(foot or feet).ti,ab.	97562
9	thigh*.ti,ab.	25165
10	ankle*.ti,ab.	49851
11	(hip or hips).ti,ab.	119217
12	exp Leg Bones/	87046
13	knee*.ti,ab.	121914
14	femur*.ti,ab.	45068
15	tibia*.ti,ab.	73410
16	patella*.ti,ab.	17803
17	talus*.ti,ab.	4094
18	fibula*.ti,ab.	10540
19	calcaneus*.ti,ab.	4884
20	navicular*.ti,ab.	2185
21	cuneiform*.ti,ab.	1321
22	cuboid*.ti,ab.	4749
23	metatarsal*.ti,ab.	7996
24	exp Foot Bones/	16512
25	phalan*.ti,ab.	9815
26	Leg/	62724
27	(toe or toes).ti,ab.	17450
28	exp Toes/	11385
29	pilon*.ti,ab.	2304

30	4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 18 or 17 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29	671851
31	3 and 30	**5767**

	Embase 1974 to the 20th of April 2017	
	Searches	**Results**
1	exp open fracture/	5640
2	*open fracture/	2603
3	((open or compound or severe* or mangle*) adj3 (fracture* or break*)).ti,ab.	11677
4	1 or 3	13474
5	exp lower limb/	352703
6	*lower limb/	843
7	exp lower extremity/ or exp buttocks/ or exp foot/ or exp hip/ or exp knee/ or exp leg/ or exp thigh/	357372
8	exp leg/	295179
9	exp foot/	56040
10	exp knee/	91003
11	exp hip/	73237
12	exp femur/	87374
13	exp tibia/	43709
14	exp fibula/	8840
15	exp ankle/	40546
16	exp talus/	5334
17	exp calcaneus/	8506
18	exp navicular bone/	156
19	exp cuneiform bone/	71
20	exp cuboid bone/	46
21	exp metatarsal bone/	6527
22	exp toe phalanx/	264
23	exp foot bone/	20513
24	exp toe/	14142
25	"lower extremit*".ti,ab.	59556
26	"lower limb*".ti,ab.	56681
27	(leg or legs).ti,ab.	127677
28	(foot or feet).ti,ab.	123942
29	exp thigh/	22631
30	thigh*.ti,ab.	33234
31	ankle*.ti,ab.	64262

32	(hip or hips).ti,ab.	151631
33	knee*.ti,ab.	151705
34	femur*.ti,ab.	56709
35	tibia*.ti,ab.	88356
36	patella*.ti,ab.	20358
37	exp patella/	10542
38	talus*.ti,ab.	4676
39	fibula*.ti,ab.	12385
40	calcaneus*.ti,ab.	5616
41	navicular*.ti,ab.	2451
42	cuneiform*.ti,ab.	1452
43	cuboid*.ti,ab.	5378
44	metatarsal*.ti,ab.	9363
45	phalan*.ti,ab.	11785
46	(toe or toes).ti,ab.	22731
47	5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46	822119
48	4 and 47	**6123**

	PsychINFO 1806 to the 21st of April 2017	
	Searches	**Results**
1	((open or compound or severe* or mangle*) adj3 (fracture* or break*)).ti,ab.	180
2	open fracture*.ti,ab.	4
3	1 or 2	180
4	"lower extremit*".ti,ab.	1788
5	"lower limb*".ti,ab.	2401
6	(leg or legs).ti,ab.	9136
7	(foot or feet).ti,ab.	9141
8	thigh*.ti,ab.	794
9	ankle*.ti,ab.	2117
10	(hip or hips).ti,ab.	5023
11	knee*.ti,ab.	3769
12	femur*.ti,ab.	325
13	tibia*.ti,ab.	1703
14	patella*.ti,ab.	237
15	talus*.ti,ab.	11
16	fibula*.ti,ab.	84
17	calcaneus*.ti,ab.	35
18	navicular*.ti,ab.	8

19	cuneiform*.ti,ab.	107
20	cuboid*.ti,ab.	26
21	metatarsal*.ti,ab.	46
22	phalan*.ti,ab.	215
23	(toe or toes).ti,ab.	1226
24	exp thigh/	44
25	exp foot/	1456
26	exp knee/	954
27	exp ankle/	412
28	exp toe/	641
29	4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28	32034
30	3 and 29	**19**

	Cumulative Index to Nursing and Allied Health Literature (CINAHL) Database. EBSCO 1937 to the 21st of April 2017	
	Searches	**Results**
S1	(MM "Fractures, Open")	
S2	TI open fracture*	507
S3	TI compound fracture*	26
S4	AB open fracture*	954
S5	AB compound fracture*	40
S6	S1 OR S2 OR S3 OR S4 OR S5	1399
S7	(MH "Lower Extremity+")	
S8	TI lower limb	
S9	AB lower limb	
S10	TI lower extremity	
S11	AB lower extremity	
S12	(MH "Hip")	
S13	TI hip	
S14	AB hip	
S15	(MM "Fractures, Open")	
S16	TI open fracture*	
S17	TI compound fracture*	
S18	AB open fracture*	
S19	AB compound fracture*	
S20	S15 OR S16 OR S17 OR S18 OR S19	
S21	(MH "Lower Extremity+")	
S22	TI lower limb	
S23	AB lower limb	
S24	TI lower extremity	

S25	AB lower extremity	
S26	(MH "Hip")	
S27	TI hip	
S28	AB hip	
S29	(MH "Femur+")	
S30	TI femur	
S31	AB femur	
S32	(MH "Knee")	
S33	TI knee	
S34	AB knee	
S35	(MH "Patella")	
S36	TI patella	
S37	AB patella	
S38	"tibial plateau"	
S39	TI tibial plateau	
S40	AB tibial plateau	
S41	(MH "Tibia")	
S42	TI tibia	
S43	AB tibia	
S44	(MH "Fibula")	
S45	TI fibula	
S46	AB fibula	
S47	(MH "Ankle")	
S48	TI ankle	
S49	AB ankle	
S50	(MH "Talus")	
S51	TI talus	
S52	AB talus	
S53	(MH "Calcaneus")	
S54	TI calcaneus	
S55	AB calcaneus	
S56	(MH "Tarsal Bones") OR "navicular"	
S57	TI navicular	
S58	AB navicular	
S59	"cuboid"	
S60	TI cuboid	
S61	AB cuboid	
S62	"cuneiform"	
S63	TI cuneiform	
S64	AB cuneiform	
S65	(MH "Metatarsal Bones")	

S66	TI metatarsal	
S67	AB metatarsal	1534
S68	"phalanx"	
S69	TI phalanx	
S70	AB phalanx	
S71	(MH "Foot") OR (MH "Foot Bones")	
S72	S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43 OR S44 OR S45 OR S46 OR S47 OR S48 OR S49 OR S50 OR S51 OR S52 OR S53 OR S54 OR S55 OR S56 OR S57 OR S58 OR S59 OR S60 OR S61 OR S62 OR S63 OR S64 OR S65 OR S66 OR S67 OR S68 OR S69 OR S70 OR S71	130012
S73	S6 AND S72	**1399**

	Cochrane CENTRAL 1996 to the 11th of May 2017	
	Searches	**Results**
#1	open fracture*:ti,ab,kw (Word variations have been searched)	1485
#2	MeSH descriptor: [Fractures, Open] explode all trees	101
#3	#1 or #2	1485
#4	lower limb:ti,ab,kw (Word variations have been searched)	6146
#6	MeSH descriptor: [Thigh] explode all trees	413
#7	MeSH descriptor: [Hip] explode all trees	369
#8	MeSH descriptor: [Femur] explode all trees	1170
#9	MeSH descriptor: [Knee] explode all trees	690
#10	MeSH descriptor: [Tibia] explode all trees	512
#11	MeSH descriptor: [Leg] explode all trees	2865
#12	MeSH descriptor: [Ankle] explode all trees	443
#13	MeSH descriptor: [Foot] explode all trees	1450
#14	MeSH descriptor: [Leg Bones] explode all trees	1845
#15	MeSH descriptor: [Foot Bones] explode all trees	266
#16	hip:ti,ab,kw (Word variations have been searched)	13792
#17	femur:ti,ab,kw (Word variations have been searched)	3889
#18	knee:ti,ab,kw (Word variations have been searched)	16216
#19	fibula:ti,ab,kw (Word variations have been searched)	185
#20	MeSH descriptor: [Fibula] explode all trees	72
#21	MeSH descriptor: [Patella] explode all trees	296

#22	patella:ti,ab,kw (Word variations have been searched)	742
#23	tibia:ti,ab,kw (Word variations have been searched)	1503
#24	ankle:ti,ab,kw (Word variations have been searched)	5560
#25	MeSH descriptor: [Foot Bones] explode all trees	266
#26	"talus":ti,ab,kw (Word variations have been searched)	73
#27	MeSH descriptor: [Talus] explode all trees	33
#28	MeSH descriptor: [Calcaneus] explode all trees	150
#29	Calcaneus:ti,ab,kw (Word variations have been searched)	309
#30	navicular:ti,ab,kw (Word variations have been searched)	36
#31	cuboid:ti,ab,kw (Word variations have been searched)	10
#32	cuneiform:ti,ab,kw (Word variations have been searched)	8
#33	MeSH descriptor: [Metatarsal Bones] explode all trees	62
#34	metatarsal:ti,ab,kw (Word variations have been searched)	260
#35	MeSH descriptor: [Tarsal Bones] explode all trees	196
#36	phalan*:ti,ab,kw (Word variations have been searched)	174
#37	toe or toes:ti,ab,kw (Word variations have been searched)	813
#38	#4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32 or #33 or #34 or #35 or #36 or #37	**42552**

8.16.2 Search updates

	Medline (Ovid MEDLINE® Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®) 1946 to the 12th of July 2019	
	Searches	**Results**
1	Fractures, Open/	8995
2	((open or compound or severe* or mangle*) adj3 (fracture* or break*)).ti,ab.	24342
3	1 or 2	27936
4	exp lower extremity/ or exp buttocks/ or exp foot/ or exp hip/ or exp knee/ or exp leg/ or exp thigh/	524638
6	"lower limb*".ti,ab.	113075
7	(leg or legs).ti,ab.	253197
8	(foot or feet).ti,ab.	247500
9	thigh*.ti,ab.	66484
10	ankle*.ti,ab.	130736
11	(hip or hips).ti,ab.	307815

12	exp Leg Bones/	192500
13	knee*.ti,ab.	316636
14	femur*.ti,ab.	113307
15	tibia*.ti,ab.	181369
16	patella*.ti,ab.	42426
17	talus*.ti,ab.	9619
18	fibula*.ti,ab.	25838
19	calcaneus*.ti,ab.	11324
20	navicular*.ti,ab.	4897
21	cuneiform*.ti,ab.	2977
22	cuboid*.ti,ab.	11131
23	metatarsal*.ti,ab.	18957
24	exp Foot Bones/	36140
25	phalan*.ti,ab.	23221
26	Leg/	133989
27	(toe or toes).ti,ab.	44724
28	exp Toes/	25104
29	pilon*.ti,ab.	5338
30	4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 18 or 17 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29	1696412
31	3 and 30	**13022**

	Embase 1974 to the 12th of July 2019	
	Searches	**Results**
1	Fractures, Open/	8995
2	((open or compound or severe* or mangle*) adj3 (fracture* or break*)).ti,ab.	24342
3	1 or 2	27936
4	exp lower extremity/ or exp buttocks/ or exp foot/ or exp hip/ or exp knee/ or exp leg/ or exp thigh/	524638
6	"lower limb*".ti,ab.	113075
7	(leg or legs).ti,ab.	253197
8	(foot or feet).ti,ab.	247500
9	thigh*.ti,ab.	66484
10	ankle*.ti,ab.	130736
11	(hip or hips).ti,ab.	307815
12	exp Leg Bones/	192500

13	knee*.ti,ab.	316636
14	femur*.ti,ab.	113307
15	tibia*.ti,ab.	181369
16	patella*.ti,ab.	42426
17	talus*.ti,ab.	9619
18	fibula*.ti,ab.	25838
19	calcaneus*.ti,ab.	11324
20	navicular*.ti,ab.	4897
21	cuneiform*.ti,ab.	2977
22	cuboid*.ti,ab.	11131
23	metatarsal*.ti,ab.	18957
24	exp Foot Bones/	36140
25	phalan*.ti,ab.	23221
26	Leg/	133989
27	(toe or toes).ti,ab.	44724
28	exp Toes/	25104
29	pilon*.ti,ab.	5338
30	4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 18 or 17 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29	1696412
31	3 and 30	13022
32	limit 31 to last 2 years	**1701**

8.17 Appendix 17. List of verbatim outcomes, and frequency of reporting. Grouped by standardised outcome headings and outcome domains and core areas using the COMET Taxonomy of Outcomes.

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
Death	Survival (1)	Survival	21	1	20	7	Death	2
							Early mortality	1
							Late mortality	1
							Mortality	11
							Mortality rate	2
							Risk of one-year mortality	1
							Standard mortality ratios	1
							Survival	2
Physiological or clinical	Blood and lymphatic system outcomes (2)	Venous thromboembolism	10	0	10	8	Deep vein thrombosis	3
							DVT	1
							Embolism	1
							PE	1
							Presence of arterial thrombosis	1
							Pulmonary embolism	1
							Rate of DVT	1
							Venous thromboembolism	1
	General outcomes (9)	Systemic sepsis or bacteraemia	3	0	3	2	Bacteraemia	2
							The risk for sepsis	1
	Musculoskeletal and connective tissue outcomes (15)	Adverse events of orthopaedic intervention	5	2	3	5	A major complication	1
							Achilles tendon contracture	1
							Adverse events	1
							Bleeding haematoma	1
							Orthopaedic complications	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
		Complications and post-operative complications	71	1	70	35	Chronic bone complications	1
							Complication	3
							Complication rate	3
							Complication rates	3
							Complication subtype (i.e. cardiac, respiratory, gastrointestinal, urinary, haemorrhage, and infection	1
							Complications	29
							Complications and re-operation	1
							Complications from external fixator application	1
							Complications-including infection, nonunion, and any cases that progressed to amputation.	1
							Early post-operative complications	1
							Early postoperative complications	1
							Incidence of complication	1
							Major and minor complications	1
							Major complication	1
							Major complications	1
							Minor complications	2
							Occurrence of any complication	1
							Other complications	1
							Other postoperative complications	1
							Overall complication rate	1
							Operatively treated complications related to the study injury	1
							Perioperative complications	2
							Pin site hypergranulation	1
							Post operative wound complications	1
							Postoperative complication	1
							Postoperative complications	4
							Potential complications	1
							Rate of complications	1
							Secondary fracture	1
							Suture failure	1
							Total complications	1
							Wound complications	1
		Hardware or implant failure	12	0	12	8	Fixation failure	1
							Hardware failure	4
							Hardware failure rate	1
							Implant failure requiring reoperation	1
							Implant failure	1
							Implant breakage/loosening	1
							Implant failure	2
							Metal failure	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
		Pin site loosening	3	1	2	2	Pin loosening	2
							Pin site loosening	1
		Time in external fixator	3	0	3	3	External fixator time	1
							Mean duration of fixator application	1
							Time of frame wearing	1
		Amputation	77	8	69	23	Amputation or salvage	1
							Amputation	49
							Amputation or salvage	1
							Amputation rate	5
							Below knee amputation	1
							Below-knee amputation	1
							Consideration of lower leg amputation	1
							Delayed secondary amputation	1
							Early amputation	1
							Early amputation or salvage	1
							Knee range of motion	1
							Limb salvage	1
							Need for amputation	1
							Primary amputation	1
							Progression to amputation	1
							Rate of amputation	1
							Rate of limb salvage	1
							Rate of primary amputation	1
							Rate of secondary amputation	2
							Secondary amputation rates	1
							Secondary amputation	3
							Secondary amputation rate	1
		Bone	2	0	2	2	Bone results	1
							Limb shortening	1
		Bone union or healing	265	15	250	76	Aseptic nonunion	1
							Average time to bone union	1
							Bone consolidation	1
							Bone healing	7
							Bone healing index days/cm	1
							Bone healing status	1
							Bone healing time	4
							Bone hypertrophy	1
							Bone union	79
							Bone union rates	2

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
							Bony union and malunion	1
							Bony complications	1
							Bony union	5
							Clinical bone union	1
							Clinical healing	1
							Clinical union	2
							Complete fracture healing	1
							Consolidation of fracture	1
							Days to radiological consolidation	1
							Defective healing	1
							Delayed union	15
							Early bone complications	1
							Early union rate	1
							Fracture healing duration	1
							Fracture consolidation	1
							Fracture healing	13
							Fracture healing problems	1
							Fracture healing rate	1
							Fracture healing time	3
							Fracture union	10
							Fracture union (clinical)	1
							Fracture union (radiological)	1
							Healing	2
							Healing after primary procedure	1
							Healing assessment	1
							Healing index	1
							Healing time	3
							Healing time for bone	1
							Heterotopic ossification	1
							Heterotrophic ossification	1
							Mean fracture healing time	1
							Mean time to healing	1
							Mean time to union	1
							Non union	1
							Presence of union	1
							Presence of union at 6 and 12 months	1
							Primary union rate	1
							Presence of callus	1
							Radiographic healing	1
							Radiographic fracture union	1
							Radiographic union	4
							Radiological bone union	2
							Radiological outcome	1
							Radiological union	2
							Rate of bone union	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
							Rate of delayed union	1
							Rate/time to union	1
							Requirement for secondary bone grafting	1
							Time taken to radiological union	1
							Time to bone union	15
							Time to bony union	3
							Time to clinical union	1
							Time to complete bone union	1
							Time to fracture union	2
							Time to osseous union	1
							Time to radiographic fracture healing	1
							Time to radiographic fracture union	1
							Time to radiographic union	3
							Time to radiological fracture healing	1
							Time to union	22
							Timing of union and callus formation	1
							To union	1
							Union	10
							Union of fracture	1
							Union rate	3
							Union rates	1
		Malunion or alignment	77	0	77	47	Ability to maintain alignment	1
							Alignment	7
							Anatomical reduction of the calcaneus	1
							Angular deformity	1
							Angular deformity >10 degrees	1
							Angular deformity of fracture	1
							Angular malalignment	1
							Angulation of fixation	1
							Angulation deformity	1
							Angulation of fracture	1
							Anterior distal tibial angle	1
							Articular reduction at the ankle	1
							Axial alignment	1
							Axial deformity on radiographic assessment	1
							Axis	1
							Bone alignment	1
							Bone malalignment	1
							Bony union and malunion	1
							Deformity	1
							Deformity at the docking site	1
							Final Alignment of the Fracture	1
							Fracture alignment	1
							Fracture unition quality	1
							Hind foot angle	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
							Limb alignment	1
							Lower limb axis alignment	1
							Mal-union	1
							Malalignment	1
							Malalignment (or malunion)	1
							Malrotation	1
							Malunion or malalignment	1
							Malunion rate	1
							Malunion	24
							Medial proximal tibial angle	1
							Post operative femoral axis	1
							Posterior proximal tibial angle	1
							Presence of bone defect	1
							Problems with union	1
							Quality of fracture reduction	1
							Quality of reduction	1
							Radiographic examination for degenerative joint changes or malignment	1
							Rate of mal-union	1
							Rate of malrotation	1
							Rate of malunion	1
							Reduction radiographically	1
							Rotational deformity	2
		Non-union	53	2	51	9	Delayed or nonunion	1
							Fracture non-union	1
							Non-union and delayed union rate	1
							Non-union rate	1
							Nonunion/non-union	42
							Nonunion rates	2
							Nonunions	1
							Rate of non-union	1
							Rate on non-union	1
		Osteonecrosis	5	1	4	5	Avascular necrosis	1
							Necrosis of tibial segment	1
							Osteonecrosis	1
							Posttraumatic osteonecrosis	1
							Radiographic osteoarthritis	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
		Pseudoarthrosis	2	0	2	2	Pseudoarthrosis	1
							Rate of Atrophic pseudoarthrosis	1
		Compartment syndrome	17	0	17	6	Compartment syndrome rate	1
							Compartment syndrome	11
							Fasciotomy	1
							Fasciotomy rate	1
							Post-operative compartment syndrome	1
							Rate of compartment syndrome	2
		Infection	157	27	130	29	Acute infection	1
							Bone union	1
							Deep infection	1
							Development of infection	1
							Increased infection rate	1
							Infection	105
							Infection in the wound of an open fracture, either deep or superficial	1
							Infection rate	6
							Infection rates	6
							Infection reported at any follow-up visit	1
							Infections	4
							Infectious complication	1
							Infectious complications	1
							Infective complications	1
							Infective symptoms	1
							Non-operatively managed infections	1
							Number of infections	1
							Overall infection rate	1
							Post-operative infection	3
							Postoperative infection	1
							Presence of infection	1
							Presence of Infection/Non-union/Mal-union	1
							Rate of infection	7
							Recurrent infection	1
							Response to infection	1
							Sepsis	1
							SSI	1
							Surgical site infection	4
							Wound infection	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
		Deep infection	88	14	74	17	Deep incisional infection	1
							Deep infection	60
							Deep infection rate	4
							Deep infection with 90 days	1
							Deep infection within one year of initial injury	1
							Deep infections	1
							Deep infective complications	1
							Deep soft tissue infection	2
							Deep surgical site infection	3
							Deep tissue infection	1
							Deep wound infection	4
							Deep wound infection rates	1
							Infection	2
							Infection deep	1
							Organ or space infection	1
							Postoperative deep infection	1
							Presence of deep infection	3
		Flap infection	2	0	2	2	Flap infection	1
							Flap infections	1
		Osteomyelitis	48	6	42	9	Chronic osteomyelitis	2
							Deep infection or osteomyelitis	1
							Infection at fracture site	1
							Infection of fracture site	1
							Osteomyelitis	39
							Osteomyelitis rate	1
							Presence of osteomyelitis	1
							Rate of chronic infection leading to osteomyelitis	1
							Recurrence of Osteomyelitis	1
		Pin site infection	30	2	28	10	Needle tract infection	1
							Pin site infection	10
							Pin site infections	1
							Pin track infection	2
							Pin track infections	1
							Pin tract infection	11
							Pin-site infection	1
							Pin-tract infection	1
							Pintract infection	1
							Presence of pin tract infection	1
		Septic arthritis	5	4	1	5	Implant sepsis	1
							Knee sepsis	1
							Occurrence of ipsilateral knee sepsis	1
							Septic joint	1
							Superficial infection	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
		Superficial or wound infection	41	1	40	13	Infection superficial	1
							Local wound infection	1
							Percentage of wound infection	1
							Postoperative superficial infection	1
							Soft tissue infection	2
							Superficial incisional infection	1
							Superficial infection	20
							Superficial infections	2
							Superficial wound infection	1
							Surface infection	1
							Wound infection	8
							Wound infection rate	1
							Wound infection rates	1
		Laboratory tests	4	0	4	4	Histological analysis of muscle tissue	1
							IL-6 level	1
							Infection cultures	1
							Positive CRP level	1
		Leg length or leg shortening	25	0	25	13	Bone shortening	2
							Leg length	1
							Leg length discrepancy	6
							Leg length ratio	1
							Leg length shortening	3
							Limb length discrepancy	1
							Limb length shortening	1
							Limb shortening	2
							Limb-length discrepancy	1
							Mean lengthening distance	1
							Rate of shortening	2
							Shortening	3
							Shortening deformity	1
		Microbiology cultures	17	1	16	15	Bacteria isolated	1
							Bacterial culture	1
							Causative organisms of infection	1
							Clostridium difficile infection	1
							Culture result	1
							Drug resistant microbiology	1
							Infectious pathogen causing infection and antibiotic resistance	1
							Microbiological profile of deep infection	1
							Microbiology cultures	1
							Pathogen cultured	1
							Positive culture	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
							Specific pathogen on culture	1
							Time taken to negative culture	1
							Wound culture	3
							Wound culture results	1
		Wound cultures	13	1	12	5	Positive wound culture	1
							Wound culture	9
							Wound culture result	1
							Wound cultures	1
							Wound cultures from infected cases	1
		Numbness and loss of sensation	3	0	3	2	Neurovascular disturbance	1
							Presence of trophic change	2
		sensory or motor impairment	17	1	16	12	Donor site power	1
							Foot strength	1
							Muscle wasting	1
							Muscle weakness,	1
							Peripheral nerve deficit	1
							Persistent foot drop	1
							Rate of residual neurological deficit	1
							Sensation	5
							Sensory recovery	2
							Severity of injury	1
							Strength of affected extremity	1
							Touch sensation	1
		Osteoarthritis	4	0	4	3	Ankle osteoarthritis	2
							Traumatic osteoarthritis	1
							Traumatic arthritis incidence	1
		Pain or discomfort	48	1	47	24	Ache	1
							Ankle pain	1
							Anterior knee pain	1
							Calf discomfort	1
							Hardware pain	1
							Knee pain	1
							Mechanical pain	1
							Midfoot pain	1
							Neuropathic pain	1
							Pain	24
							Pain and dyscomfort	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
							Pain during walking	1
							Pain free	1
							Pain on walking	2
							Pain or joint stiffness	1
							Pain or pain interference	1
							Painful hardware	1
							Persistent post-surgical pain and functional outcomes	1
							Postoperative pain rate	1
							Postoperative pain	1
							Rate of Anterior knee pain	1
							Stump pain	1
							Tenderness	1
							Visual pain scores	1
		Medication use for pain	1	0	1	1	Pain medication use	1
		Plastics intervention e.g. flap or graft	2	0	2	2	Donor-site morbidity	1
							Need for skin graft or flap coverage	1
		Adverse event or complication of graft or flap	18	1	17	17	Donor site complications	1
							Donor site problems	1
							Flap complication	1
							Flap complications	1
							Flap donor site problems	1
							Flap oedema	1
							Flap reconstruction	1
							Flap take backs	1
							Flap thrombosis	1
							Flap venous congestion	2
							Flap-related complications	1
							Partial flap failure	1
							Partial flap loss	1
							Postoperative circulatory disturbances opf flap	1
							Postoperative venous stasis in flap	1
							Skin invagination at the docking site	1
							Venous congestion	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
		Flap failure or survival	51	4	47	17	Complete flap loss	1
							Flap failure	12
							Flap failures	2
							Flap healing	2
							Flap loss	4
							Flap necrosis	1
							Flap outcome	1
							Flap salvage	1
							Flap success	1
							Flap survival	13
							Free flap survival	3
							Need for second stage procedure of partial or complete flap failure	1
							Partial flap loss	2
							Time to flap healing	1
							Total and partial flap failure	1
							Total flap failure	1
							Total flap loss	4
		Graft or flap necrosis	10	0	10	4	Flap necrosis	6
							Graft necrosis	1
							Marginal necrosis	1
							Partial necrosis	2
		Reoperations	21	5	16	16	Characteristics of external fixator revisions	1
							Conversion to IM nailing	1
							Need for additional operations	1
							Need for re-exploration with reason	1
							Need for reoperation	1
							Need for unplanned reoperation	1
							Number of flap take backs (taking back to theatre for revision)	1
							Number of soft tissue coverage procedures	1
							Reoperation	4
							Reoperation due to loss of reduction or non-union	1
							Reoperations	2
							Revision surgery	2
							Secondary interventions	1
							Total number of debridements until wound closure	1
							Unplanned surgeries	1
							Unplanned, clinically important reoperations	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
		Number of debridements	7	0	7	7	Frequency of debridement	1
							Need for debridement	1
							Number of debridements and irrigation procedures	1
							Number of debridements before discharge	1
							Number of debridements	1
							Number of serial debridements	1
							The number of debridements	1
		Number of operations	62	1	61	40	Additional procedures	2
							All-cause reoperation	1
							Average number of revision surgeries	1
							Complications leading to reoperation	1
							Further theatre visits for infection during the index admission	1
							Incidence of reoperation	1
							Incidence of revision surgery	1
							Mean number of operations	1
							Need for additional procedures	1
							Need for further surgery	1
							Need for secondary procedure	1
							Number of external fixator construct revisions	1
							Number of further procedures	1
							Number of operations	8
							Number of Operative Procedures after index admission	1
							Number of orthopaedic operations	1
							Number of procedures	4
							Number of reinterventions on the bone	1
							Number of reoperations	1
							Number of revisions	2
							Number of secondary procedures performed	1
							Number of surgical interventions	1
							Number of surgical procedures	3
							Number or reoperations	1
							Rate of secondary surgeries	1
							Re-operation rates	3
							Reoperation	2
							Repeat surgery	1
							Requirement of secondary procedures for delayed flap healing	1
							Revision surgery	2
							Secondary procedures	1
							Secondary intervention rate	2
							Secondary operation rates	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
							Secondary outcomes included number of venous anastomoses, rates of venous anastomotic revision, and operative take backs, as well as rates of arterial and venous compromise necessitating return to the operating room	1
							Secondary procedures	2
							Secondary surgical procedures	1
							Total number of operations	3
							Total number of surgical procedures	1
							Total operations per patient	1
							Unplanned surgical procedures	1
		Swelling	2	0	2	2	Limb oedema	1
							Peripheral oedema	1
		Wound	3	0	3	3	Wound complications	1
							Wound haematoma	1
							Wound problems	1
		Wound closure and dehiscence	7	1	6	3	Successful closure of the soft tissue defect was our primary outcome measure.	1
							Time to wound closure	1
							Wound dehiscence	5
		Wound healing	43	2	41	22	Delayed healing	1
							Delayed healing of the stump	1
							Healing assessment	1
							Healing time	2
							Healing time for soft tissue	1
							Incidence of acute fracture wound complications	1
							Primary wound healing	1
							Rates of wound healing complications	1
							Skin maceration	1
							Soft tissue healing	1
							Tie for soft tissue healing	1
							Time taken for wound to heal	2
							Time to complete granulation tissue coverage	1
							Time to skin healing	1
							Time to wound healing	1
							Type of healing	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
							Ulcer development	1
							Wound healing	17
							Wound healing problem	1
							Wound healing problems	4
							Wound healing time	1
							Wound infection	1
		Wound necrosis	14	1	13	9	Partial necrosis	1
							Postoperative wound necrosis	1
							Rate of tissue necrosis	1
							Rate of wound necrosis	1
							Skin necrosis	6
							Soft tissue necrosis	1
							Tissue breakdown	1
							Tissue necrosis	1
							Wound necrosis	1
	Renal and urinary outcomes (19)	Acute Kidney Injury	4	2	2	4	Acute kidney injury	1
							Aki	1
							AKI rate	1
							Improvement in renal function	1
		Renal failure	1	0	1	1	Renal failure	1
Life impact	Physical functioning (25)	Ability to climb stairs	2	0	2	2	Ability to climb stairs	1
							Climbing stairs	1
		Ability to do activities of daily living	4	0	4	4	Ability to resume activities of daily living	1
							Activities of daily living	1
							Regain of walking and adls	1
							Status of activities of daily living	1
		Disability	3	1	2	3	Average overall disability rating	1
							Disability	1
							Overall disability rating	1
		Function - lower limb functional	88	8	80	30	Bony and functional assessment	1
							Clinical and functional outcomes	1
							Donor site function	1
							Foot functional outcomes	1
							Function	20

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
							Function evaluation	1
							Functional and bone results	1
							Functional and clinical outcomes	1
							Functional assessment	2
							Functional outcome	18
							Functional outcomes	3
							Functional results	3
							Functionality	1
							Functional outcomes	1
							Limb function	13
							Long term function	1
							Lower extremity function	1
							Lower leg and ankle function	1
							Lower limb function	5
							Measure of function	1
							Objective physical function	1
							Overall function	1
							Patient function	1
							Patient-reported outcome	1
							Patient-reported function	1
							Physical activity	2
							Physical functioning	1
							Return to limb function	1
							Time to return to full function	1
							Upper limb donor site assessments	1
		Ankle function	16	0	16	7	Ankle and foot function	1
							Ankle function	8
							Ankle functional outcome	1
							Ankle joint function	1
							Foot and ankle function	3
							Functional outcome	1
							Knee functionality	1
		Foot function	7	0	7	4	Ankle and foot function	1
							Foot and ankle function	3
							Foot function	2
							Foot functional outcomes	1
		Knee function	12	0	12	7	Additional functional assessment	1
							Functional outcome	1
							Knee function	5
							Knee functional results	1
							Knee range of movement	2
							Knee Society scoring	1
							Ligament integrity of knees	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
		Shoulder function	1	0	1	1	Shoulder function	1
		Gait, walking and mobility	29	3	26	22	Ability to walk	3
							Able to walk without aids	1
							Ambulating without support	1
							Ambulation	1
							Ambulatory status	1
							Gait	2
							Impairment of walking function	1
							Limping	1
							Mobility	5
							Mobility - Objective outcome	1
							Mobility status	1
							Observable limp	1
							Post operative ambulation status	1
							Regain of walking and ADLs	1
							Return to ambulation	1
							Return to ambulation and discharge destination	1
							Time to weight bearing status	1
							Use of a walking aid	1
							Use of crutches	1
							Walking speed	1
							Walking ability	1
							Walking without assistance	1
		Weight bearing	2	0	2	2	Ability to fully weight bear pain free	1
							Time to weight bearing	1
		Weight bearing status and time to weight bear	14	0	14	10	Full weight bearing	2
							Partial or painless weight bearing	1
							Time to full weight bearing	3
							Time to full weight bearing without crutches	1
							Time to full weightbearing ambulation without an aid	1
							Time to weight bear without crutches	1
							Time to weight bearing	2
							Time to weight bear	1
							Weight bearing capacity	1
							Weight bearing status	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
		Movement, range of movement and stiffness	25	0	25	19	Active range of motion of the tibiotalar joint	1
							Ankle stiffness	1
							Fixed flexion deformity	1
							Joint mobility	1
							Joint stiffness	3
							Joint stiffness at the ankle and knee	1
							Jumping	1
							Knee stiffness	1
							Mobility	2
							Presence of subtalar arthrosis	1
							Range of motion	4
							Range of motion in nearby joints	1
							Range of motion of joints close to fracture site	1
							Range of movement	1
							Range of movement at the hip	1
							Ranges of movement	1
							Stiffness	1
							The active range of motion of the subtalar joint	1
							Time taken to achieve complete range of movement	1
		Ankle range of movement	22	0	22	14	Ankle arthrosis	1
							Ankle joint stiffness	1
							Ankle range of motion	1
							Ankle range of movement	6
							Ankle rom	1
							Ankle stiffness	1
							Knee joint stiffness	1
							Mange of motion at the ankle	1
							Mobility of the ankle	1
							Range of ankle motion	1
							Range of motion at ankle	2
							Range of motion at the ankle	3
							Range of motion of the ankle	1
							Range of movement of the ankle	1
		Knee range of movement	25	0	25	16	Knee and ankle range of movement	1
							Knee joint stiffness	1
							Knee range of movement	1
							Knee range of motion	2
							Knee range of motion/knee stiffness	1
							Knee range of movement	1
							Knee range of movement	2
							Knee rom	1
							Knee stiffness	4
							Mobility of the knee	1
							Postoperative knee range of motion	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
							Range of knee motion	2
							Range of motion at knee	1
							Range of motion at the knee	3
							Range of motion at the knee	1
							Range of movement at the knee	2
		Sports, exercise and fitness	7	0	7	7	Ability to jump	1
							Ability to run	1
							Ability to squat	1
							Return to adapted sports activity	1
							Return to sport	1
							Running	1
							Sporting activity	1
		Wearing shoes	1	0	1	1	Ability to wear shoes	1
	Social functioning (26)	Participation	3	0	3	3	Ability to resume recreation activities	1
							Patient activity	1
							Recreational activity	1
		Reliance on others	1	0	1	1	Ancillary requirements	1
	Role functioning (27)	Work and employment	1	0	1	1	Return to work	1
		Return to work or duty	16	2	14	8	Employment status	4
							Employment status before and after injury.	1
							Occupation status	1
							Return to work	4

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
	Emotional functioning and wellbeing (28)	Appearance	5	0	5	3	Aesthetic outcome	2
							Cosmetic outcome	1
							Scar quality	2
		Donor site appearance	1	0	1	1	Donor site appearance	1
		Mood	1	0	1	1	Mood	
		Worry and anxiety	1	0	1	1	Fear	1
		Stress	3	1	2	3	Physical and mental stress	1
							Post-traumatic stress	1
							Stress	1
	Global quality of life (30)	Quality of life	32	0	32	7	General health status	1
							General Health/quality of life	1
							Health related quality of life	9
							Health-related quality of life	3
							Preference-based health-related quality-of-life outcomes	1
							Quality of life	7
							Quality of life and physical function	1
	Perceived health status (31)	Subjective assessment of success	2	0	2	1	Subjective assessment of success	2
	Delivery of care (32)	Communication	1	0	1	1	Whether the leaflets were used to improve communication with other healthcare professionals.	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
		Patient satisfaction	5	0	5	4	Patient satisfaction	2
							Patient satisfaction with the treatment result at the time of consultation	1
							Satisfaction with treatment	1
							Subjective outcome: satisfaction	1
Resource use	Economic (34)	Cost	24	8	16	12	Cost	10
							Cost analysis	1
							Cost saving	2
							Describe the economic burden on the healthcare system from the perspective of a payer.	1
							Healthcare costs	1
							Hospital costs	1
							Patient level costing	1
							Projected lifetime disability cost	1
							Resource use	2
							Total healthcare costs	1
							Treatment cost	2
							True remuneration	1
	Hospital (35)	Hospital re-admission	5	0	5	5	Re-admission rates	1
							Number of secondary surgical admissions	1
							Rates of readmission	1
							Readmissions	1
							Re-hospitalisation rates at 1 year	1
		Length of hospital stay	52	0	52	22	Average hospital stay	1
							Duration of hospital stay	1
							Duration of hospitalisation	1
							Hospital duration	1
							Hospital length of stay	1
							Hospital LOS	1
							Hospital stay	4
							Hospitalisation period	2
							Inpatient length of stay	2
							Inpatient stay	1
							Length of hospital stay	16
							Length of hospitalisation	3
							Length of in-hospital stay	1
							Length of inpatient stay	1
							Length of stay	9
							Length of stay (LOS)	1
							Length of stay in hospital	1
							Mean inpatient hospital costs	1
							Mean length of hospital stay	1
							Number and length of hospital stays	1
							Number of in-patient days	1

Core Area	Outcome domain (domain number)	Standardised outcome heading	Number of times reported	Primary outcome	Secondary outcome	Number of unique outcome terms	Verbatim outcomes	Number of times reported
							Total duration of hospitalisation	1
		Length of ICU stay	6	0	6	5	ICU length of stay	2
							ICU LOS	1
							ITU length of stay	1
							Length of ICU stay	1
							Length of stay in ICU	1
		Number of emergency department	1	0	1	1	Number of emergency department attendances	1
		Number of outpatient	5	0	5	4	Number of clinic visits	1
							Outpatient appointments	2
							Outpatient attendances	1
							Total number of outpatient visits	1
		Number of primary care encounters	1	0	1	1	Primary care encounters	1
Adverse events	Adverse events or effects (38)	Adverse events	5	0	5	1	Adverse events	5

8.18 Appendix 18. Inventory of Outcome Measurement Instruments.

Name	Description of OMIs including definitions	Frequency of use
1. Death outcome measurement instruments		
Survival (1)		
Charlson co-morbidity index (323)	Physician reported outcome measurement instrument used to predict 10-year survival in patients with multiple co-morbidities. (323)	1
Definitions of mortality	1. Early mortality, defined as death within 90 days after injury. 2. Defined as death between 90 days and 2 years 3. Mortality was defined as overall in-hospital death from any cause.	3
2. Physiological or clinical outcome measurement instruments		
1. Musculoskeletal and connective tissue outcome measurement instruments (15)		
Bone outcome measurement instruments		
Definitions of bone union	1. A fracture was considered healed if, on clinical assessment, there was no fracture site tenderness on manual palpation or no pain at the fracture site with full weight-bearing, radiographic fracture union demonstrated by the presence of bridging callus or the disappearance of the fracture lines on at least one diaphyseal aspect of each orthogonal radiograph, no hardware failure resulting in intra- medullary nail dynamization or dislocation, and no secondary procedure recommended or performed to promote fracture-healing or any other procedure that would interfere with the process of fracture-healing. The reason for the use of two of four cortices to define fracture union was to detect the earliest signs of fracture union and therefore optimize the detection of any acceleration of fracture-healing. 2. Bone consolidation was clinically assessed by a non painful callus palpation and a full weight bearing without any contention system. Radiological bone consolidation was analysed by two incidences on standard radiographs (antero posterior and lateral). Consolidation was attested when a bone bridge or a fracture disappearance was seen on three out of four cortices. Radiographs were analysed by two different orthopaedic surgeons. 3. Union was determined both clinically and radiographically. Clinical union was based on direct documentation by the treating surgeon. Radiographic union was declared when cortical bridging was seen on at least 2 of 4 cortices with a stable implant. Nonunion was declared when documented by the treating physician and scheduled for nonunion surgery, or, when documentation was lacking, by a lack of radiographic union on the most recent available radiographs.	50

Name	Description of OMIs including definitions	Frequency of use
	4. Malunion was defined as deformity of united bone with angulation> 5 degrees, shortening>1 cm and distal fragment rotation>15 degrees.13 Nonunion was defined when fractures were not developed union up to nine months after applying external fixator judged on clinically and radiologically. Delayed union was defined when fractures were not developed union up to 6 months judged on clinically and radiologically. 5. Fractures were considered clinically united when walking without pain was possible. On radiographs, union was defined as callus on two radio- graphic views with disappearance of the fracture line. 6. X-rays showed corticalization with bone thickness equal to that of the bone adjacent to the regenerated bone and/or consolidation of the docking site. 7. Early, delayed and late unions were defined when complete bone healing took place within the following time frames, respectively: <6 months, 6–9 months and >9 months. 8. Union was defined as the time when a bridging callus was identified on the radiographs and the fracture site was painless during weight bearing. 9. Time when both clinical (absence of pain or movement with the patient bearing full weight on the limb; the fixator attached but dynamised) and radiological union (presence of bridging callus in two planes) were complete and all types of support or immobilisation was removed. 10. Radiological union was defined as the presence of bridging callous in at least three out of the four cortices [18]. Clinical union was defined as a full painless weight bearing with the circular frame having been dynamised. The frame was removed when there was evidence of union across a minimum of three cortices and a painless full weight bearing. 11. Fracture union was assumed when bone healing progressed uneventfully. 12. Union was determined both clinically and radiographically. Clinical union was defined as pain-free full weight-bearing and radiographic union was defined as bridging callus of at least three of four cortices on final imaging. The computed tomography (CT) scan was obtained in the setting of uncertainty of radiographic union on plain film radiographs. 13. Bridging bone on 3 of 4 cortices and resolution of pain in the supracondylar region. 14. When callus maturation was closed over 3/4 of the fracture faces, according to the anteroposterior and lateral radiographs, and the fracture site showed movement or tenderness, clinically.	

Name	Description of OMIs including definitions	Frequency of use
	15. Bone union was evaluated based on the clinical evaluation of the fracture site, as well as radiologically. The definition of bone union was: (1) no fracture line and a continuous bridge of four cortices on X-rays (A-P and lateral views), (2) no instability at the fracture site, and (3) no pain at the fracture site on full weight bearing. 16. We defined fracture union as bridging callus being present on both the anteroposterior and lateral radiographs, the patient being nontender at the fracture site, and the patient being able to bear full weight on the affected extremity 17. The progress of bony union was assessed clinically and radiographically at 3-week intervals until union was sound. Radiographic criteria for union were the same for both groups (i.e. good evidence of bridging periosteal and endosteal callus formation as seen by the obliteration of the fracture line on two orthogonal views). The clinical assessment of the union was mainly based on complete absence of pain and tenderness at the fracture site. 18. Fracture union was defined as bridging callus on 2 of 4 cortices on biplanar radiographs combined with a lack of patient symptoms. Radiographic data were available using the picture archiving and communication system and were re- viewed by 2 trauma fellowship–trained orthopedic attending surgeons. Agreement was obtained by consensus. 19. Union was declared when the patient was able to bear weight without pain or walking aid and formation of good callus. 20. Union was defined as callus formation involving at least three cortices or fading of fracture lines on each anteroposterior and lateral radiograph, combined with painless full weight bearing on the affected limb. 21. According to radiographic (bridging of the fracture by bone, callus or trabeculae) and clinical criteria (absence of pain or tenderness when weight-bearing) 22. We considered union to have occurred when radiologically anteroposterior and lateral radiographs showed bridging of at least three of the four bony cortices and clinically patient was able to walk full weight bearing without any pain. 23. Early, delayed and late unions were defined when complete bone healing took place within the following time frames, respectively: <6 months, 6–9 months and >9 months. 24. Union was determined both clinically and radiographically. Clinical union was defined as pain-free full weight-bearing and radiographic union was defined as bridging callus of at least three of four cortices on final imaging. The computed tomography (CT) scan was obtained in the setting of uncertainty of radiographic union on plain film radiographs. 25. Fracture healing was defined as: clinically, no pain or tenderness over the fracture zone and radiographically, three solid bridging callus ridges connecting the fracture fragment on both the anteroposterior (AP) and the lateral views. We followed the US Food	

Name	Description of OMIs including definitions	Frequency of use
	and Drugs Administration (FDA) guidelines, defining nonunion as a fractured bone that had not completely healed within nine months of injury and that had not shown progression towards healing over the past three consecutive months on serial radiographs 26. Fracture union was clinically defined as the ability to walk without aids and no pain or tenderness at the site. Radiographically, fracture union was defined as a solid bridging callus connecting the fracture fragments in both the AP and lateral radiographs 27. Bone union was defined as the ability to bear weight without pain with evidence of callus bridging at ≥3 cortices on radiographs. 28. Healing is determined by the treating surgeon based on the modified radiographic union scale in tibias (mRUST) and clinical assessments. Due to acknowledged uncertainty of these assessments, surgeons grade the radiographic, clinical, and overall assessment of fracture healing together with their certainty of these assessments. 29. As either - non-union - Failure of the fracture to progress towards healing as observed by the treating surgeon and that requires further intervention to promote healing either surgical (i.e. bone graft) or non-surgical (i.e. bone stimulator). - Or Failure of progression of fracture healing for at least 2 or 3 successive months with pain at the fracture site. 30. The definition of malunion was documented for each article. The rate of malunion according to the authors' definition was extracted from each article. The non-union rate included those fractures that developed osseous non-union after 1-year follow-up. Delayed unions were not included in the non-union rate if the fractures subsequently healed 31. Time to fracture union was based on radiological evidence of calus bridging at least three cortices. 32. All radiographs were reviewed and healing was defined as follows: bridging callus on at least three cortices as assessed on orthogonal plain radiographs and weight bearing without pain at the fracture site. 33. When both clinical (absence of pain) and radiological union (presence of bridging callus in two planes) 34. Evidence of callus formation. Localised osteolysis around fracture site if any. Locking bolt loosening/Nail loosening/Bone destruction if any/ Loss of fixation. 35. With regard to fracture healing, fractures were classified as union, delayed union or nonunion. Owing to disagreement in the literature regarding the accuracy of radiographs in diagnosing fracture union, 20 we used a combination of clinical and radiological criteria. To be classified as union, fractures had to meet 2 criteria: 1) radiographic evidence of callus cortical bridging and 2) clinical evidence of being able to tolerate functional axial and torsional load at 16 weeks or less postoperatively. Delayed union was defined as fractures that did not meet both of the previously mentioned criteria at 16 weeks post- surgery. Delayed	

Name	Description of OMIs including definitions	Frequency of use
	fractures were treated either with a pro- longed period of immobilization or with operative débridement and stabilization. Delayed unions that did not meet the criteria for union following treatment were defined as nonunions. 36. Union was defined on orthograde plain radiographs at the 6 month-and 12-month mark. For the definition of bony union, the Radiographic Union Score for Tibial fractures was used. This was then correlated with clinical information (tender and painful fracture area).11–14 The Radiographic Union Score for Tibial fractures score assigns a score based on the healing (callus formation) at each of the four cortices on an anterior-posterior and lateral radio- graph.15 Patients were categorized into two groups. The first group with a score from 4 to 6 and tenderness or pain in the fracture side was categorized as not united (radiologic and clinical nonunion). The second group was patients with a score of 10 to 12 without pain and tenderness and classified as united (radiologic and clinical union). Patients with a score from 7 to 9 were allocated to 1 of the 2 groups depending on the clinical finding. Patients with tenderness and pain over the fracture area (clinical nonunion) were considered as not united and included into the first group. Patients without tenderness and pain over the fracture area (clinical union) were categorized as united and included into the second group. 37. Diagnosis of nonunion will include a failure of the fracture to progress towards healing as observed by the treating surgeon and that requires further intervention to promote healing either surgical (i.e. bone graft) or non-surgical (i.e. bone stimulator). Final consensus on nonunion will be determined by the Central Adjudication Committee. 38. Delayed union is defined as union after 3e6 months of definitive treatment 12 without the need for revision surgery to effect union. 39. Non-union was defined as lack of healing within 6 months requiring operative care. Delayed union was defined as lack of any healing on radiographs within 3 months that required further surgical treatment. Mal-union was defined as angular deformity, translation, or rotational alignment that required surgical correction. 40. Non-union was defined as lack of healing within 6 months requiring operative care. Delayed union was defined as lack of any healing on radiographs within 3 months that required further surgical treatment. Mal-union was defined as angular deformity, translation, or rotational alignment that required surgical correction. 41. We considered union to have occurred when radiologically anteroposterior and lateral radiographs showed bridging of at least three of the four bony cortices and clinically patient was able to walk full weight bearing without any pain. 42. Fracture union where no local tenderness or percussion pain, blurred fracture lines or the formation of a continuous callus, and the ability to walk three minutes with- out external fixation. Fracture radiographic union was defined as a bridging callus across three of four cortices on orthogonal radiographs evaluated by a research investigator, as previously described.	

Name	Description of OMIs including definitions	Frequency of use
	43. The fracture was considered as united radiologically if three of four cortices showed bridging callus. Implant was removed after achieving union at fracture site. 44. Bony union was defined as radiographic union or clinical union (full painless weight bearing) reported by the radiologist or surgeon. 45. Defined as lack of bridging callus at 5 months that eventually healed within seven to nine months. 46. Union was assess radiographically using Hammer *et al.* criteria which has 5 grades with grade 1 & 2 regarded as union with "obliterated and barely discernible fracture line" with "union" achieved. The grade 3 has "uncertain" union with "discernible fracture line" and grade 4 & 5 defined as stage of union "not achieve". 47. Defined union as > 50% visible bridging callus across the fracture on the conventional radiographs and no movement or tenderness was present. 48. Normal healing was defined as healing within 6 months, and delayed union was regarded as healing after 6 months. A fractured bone that did not completely heal within 9 months of injury, as well as showing inapparent progression towards healing over three consecutive months on serial radiographs was characterized as non-union. 49. Fracture union was based on radiological evidence of callus bridging at least three cortices. Assessment of radiographic union was independently performed using two of the authors. 50. Union was defined as the presence of 3 cortices in continuity on the anteroposterior (AP) and lateral (L) x-rays and concomitant ability of the patient to fully weight-bear without pain.	
Definitions of clinical union	1. Clinical union where patients were able to walk without pain. 2. If the patient could walk on the affected limb without aid or discomfort at the fracture site. 3. Clinical union assessed by the absence of movement at fracture site and time to painless weight-bearing. 4. Clinical healing was arbitrarily defined as having achieved full weight-bearing and VAS pain score less than 4 while walking. VAS < 4 was selected because it represents mild pain. 5. Painless weight bearing and lack of local tenderness over the site on physical examination. 6. Clinical union was defined as absence of tenderness at the fracture site.	6

Name	Description of OMIs including definitions	Frequency of use
Definitions of malunion	1. Malunions were defined as more than 5° of angular deformity in any plane. Nonunions were defined by lack of bony continuity and/or failure of progression toward healing with the need for an additional unplanned procedure to gain union. 2. Malunion is defined as: 1) valgus; 2) varus, both with an angulation of more than 5 degrees in the coronal or sagittal plane; 3) malrotations; and 4) limb length discrepancy, larger than 1.5 centimeters. 3. In evaluation of fracture reduction, an angle of less than 5° was considered excellent, an angle of 5–10° fair, and an angle of more than 10° is poor. 4. Malunion or malalignment defined as an angular or rotational deformity exceeding 5° or shortening exceeding 15 mm. 5. Initial and united anatomic lateral distal femoral angles (81°65°) were evaluated on anteroposterior views. Sagittal plane re- ductions were evaluated on lateral views. Clinically significant bone loss was de- fined as the radiographic presence of antibiotic beads within a cavitary metaphyseal defect. All patients had a minimum 3-month follow-up. 6. Malalignment (or malunion) was defined as angulation or rotational deformity of 5or more, compared to the uninjured leg. 7. As more than 5 degrees or varus/valgus, more than 10 degrees of anterior/posterior angulation, more than 15 degrees of rotation or shortening of more than 1 cm. 8. Lower limb axis alignment in both the frontal and the sagittal planes. Mechanical axis deviation (MAD) was measured on the anteroposterior view standing radiograph; MAD was assessed as normal within the range of 6 mm lateral to 17 mm medial from the center of the knee. 9. > 5deg angulation. 10. Rotational alignment was checked by looking at the foot progression angle to see any excessive in toeing or out toeing as compared to the opposite foot. 11. Malalignment was evaluated as varus/valgus angulation greater than 7 degrees on radiographs. 12. Deformity was defined as angulation, when there was > 5° angulation. 13. Angular malalignment (.5 degrees of sagittal or coronal angulation referenced in contralateral leg radiographs, if non-injured. 14. Shortening was defined as > 10 mm shortening compared to the unaffected side.	20

Name	Description of OMIs including definitions	Frequency of use
	15. Bony complications were defined as mal-union, non-union, delayed union or a failure of the implant. 16. Limb alignment was determined by angulation, shortening, and rotation. Angulation was measured in the coronal or sagittal plane. Shortening was determined by clinical comparison with the contralateral leg. Rotational malalignment was measured in both lower extremities clinically as the thigh-foot angle (TFA) and when suspicions remained, a determination was made by CT. Unsatisfactory alignment was defined when one of the following criteria was met: [1] shortening of 1 cm or more; [2] varus or valgus angulation of 5 degrees or more; [3] anterior or posterior angulation of 10 degrees or more; or [4] rotational malalignment of 10 degrees or more compared with the contralateral leg. 17. Malrotation (.10 degrees, determined by the foot-thigh angle). 18. Defined as a varus or valgus angulation of more than 5 degrees, anterior or posterior angulation of more than 10 degrees, shortening of more than 1.5 cm or more than a 0.5 cm gap at the fracture site. 19. Malunion was defined as more than 5 of angular or rotational malposition or of more than 1 centimeter of shortening. 20. Malunion defined as leg length discrepancy (.1 cm shortening)	
Definitions of non-union	1. Nonunion, was defined as lack of union requiring unplanned surgical intervention after definitive wound closure or incomplete radiographic healing at 1 year. 2. Nonunion was indicated by recommendation of bone-grafting or other surgical intervention for nonunion. 3. Nonunion was defined as lack of radiological union 12 months post injury, as evidenced by bridging callus across three of four cortices, in two views on plain radiographs. Fractures requiring secondary procedures to promote union, excluding simple dynamization, or if diagnosed as such by an attending surgeon, were also classified as a nonunion. 4. Nonunion was described when either there was no progression of healing for continuous 3 months with the sclerosis of fracture ends or there was gap between fracture ends. Union was considered to be delayed whenever the progression of bridging callus is slow as evident from the serial radiographs usually diagnosed early at 24–28 weeks. 5. Non-union was described when either there was no progression of healing for continuous 3 months with sclerosis of fracture ends or there was gap between fracture ends. 6. Nonunions were defined by lack of bony continuity and/or failure of progression toward healing with the need for an additional unplanned procedure to gain union.	16

Name	Description of OMIs including definitions	Frequency of use
	7. Failure of the fracture to progress toward healing, as observed by the treating surgeon, and required further surgical (i.e. bone graft) or nonsurgical (i.e. bone stimulator) intervention to promote healing 8. Final outcome was assessed in terms of presence or absence of non-union at 16 weeks on AP and lateral X-rays of the tibia and Fibula. 9. Nonunion was described when either there was no progression of healing for continuous 3 months with the sclerosis of fracture ends or there was gap between fracture ends. 10. Nonunion was described when either there was no progression of healing for continuous 3 months with the sclerosis of fracture ends or there was gap between fracture ends. 11. Diagnosis of nonunion was based on clinical and radiological findings over a minimum follow-up period of >1.2 years. A fracture was not considered to be a nonunion until 12 months after the injury, to account for potential cases of delayed union. The clinical criteria used to define nonunion included the presence of pain and/or motion in response to physiological strain of the affected limb (eg, the inability to fully weight bear without pain). The radiographic confirmation of union relied on the presence of bridging callus in at least 3 of 4 cortices assessed on anteroposterior and lateral radiographs. 12. Non-union was defined as failure of union of two or more cortices on biplanar radiographs at six months or no radiological progress in union for the preceding three months in the presence of bone defect involving two or more cortices 13. Time to union was defined by the radiographic union score in the tibia (RUST) score at 6 months. 14. Defined as absence of a bridging callus across a fracture site after the expected time interval for that injury (usually 10 months) 15. Diagnosis of nonunion was based on clinical and radiological findings over a minimum clinic follow-up period of >1.2 years, according to the principle outlined by Frölke *et al*, which reaffirms the contribution of the Weber and Cech model of nonunion, specifying that in long bones, a minimum of 6 months should pass before nonunion is considered. 16. Nonunion was defined as painful fracture with inadequate healing of the fracture 6 months after injury and requiring revision surgery to achieve union.	
Definitions of radiographic bone union	1. X-rays were rechecked regularly to examine the status of fracture healing, and we used the Lane-Sandhu score (Table II) to evaluate the callus formation rate and visible level of fracture line at the same time points as above. 2. The main outcome measure was fracture healing (i.e. adequate callus formation) on X-ray at twenty four weeks.	33

Name	Description of OMIs including definitions	Frequency of use
	3. Radiographic union if callus on two radiographs with absence of the fracture line. 4. Union and consolidation were defined as the union of three of four cortices on antero-posterior and lateral radiographs. 5. Radiological union was defined as bridging callus formation and absence of a fracture line at the site of three out of four cortices. Time to heal was defined as the time of radiologic union allowing removal of external fixation [26]. Callus volume was evaluated by CT scan at 12 months, and compared to the pre-grafting CT scan. 6. Routine follow- up radiographs were obtained every 4 weeks until solid continuous callus formation was observed; callus formation on 3/4 of the cortices and radiographic evidence of fracture line fading were considered signs of fracture union. 7. Bridging callus on anteroposterior and lateral radiographs as well as the absence of pain on palpation and weight bearing 8. Delayed healing was defined as at least 2 consecutive postoperative visits with lack of radiographic progression or incomplete radiographic healing with ongoing clinical symptoms between 6 months and up to 1 year after fracture. 9. Presence of at least three corticals in anterolateral and lateral x-ray. 10. Radiographic union presence of a mature bridging callus in at least three of the four cortices in antero-posterior and lateral radiographs. Clinical union was defined as complete when the patient was able to bear full weight on the operated leg without pain or support. 11. Presence of bridging calluses on 2+ cortices. 12. Presence of callus. 13. Defined as complete union of the cortexes with sufficient callus support and continuity of the medullary canal on both anteroposterior and lateral radiographs. 14. Three or more of four cortices had bridging callus in anteroposterior and lateral views. 15. Union was considered to have occurred when anteroposterior and lateral radiographs showed bridging of three of the four cortices. 16. We defined union as more than 50% visible bridging callus across the fracture on conventional radiographs.	

Name	Description of OMIs including definitions	Frequency of use
	17. Callus formation on 3/4 cortices and radiographic evidence of fracture line fading were considered signs of fracture union. 18. Bridging callus across three of four cortices on orthogonal radiographs evaluated by one investigator at each site. 19. Fracture union was assessed on the basis of clinical and radiographic criteria: 1) bridging cortical bone on at least three cortices; 2) incorporation of the grafted fibula into the tibia; 3) no motion at the fracture site; and 4) painless ambulation. 20. Bone union is defined as the return of bone anatomic continuity at the fracture site (radiological union). 21. Within an average of 6 months (range 5–9 months), all patients had radiographic evidence of bony union (100 %) with a bridging callus and blunting of the fibula at both the proximal and the distal graft–host bone junction. 22. Fracture radiographic union was defined as a bridging callus across 3 of 4 cortices on orthogonal radiographs evaluated by a research investigator, as previously described. 23. Bridging callus across three of four cortices on orthogonal radiographs evaluated by one investigator at each site. 24. Bridging callus across three of four cortices on orthogonal radiographs evaluated by an MD research investigator. 25. The presence of external callus bridging the fracture site or absence of fracture lines was regarded as radiological union. 26. A radiographic union score for tibia (RUST) fractures. 27. The last available radiographs (anteroposterior and lateral) closest to the 52-week visit were independently adjudicated by 3 orthopaedic trauma surgeons blinded to treatment assignment using Radiographic Union Score for Tibial fractures criteria. 28. Healing was defined radiologically by the presence of a bridging callus. 29. We defined an uncomplicated fracture union as a patient who went on to fracture union without any additional surgeries. 30. Radiographic union as measured by the modified Radiographic Union scale in Tibia score. Whelan DB, Bhandari M, Stephen D, *et al*. Development of the radio- graphic union score for tibial fractures for the assessment of tibial fracture healing after intramedullary fixation. J Trauma. 2010;68:629–632. 31. Radiological union: Bridging of the bone on a minimum of three cortices on conventional antero-posterior and lateral radiographs.	

Name	Description of OMIs including definitions	Frequency of use
	32. Radiographic union was achieved according to union score described by Hammer *et al*. Accuracy of radiologic assessment of tibial shaft fracture union in humans. Clin Orthop Relat Res 1985;199:233–8. 33. Time to radiological fracture healing was measured. According to Angelini *et al*. radiographic union was defined as bridging bone on a minimum of 3 cortices in antero-posterior and lateral radiographic views.	
Definitions of amputation	1. amputation occurring at or below the knee and up to the ankle. 2. Any amputation occurring within the first 3 months of the initial injury. 3. Surgical removal of limb or part thereof. 4. A late or delayed amputation was defined as one performed more than three months after the injury, an early amputation was performed between twenty-four hours and three months after the injury, and an immediate amputation was defined as one performed less than twenty-four hours after the injury. 5. The amputation was defined as “early” if performed within 3 months of the trauma and “delayed” if performed thereafter.	5
Definitions of pin site loosening	1. A pin was considered loose if the pin site demonstrated erythema, pain, or discharge and the concordant radiographs showed at least 1 mm of radiolucency on both sides of the proximal cortex around the pin.	1
Definitions of range of movement	1. Range of movement at knee and ankle. 2. Defined as 70°loss of knee flexion or 15° loss of knee extension, 50° loss of ankle motion, all as compared with the normal contralateral side. 3. Reported in degrees of motion. 4. Reported in degrees of motion. 5. Clinical examination, knee and ankle range of movement were examined by an independent examiner in comparison to the contralateral healthy side using a goniometer.	5
External fixation index (EFI) (324)	Physician reported outcome measurement instrument. The EFI was calculated by dividing the time (days) in the external fixator by the lengthening achieved (centimeters).	1
Infection outcome measurement instruments		

Name	Description of OMIs including definitions	Frequency of use
Definitions of deep infection	1. Clear counts of some bacterial organisms from bone or tissue below the muscular fascia. 2. Infection of the bone and deep tissue necessitating unplanned operative irrigation and debridement. Planned repeat debridements and superficial infections, which did not need further surgery, were not considered to be deep infections. 3. The diagnosis of 'deep Infection' was based on the criteria described by the Centers for Disease Control and Prevention (CDC) for 'deep incisional surgical site infection' as per Fig. 1. In particular, the definition was not reliant on positive deep cultures and assumed that any intervention, revision or antibiotic use was indicative of infection in this cohort. 4. Deep infections were defined as culture positive and requiring surgical debridement. 5. Defined as infection of the injured bone and deep tissue necessitating an unplanned operative irrigation and debridement at more than two weeks after the injury. We chose a two-week cutoff in order to address the concern of whether an early debridement was planned or unplanned. Planned repeat debridements and superficial infections not requiring surgery were not considered to be deep infections. 6. Deep infection was defined as infection requiring unplanned surgical debridement and/or sustained antibiotic therapy after definitive wound closure. Cellulitis and pin tract infections alone were not considered indicative of deep wound infection, but these were treated with the appropriate antibiotics at the surgeons' discretion and outcomes recorded. Nonunions were defined as unplanned surgical intervention after definitive wound closure or incomplete radiographic healing 1-year post fracture. 7. Centers for Disease Control criteria for deep surgical site infection. Gopal S, Majumder S, Batchelor AG, *et al*. Fix and flap: the radical orthopaedic and plastic treatment of severe open fractures of the tibia. J Bone Joint Surg Br. 2000;82:959–966. 8. The presence of a deep surgical site infection (SSI) was determined using the criteria of the Centers for Disease Control.19 Deep SSI is defined as occurring within 30 days after the operation, if no implant is left in place, or within 1 year, if implant is in place and the infection appears to be related to the operation. In addition, the infection must involve deep soft tissues (eg, fascial and muscle layers) of the incision and at least one of the following: (1) purulent drainage from the deep incision; (2) a deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (38.8C), localized pain, or tenderness; (3) an abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination; or (4) diagnosis of a deep SSI by a surgeon or attending physician. 9. Deep wound infections required surgical debridement for a purulent wound or osteomyelitis and were treated with intravenous antibiotics for at least several weeks.	31

Name	Description of OMIs including definitions	Frequency of use
	10. wound infections that required an unplanned return to the operating room for irrigation and debridement after wound closure or application of a negative pressure dressing. 11. Centers for Disease Control and Prevention definition of a 'deep surgical site infection': that is, a wound infection involving the tissues deep to the skin that occurs in the first year following the injury.14 Any infection that requires continuing medical intervention or has already led to amputation at or after the routine 6-week outpatient appointment will be considered a deep infection. 12. Deep infection was defined as present only if the infection required surgical debridement and long-term IV antibiotics based on infectious disease service consultation. 13. Any infection that warranted operative debridement was considered a deep infection. 14. The diagnosis of postoperative wound infection was confirmed using clinical signs and symptoms (erythema, swelling, warmth, constitutional symptoms), documented presence of a draining sinus and elevated serum markers (C-reactive protein, erythrocyte sedimentation rate). Deep infections were those extending to the fracture site, causing abscess formation and/or osteomyelitis. 15. Required IV antibiotics and operative intervention including soft tissue or bone debridement, secondary wound closure or soft tissue transfer and possible hardware removal. 16. Deep-site infection" was defined as an infection existing in a body part deeper than the skin/adipose tissue, including that leading to abscess formation or osteomyelitis. 17. Deep infection involving bone was diagnosed if there was a purulent discharge requiring further bony debridement. 18. Apart from explicitly documented, a deep infection was also considered to occur when terms such as fistula, deep abscess, sequestration and infected non-union were used in the manuscripts. 19. Infection within 30 days after the operation if no implant is left in place or within 1 year if implant is in place and the infection seems to be related to the operation and infection involves deep soft tissue (eg, fascia, muscle) of the incision. 20. A wound or deep infection is defined as an invasion of the joint or the soft tissues around the joint by pathogenic microorganisms. 21. Deep infection was defined as infection requiring surgical debridement with positive deep tissue or bone cultures.	

Name	Description of OMIs including definitions	Frequency of use
	22. Infection occurred at any point in the study period and appeared to be related to the initial injury, or operation. The diagnosis of deep infection was not reliant on positive deep cultures and assumed that any surgical intervention, revision, or antibiotic use was indicative of infection. And infection involved the deep soft tissues (e.g. fascial and muscle layers) of incision. And at least one of the following: 1. purulent drainage from deep incision. 2. the deep incision spontaneously dehisced, or was deliberately opened by a surgeon when the patient had at least one of the following signs or symptoms: fever (>38 degrees C), localized pain, or tenderness. 3. An abscess or other evidence of infection involving the deep incision was found on clinical examination, during reoperation, or by histopathological/radiological examination. 23. Deep incision surgical site infection', as outlined by the Centers for Disease Control and Prevention (CDC). 24. Infection requiring surgical debridement and irrigation after operative treatment of an open fracture or the development of an infected nonunion requiring treatment (positive intraoperative cultures), within one year after fracture treatment. 25. Deep infection was defined as infection deep to fascia requiring surgical debridement. 26. Defined by the surveillance definitions of Center of Disease Control and Prevention. 27. Major deep infection' was defined as patients requiring removal or exchange of metalwork for infection, delayed flap failure (partial or complete) due to infection, or deep infected collection requiring surgical drainage. Clinically diagnosed superficial infections that resolved with the administration of antibiotics (e.g. cellulitis) were not included. 28. Centers for Disease Control (CDC) definition.12 This definition covers infection occurring within 30 days of sur- gery, unless an implant is in place, in which case this period is extended to 12 months. Deep SSI presenting within 12 months of injury and any wound infection requiring continuing medical or surgical intervention after 30 days, including those leading to amputation, were also recorded as a deep SSI. 29. Surgical site infection (SSI) at 30 days as per the Centers for Disease Control and Prevention definition. 30. Deep surgical site infection (SSI) at 30 days as per the Centers for Disease Control and Prevention definition. 31. Defined as purulent drainage or osteomyelitis presenting after definitive wound healing and diagnosed based on clinical suspicion and subsequent culturing, which required prolonged antibiotics or surgical debridement.	
Definitions of deep Wound Infection	1. Deep wound infections included in this study are defined using the criteria set out in the Centers for Disease Control and Prevention document 'Definition of Healthcare- Associated Infection and Criteria for Specific Types of Infections in the Acute Care Setting' [11]. Where studies did not describe infection according to these criteria, judgements on inclusion were taken. CDC. CDC/NHSC Surveillance definition of healthcare-associated infection and criteria for specific types of infections in the	5

Name	Description of OMIs including definitions	Frequency of use
	acute care setting. 2013 . Available from: http://www.cdc.gov/nhsn/pdfs/ pscmanual/17pscnosinfdef_current.pdf. Cited 8 July 2013 2. The diagnosis of postoperative wound infection was confirmed using clinical signs and symptoms (erythema, swelling, warmth, constitutional symptoms), documented presence of a draining sinus and elevated serum markers (C-reactive protein, erythrocyte sedimentation rate). Superficial infections were those limited to the skin and subcutaneous tissues. 3. A deep soft tissue infection was defined as any soft tissue infection that was not successfully treated by antibiotics alone and required operative intervention. 4. Deep soft tissue infection was defined as any soft tissue infection characterized by redness, warmth, swelling, or purulence that required operative intervention. 5. Any soft tissue infection greater than 2 weeks after the coverage procedure that was not successfully treated by antibiotics and required a return to the operating room	
Definitions of infected implant	1. Any chronic wound in the vicinity of the implant, including intermittently draining sinuses.	1
Definitions of Infection	1. Laboratory culture results and presence of clinical infection. 2. CRP and/or white cell count was elevated in combination with pus, discharge or wound breakdown, pro- vided it was related to the initial lesion, including the flap. 3. Centers for Disease Control criteria. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR; Hospital Infection Control Practices Advisory Committee. Guideline for prevention of surgical site infection, 1999. Infect Control Hosp Epidemiol. 1999 Apr;20(4):250-78; quiz 279-80. 4. Wound infection or osteomyelitis treated within the first three months after the injury. 5. The infection (outcome variable) was identified based on clinical and laboratory findings, according to the criteria of early infection within a two week interval proposed by Willenegger and Roth. This means that the lesion was considered to be infected if the wound had any aspect of superficial or deep infection with or without fever, leukocytosis and elevated erythrocyte sedimentation rate (ESR).	45

Name	Description of OMIs including definitions	Frequency of use
	6. The primary outcome variables collected were the presence of infection, type of infection, and the microbiological details of the infections identified. The definition of infection was adapted from the Centre for Disease Control definitions of nosocomial surgical site infections and definitions of infection proposed by Dellinger. Superficial infection was defined as redness and/or discharge from a wound which was treated with antibiotics. Operative debridement may have been performed, but there was no evidence documented of infection below the deep fascia. To be classed as a superficial infection, it must have been managed entirely without exposure of the underlying bone and/or implants. If symptoms of a superficial infection commenced more than 30 days after injury, it was not included, as this deemed unlikely to be a complication of the initial treatment of the open fracture wound. Deep infection was defined as redness and/or discharge from the wound with documented evidence of infection below the level of the deep fascia. If exposure of the underlying bone or implants occurred, either by wound breakdown or by operative debridement, then the infection was classified as deep. Deep infection was excluded if symptoms commenced more than a year after the injury date, as suggested by the Centre for Disease Control definitions by Horan *et al*. 7. Assessment of wound healing and infective complications were made using a modified version of the ASEPSIS wound scoring system as recommended by the surgical infection study group. The maximum score is 65. According to study by Ashby *et al*. a score of more than 20 is suggestive of infection. It is objective and repeatable with high sensitivity. For the purpose of this study, a score of 0–20 was taken as normal wound healing and a score of more than 20 as wound infection. The score was recorded at day 2, day 5 and day 14 following debridement. The highest score for each patient was adopted as determined at days 2, 5 and 14. Peel AL, Taylor EW. Proposed definitions for the audit of postoperative infection: a discussion paper. Surgical Infection Study Group. Ann R Coll Surg Eng 1991;73:385–8. 8. The definition of infection required the presence of pus and surgical treatment, along with the prescription of antibiotics, targeting the infection. Infections occurring after two months of the first surgical treatment or during a subsequent hospitalisation were considered to be hospital-acquired and excluded, as were patients with infections caused by methicillin-resistant Staphylococcus aureus (MRSA) or methicillin-resistant coagulase-negative staphylococci. 9. Infection was defined as chart documentation of either a superficial or deep regardless of culture positivity. Superficial infections involved a documented SSI not affecting bone that required treatment with systemic antibiotics or local debridement. Deep infections involved a documented SSI with bone involvement as well as the need for surgical debridement. 10. Requiring unplanned surgical debridement and/or sustained antibiotic therapy. 11. The determination as to whether a patient incurred an infection varied from institution to institution. Factors that were used as determinants of infection included identification through patient records, the presence of deep wound cultures obtained at surgery, the administration of oral and/or paren- teral antibiotics, or consultation with infectious disease physicians. The incidence of infection was then compared between seasons within a given region, and then between institutions for each season.	

Name	Description of OMIs including definitions	Frequency of use
	12. Classified by use of a modified CDC criteria: Superficial incisional surgical site infection (SSI) is defined as an infection that involves only the skin or subcutaneous tissue and at least one of the following: o Purulent drainage, with or without laboratory confirmation, from the superficial incision. Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision. o At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat and superficial incision is deliberately opened by the surgeon, unless incision is culture-negative. Deep incisional SSI is an infection that involves deep soft tissues (e.g. fascial and muscle layers) and at least one of the following: o Purulent drainage from the deep incision but not from the organ/space component of the surgical site. o A deep incision spontaneously dehisces or is deliberately opened by the surgeon when the patient has at least one of the following signs or symptoms: fever (>38C), localized pain, or tenderness, unless the site culture is negative. o An abscess or other evidence of infection involving the deep incision found on direct examination, during re-operation, or by histopathologic or radiologic examination. Organ/space SSI is an infection that involves any part of the anatomy (e.g. organs or spaces), other than the incision, which was opened or manipulated during an operation and at least one of the following: o Purulent drainage from a drain that is placed through a stab wound into the organ/space. o Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space. o An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination. When interpreting these criteria, any infections that are superficial to the fascia were considered “Superficial Incisional SSI” and any infections that were deep to the fascia were considered “Deep Incisional SSI” (including infections of bone (osteomyelitis)). Organ/Space SSI referred to any infections that affect an organ other than bone. 13. Infection was defined when pus was present also when surgical and antibiotic care was considered necessary for the treatment of the infection. 14. ASEPSIS19 (Additional treatment, presence of Serous discharge, Erythema, Purulent exudate, Separation of deep tis- sues, Isolation of bacteria, and duration of inpatient Stay) wound score. Wilson AP, Treasure T, Sturridge MF, Grüneberg RN. A scoring method (ASEPSIS) for postoperative wound infections for use in clinical trials of antibiotic prophylaxis. Lancet 1986;1:311–313. 15. Pyrexia, raised total leucocyte count and local signs like pus discharge from the wound with erythema of skin edges within 1 week of primary debridement. 16. Centers for Disease Control diagnostic criteria for infection were used 17. Infection was classified into two groups, namely, superficial or deep (implant-related) infections, which were defined according to Dellinger *et al*. and CDC-guidelines. A superficial wound infection was one located above the fascia, with erythema and tenderness. A deep implant-related infection was defined as an infection involving deeper tissues as muscular fascia and bone, which could necessitate removal of the osteosynthetic material.	

Name	Description of OMIs including definitions	Frequency of use
	18. Superficial infection was defined as cellulitis or presence of serous discharge from the wound or pin tracks that resolved with oral antibiotic therapy and dressings. Deep infection was defined as soft-tissue or bone infection requiring surgical debridement, intravenous antibiotics, and/or removal of implants. 19. The diagnosis of infection was based on the presence of discharge, fever, local induration, gaping of the wound, and culture of wound swabs. 20. Outcome measures included presence of infection requiring rehospitalization and need for soft tissue coverage or limb amputation within 3 months of the initial injury. Infection was determined by positive growth from intraoperative cultures or documentation of the presence of infection by the treating surgeon (to allow inclusion of culture negative infections). Need for soft tissue coverage included local flap or free flap procedures. Limb amputation was subclassified into 2 categories: acute amputation (#1 week from injury) and delayed amputation (1 week–3 months from injury). 21. Infections are categorized according to standard Centers for Disease Control and Prevention definitions of surgical site infection. Deep infections are defined as those that require operative treatment; superficial infections are those treated only with antibiotics and wound care, and no operative treatment for the infection. All cases of infection collect the same information recorded on the METRC infection case report form (CRF) to help adjudication of this outcome. 22. Deep infection was defined as positive deep wound cultures without positive bone cultures. 23. Based on hematological, microbiological, clinical, and, where performed, nuclear medicine investigations - but not clearly defined. 24. Deep infection was considered to occur when terms such as fistula, deep abscess, sequestration, osteitis and infected non-union were used in the manuscripts. 25. Occurrence of a fistula, an abscess, need for antibiotics or follow-up surgery related to infection was considered as a recurrence of the original infection. Normal kinetics for CRP were defined as an increase after surgery until a peak value was reached, followed by a decrease. Peak value was defined as the earliest value obtained after surgery which was preceded and followed by measurements with lower values. Normalization of CRP was evaluated during follow up. 26. Infections will be classified according to the Center for Disease Control (CDC) Criteria. We will define infection in patients as a constellation of clinical symptoms and laboratory examinations. These will include (but are not limited to) fever, erythema/cellulitis, positive tissue cultures, and frank purulent drainage. 27. Centers for Disease Control and Prevention criteria.	

Name	Description of OMIs including definitions	Frequency of use
	28. ASEPSIS19 (Additional treatment, presence of Serous dis- charge, Erythema, Purulent exudate, Separation of deep tis- sues, Isolation of bacteria, and duration of inpatient Stay) wound score. Wilson AP, Treasure T, Sturridge MF, Grüneberg RN. A scoring method (ASEPSIS) for postoperative wound infections for use in clinical trials of antibiotic prophylaxis. Lancet 1986;1:311–313. 29. Soft tissue and deep metal infection were defined by the presence of clinical signs of infection (increasing erythema and/or suppurative discharge from the wound as assessed by a PRSU surgeon, orthopaedic surgeon or infectious diseases physician) with positive cultures from soft tissues and fixation hardware, respectively. 30. Although the definition of wound infection following operative treatment of fractures has considerable variation, we utilized the following Centers for Disease Control and Prevention (CDC) criteria for surgical site infection as applied to orthopaedic wounds. A superficial wound infection was one that was located entirely above the fascia and did not require exposure of the bone or hardware. In those cases in which the fascia was absent secondary to the initial injury or subsequent debridements prior to definitive fracture fixation, the wound infection was considered superficial if there was no exposed bone or hardware and the infection did not track down to these structures. A deep wound infection was one that tracked down to the level of the bone and/or implants. In this study, all deep infections, in addition to meeting the CDC criteria, were required to have positive deep-tissue cultures and/or were treated with six weeks of parenteral antibiotic treatment in addition to irrigation and debridement of the wound. 31. Infection was diagnosed when there was purulent discharge with positive bacteriological culture. 32. Infection was diagnosed when there was purulent discharge with positive bacteriological culture. 33. Infection within 30 days after the operation if no implant is left in place or within 1 year if implant is in place and the infection seems to be related to the operation and infection involves any part of the anatomy (eg, organs and spaces) other than the incision. 34. Presence of culture-positive osteomyelitis, infected nonunion, cellulitis, or abscess requiring treatment. 35. The development of infection was identified based on the surgeon’s or infectious disease physician’s documentation in the chart. 36. Clinical criteria for diagnosis of infection included: new pain/tenderness at the level of the fracture, nail insertion site, or locking screws; episodes of fever/chills; night sweats; tachycardia; localized swelling; erythema; or drainage. In addition, radiographs were reviewed for signs of infection: lucency around the nail or locking screws, loss of cortical density around the fracture site, or periosteal reaction around the intra-medullary nail.	

Name	Description of OMIs including definitions	Frequency of use
	37. Infection was diagnosed according to the criteria of Willenegger and Roth. The diagnosis was made based on the presence of signs and symptoms of infection such as pain out of the area of injury, swelling, redness, purulent drainage, and high fever with a body temperature >38.5°C, along with laboratory test results such as an increased white cell count, continuously or increasingly raised erythrocyte sedimentation rate and C-reactive protein, as well as positive fluid culture results. 38. We considered any infection reported at follow-up to be clinically significant and therefore did not differentiate between deep and superficial infections. 39. Infection was assessed using South-Hampton criteria 40. Infection included all of bone and joint infection, which required a surgical debridement and shaving procedure associated to an antibiotic delivery 41. Infections were defined using standard Centers for Disease Control and Prevention criteria. Deep infections were defined as those requiring operative treatment; superficial infections were treated with antibiotics and wound care. 42. Infection was defined using the Horan criteria and definition for surgical site infections. 43. Infective complications were defined as osteomyelitis, implant infection or soft tissue infection. 44. Infection was diagnosed when there was purulent discharge with positive bacteriological culture. 45. Infection was subdivided into pin-track infection, superficial wound infection, and deep tissue infection. A pin-track infection was inflammation around the pin-track. A superficial wound infection was one located in the initial or operative wound that was above the fascia, with erythema and tenderness. A deep infection was defined as infection involving deeper tissues, such as muscular fascia and bone.	
Definitions of joint sepsis	1. Knee with infection that required reoperation with arthrotomy or arthroscopy. 2. We defined knee sepsis as clinical signs and symptoms of infection leading to reoperation with an arthrotomy or arthroscopy within 1 month. 3. Defined as presence of a positive culture from knee aspiration or arthrotomy. Deep infection requiring operative debridement, superficial infection requiring antibiotic therapy alone.	3
Definitions of osteomyelitis	1. Osteomyelitis was identified by a positive bone culture obtained in the operating room that required antibiotic treatment, as documented in the health systems network medical records.	11

Name	Description of OMIs including definitions	Frequency of use
	2. Deep osteomyelitis is defined as the inflammation of bone, bone marrow, and surrounding soft tissues, characterized by ongoing pain, secretion, or swelling accompanied by a significant increase in inflammatory markers [increased body temperature > 38°C and white blood count (WBC) > 12,000], with or without radiological evidence. 3. Discharging sinus, fixed puckered overlying soft tissue and radiological changes consistent with chronic osteomyelitis 4. Osteomyelitis was defined as a deep infection with positive intraoperative bone cultures. 5. Osteomyelitis was defined as deep infection with positive bone cultures. 6. Including the first day surgery, debridements, vacuum dressing placements, fasciotomy closures and all procedures performed later. 7. Positive bone and indium or magnetic resonance imaging scan results, or positive bone cultures testing results. 8. Osteomyelitis was identified acutely by clinical evidence with positive cultures from bone, and chronically by X-rays, MRI or CT imaging. 9. Positive bone culture and those treated for presumptive osteomyelitis with 6 weeks of intravenous antibiotics. 10. Deep infection with positive intraoperative bone cultures during the return to the operating room. 11. Osteomyelitis diagnostic criteria were classified as definite/probable (positive bone culture, direct evidence of infection, or symptoms with culture and/or radiographic evidence) and 105 were classified as possible (bone contamination, organism growth in deep wound tissue, and evidence of local/systemic inflammation). Osteomyelitis recurrence was defined as a subsequent osteomyelitis diagnosis at the original site ≥ 30 days after completion of initial treatment	
Definitions of pin site infection	1. Pin site infection was defined using Checkett score. Checketts RG, Otterburn M, MacEachern G. Pin track infection: definition, incidence and prevention. Int J Orthop Trauma 1993:3(Suppl)16–18. 2. Pin site infections were classified into 6 grades, from grade 0 to grade V (grade 0, normal; grade I, inflamed; grade II, serous discharge; grade III, purulent discharge; grade IV, osteolysis; and grade V, ring sequestrum). 3. Pin site infections were graded according to Paley [14] as follows: grade I (soft-tissue inflammation), grade II (soft-tissue infection), or grade III (bone infection). 4. Pin tract infection was classified and treated according to the Checketts-Otterburn classification system.	4
Definitions of recurrent infection	1. Recurrent infection was defined as the presence of two of the following signs: • local inflammation with or without pus; 2 • C-reactive protein ≥ 10 mg/L; 3. • presence of bone sequestrum on radiographs	1

Name	Description of OMIs including definitions	Frequency of use
Definitions of wound infection	1. The Cutting and Harding criteria were used to define the presence of infection clinically. These criteria included abscess, cellulitis, wound discharge, discolouration, delayed healing, friable granulation tissue, unexpected pain and tenderness, pocketing at the base of the wound, epithelial bridging, abnormal smell and wound breakdown. Fernandez R (2008) Review: infection rates do not differ for wounds cleansed with saline or water. Evidence-based Medicine 13, 179. 2. ASEPSIS scoring system. Wilson AP, Treasure T, Sturridge MF, Grüneberg RN. A scoring method (ASEPSIS) for postoperative wound infections for use in clinical trials of antibiotic prophylaxis. Lancet 1986;1:311-13. 3. Which consisted of wounds with skin edge necrosis and prolonged serous drainage 4. A diagnosis of superficial soft-tissue infection was made if there were clinical signs of infection with positive bacteriological cultures. 5. The presence of cellulitis or pus involving the soft tissues at the traumatic wound in the absence of clinical or radiological features of osteomyelitis (requiring antibiotic treatment or surgical intervention). 6. Infection within 30 days after the operation and only involves skin and subcutaneous tissue of the incision. 7. A superficial infection was defined as local cellulitis with or without serous discharge treated with oral antibiotics. 8. The indicators for late deep infection include prolonged courses of antibiotics and/or debridement surgery. For any such outcomes that may be unclear, blinded data and imaging review will be per- formed by two independent orthopaedic surgeons who will adjudicate the final recorded outcome. 9. Defined as clinical findings of superficial and local erythema, swelling, and tenderness of the wound or pin track, which were resolved with the administration of antibiotics 10. Superficial infection was defined as infection superficial to fascia, treated with local wound care and/or oral antibiotics. 11. As defined by the surveillance definitions of Center of Disease Control and Prevention	11
Pain outcome measurement instruments		
Brief Pain Inventory (BPI) (286)	Patient-reported outcome measurement instrument assessing the severity of a patient's pain and the impact of this pain on the patient's daily functioning. The BPI consists of 9 items assessing the following: 1. pain other than every day kind of pains 2. location of pain (shading diagram) 3. worst pain in the last 24-hours	2

Name	Description of OMIs including definitions	Frequency of use
	4. least worst pain in the last 24-hours 5. Pain on average 6. Pain right now 7. treatments/medications for pain 8. relief of pain from treatment/medication 9. pain interference in the last 24 hours (general activity, mood, walking ability, normal work, relations with other people, sleep, enjoyment of life)	
Visual Analogue Scale (VAS) (287)	Patient-reported outcome measurement instrument to assess pain. The VAS is a unidimensional measure of pain intensity. Often assessed on a 0-100mm scale.	6
2. Nervous system outcome measurement instruments (17)		
Oxford MRC score (325)	Physician reported OMI to assess muscle strength. Response items: 1. flicker of movement 2. through full range actively with gravity counter balanced 3. through full range actively against gravity 4. through full range actively against some resistance 5. through full range actively against strong resistance	2
3. Renal and urinary outcome measurement instruments (19)		
Acute Kidney Injury outcome measurement instruments		
Definitions of acute kidney injury	1. Defined as any increase in the serum creatinine concentration >50% above the patient's admission value. 2. Acute kidney injury was defined as a serum creatinine concentration greater than or equal to 1.5 times baseline during hospitalization	2
RIFLE Criteria (326)	Physician reported OMI assessing acute kidney injury Assessment areas: 1. Risk of kidney injury 2. Injury to kidney 3. Failure of kidney 4. Loss of kidney function 5. End-stage kidney disease	1
4. Psychiatric outcome measurement instruments (21)		

Name	Description of OMIs including definitions	Frequency of use
Depression outcome measurement instruments		
Patient Health Questionnaire (PHQ-9) (327)	Patient-reported outcome measurement instrument measuring depression against 9 domains for depression taken from the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition.	1
Post-traumatic stress disorder outcome measurement instruments		
Post-traumatic Stress Disorder (PTSD) Checklist (328)	Patient-reported outcome measurement instrument assessing the severity of PTSD symptoms. The checklist has 17 response items based on the Diagnostic and Statistical Manual of Mental Disorders-IV criteria for PTSD.	1
Stress outcome measurement instruments		
Definitions of physical and mental stress	The physical and mental stress of the treatment for the patients and the nearest relative of patients were assessed at the time of frame removal using a custom-made questionnaire on a 10-point rating scale, with 0 indicating no stress and 10 indicating maximum stress.	1
3. Life impact outcome measurement instruments		
1. Physical functioning (25)		
American Orthopedics Foot and Ankle Society (AOFAS) ankle-hindfoot scale (199)	Patient and clinical reported outcome measurement instrument. Response domains include: 1. pain 2. functional limitation on recreational and daily activities 3. maximum walking distance in blocks 4. walking ability on different surfaces 5. Gait abnormality 6. Sagittal motion 7. hindfoot motion 8. ankle -hindfoot stability 9. Alignment	23
Association for the Study and	Physician reported outcome measurement instrument. The ASAMI criteria assess two domains: 1. bone results (union, infection, deformity, re-fracture and limb length discrepancy)	24

Name	Description of OMIs including definitions	Frequency of use
Application of the Methods of Ilizarov (ASAMI) criteria (198)	2. functional results (active walking, limp, stiffness, knee extension, ankle doors flexion, reflex sympathetic dystrophy, pain, amputation, employment and return to activities of daily living)	
Chen grading system (329)	Physician reported outcome measurement instrument to grade the functional status of the lower limb. Domains covered include: 1. return to previous work 2. walking with a normal gait 3. range of movement of the knee and ankle 4. sensation 5. trophic ulcers	1
Disability Rating Index (DRI) (282,283)	Patient-reported outcome measurement instrument assessing the level of disability. It consists of 3 domains with the following 12 response items: 1. basic activities of daily life: dressing, outdoor walks, climbing stairs and sitting a long time. 2. daily physical activities: standing bent over a sink, carrying a bag, making a bed and running. 3. work-related/more vigorous activities: light work, heavy work, lifting heavy objects and participating in exercise/sports.	3
Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire (330)	Patient-reported outcome measurement instrument specific to the upper-extremity. The DASH is a 30 item symptom scale delivered over 3 domains: 1. degree of difficulty in performing different physical activities because of the arm, shoulder, or hand problem (21 items) 2. the severity of each of the symptoms of pain, activity-related pain, tingling, weakness and stiffness (5 items) 3. the problem's impact on social activities, work, sleep, and self-image (4 items)	3
Enneking score (180)	Physician reported outcome measurement instrument that includes functional assessment measures. It assesses: 1. pain 2. function 3. emotional acceptance 4. supports (walking aids) 5. walking 6. gait	5
Frequency intensity time (FIT) index (331)	Patient-reported outcome measurement instrument assessing a person’s level of physical activity over 3 domains: 1. frequency of exercise 2. intensity of exercise 3. time spent on workout	1
Functional outcome criteria	Physician reported outcome measurement instrument assessing functional outcome following open lower limb fractures in the following domains: 1. pain	1

Name	Description of OMIs including definitions	Frequency of use
by Tu *et al*. 1995 (332)	2. range of motion 3. ability to return to normal work	
Hamlyn Mobility Score (HMS) (208)	Physical performance and patient-reported outcome measurement instrument to assess the physical performance of patients doing a timed 6-minute walk test, timed up and downstairs test and a timed up and go test. Standard test metrics are recorded, e.g. time and distance with the addition of estimated step variation using a ear-worn accelerometer. The HMS also consists of 4 questions assessing: 1. use of mobility aids 2. participation in work and leisure activities 3. satisfaction with walking 4. pain	1
Hospital for Special Surgery (HSS) knee scoring system (333,334)	Physician reported outcome measurement instrument to assess outcome after knee replacement surgery. The HSS knee score assesses 7 domains: 1. pain (rest pain, support required because of pain) 2. stability (measured as total varus-valgus arc, extension) 3. motion (measured as total passive arc) 4. quadriceps strength (measured as a percentage of normal for age and gender) 5. subtractions (for extension lag, flexion contracture, fixed varus or valgus deformity)	1
Iowa ankle-evaluation rating system (335)	Physician reported outcome measurement instrument assessing the function of the ankle. Domains assessed include: 1. function (housework or job, stair climbing, carrying heavy objects, ability to run, participate in athletics or heavy labour, walking independently, able to do garden work, difficulty getting in and out of a car) 2. pain 3. gait 4. range of motion	5
Johner-Wruhs evaluation (336)	Physician reported outcome measurement instrument assessing surgical outcome following a tibial fracture. Domains assessed: 1. bone union, osteitis or amputation 2. neurovascular disturbances 3. bone deformity 4. range of motion 5. pain 6. gait 7. Participation in strenuous activities	10
Lower Extremity Functional Scale (LEFS) (166)	Patient-reported outcome measurement instrument to assess a broad range of lower-extremity orthopaedic conditions including the hip, knee, leg ankle or foot. The LEFS contains 20-items specifically assessing the International Classification of Functioning, Disability, and	3

Name	Description of OMIs including definitions	Frequency of use
	Health model (ICF) domains of activity and participation.	
Lysholm Knee Scale (337)	Patient-reported outcome measurement instrument to assess knee function. Is assess 8 domains including: 1. limp 2. walking support 3. pain 4. instability 5. locking 6. swelling 7. stair-climbing 8. squatting	1
Maryland foot score (MFS) (338)	Patient and Physician reported outcome measurement instrument to assess foot injuries. Domains include: 1. pain 2. function (gait, distance walked, stability, support, limp and wearing shoes)	3
Mazur ankle function evaluation (339)	Patient and physician reported outcome measurement instrument to assess ankle function over 12 response items in 2 domains: 1. pain 2. function (limp, walking distance, support, hills up, hills down, stairs up, stairs down, ability to rise on toes, running, range of motion, plantar flexion)	1
Musculoskeletal Function Assessment (MFA) (340-342)	Patient-reported outcome measurement instrument assessing musculoskeletal function consisting of 100 response items over the following domains: 1. mobility 2. hand and fine motor 3. housework 4. self-care 5. sleep and rest 6. leisure and recreation 7. family relationships 8. cognition and thinking 9. emotional adjustment and adaptation 10. employment	1
Neer knee score (343,344)	Physician reported outcome measurement instrument to assess knee function following a supracondylar fracture. The following domains are assessed: 1. pain 2. function (as before injury, mild restriction, restricted; stairs sideways, cane or severe restriction, crutches or brace)	2

Name	Description of OMIs including definitions	Frequency of use
	3. range of motion 4. work 5. gross anatomy 6. roentgenogram	
Objective physical performance outcome measurement instruments		
6-minute walk test (204)	Objective physical performance measurement instrument used to assess functional exercise capacity. the 6-minute walk test measures the distance an individual is able to walk over a total of 6 minutes on a hard, flat surface.	2
Timed up and downstairs (206,345)	Objective physical performance measurement instrument to assess physical performance by measuring the time taken to ascend and descend a flight of stairs consisting of 14 steps.	1
Timed up and go test (207)	Objective physical performance measurement instrument to determine fall risk and measure the progress of balance, sit to stand and walking. An individual is timed standing up from a chair with an armrest, walking 3m, turning around, walking back and sitting down again.	1
Timed walk test (346)	Objective physical performance measurement instrument to assess mobility by timing a patient to walk 30.5m.	1
Olerud and Molander scoring system (347)	Patient-reported outcome measurement instrument assessing symptoms after ankle fracture in 9 domains: 1. pain 2. stiffness 3. swelling 4. stair climbing 5. running 6. jumping 7. squatting 8. supports 9. work and activities of daily living	1
Paley Criteria (348-350)	Physician reported outcome measurement instrument assessing bone and functional outcomes of the lower leg. Domains assessed: 1. Bone (consolidation, absence of infection, axial defect, limb-length discrepancy, docking site and osteogenesis zone consolidation solid enough not to require protection, non-union and bone infection) 2. Function (pain free, walking, joint stiffness, talocrural or subtalar motion, use of analgesia, and activities of daily living)	12
Sanders knee score (351,352)	Physician reported outcome measurement instrument assessing knee function following distal femoral fracture assessing the following domains: 1. Range of movement 2. Pain	1

Name	Description of OMIs including definitions	Frequency of use
	3. Deformity 4. walking ability (walking and stair climbing) 5. return to work (employment/return to pre-injury functioning)	
Severn scale scoring system by Puno *et al.* (353)	Physician reported outcome measurement instrument assessing limb salvaged limb function in the following domains: 1. pain 2. activities of daily living 3. range of motion at the ankle and knee 4. residual deformity 5. radiological examination of degenerative joint changes and alignment 6. muscle strength of the foot 7. sensation	7
Short Musculoskeletal Function Assessment Questionnaire (SMFA) (284)	Patient-reported outcome measurement instrument assessing musculoskeletal function consisting of 46 items reduced from 101 in the MFA. There are two parts to the SMFA: 1. dysfunction index (34 items assessing patient perceptions of functional performance in 4 categories including daily activities, emotional status, function of the arm and hand and mobility) 2. bother index (12 items assessing broad functional areas including recreation and leisure, sleep and rest, work and family)	3
The knee society clinical rating system (354)	physician and patient-reported outcome measurement instrument assessing: 1. pain (on walking and climbing stairs) 2. range of motion 3. stability (medial/lateral and anterior/posterior) 4. deductions for extension lag, flexion contracture, malalignment and pain at rest	4
Visual Analogue Scale Foot and Ankle (VAS FA) (355,356)	Patient-reported outcome measurement instrument to assess the foot and ankle in the following domains: 1. pain 2. function 3. other complaints	1
2. Emotional functioning and wellbeing (28)		
Appearance outcome measurement instruments		
Cosmetic outcome score by O'Toole *et al*. (357)	Patient-reported outcome measurement instrument to assess satisfaction. The patient's cosmetic outcome score was based on the question, ''How satisfied are you with the appearance of your injured leg or artificial leg?'' Participants were asked to respond to each question by using a 5-point scale of descriptors that included ''not at all satisfied,'' ''slightly satisfied,'' ''moderately satisfied,'' ''very	1

Name	Description of OMIs including definitions	Frequency of use
	satisfied," and "completely satisfied." This was a novel instrument only cited in this study	
Vancouver scar scale (358)	Physician reported OMI to assess scare scars and burns. Assessment areas: 1. Vascularity 2. Height/thickness 3. pliability 4. pigmentation	1
3. Global quality of life outcome measurement instruments (30)		
EuroQol 5-Dimensions 3-Level (EQ-5D-3L) (277)	The EQ-5D-3L descriptive system comprises the following five dimensions: 1. mobility 2. self-care 3. usual activities 4. pain/discomfort 5. anxiety/depression Each dimension has 3 levels: no problems, some problems, and extreme problems. The patient is asked to indicate his/her health state by ticking the box next to the most appropriate statement in each of the five dimensions.	2
EuroQol 5-Dimensions 5-Level (EQ-5D-5L) (200)	Patient-reported outcome measurement instrument. The descriptive system comprises five dimensions: 1. mobility 2. self-care 3. usual activities 4. pain/discomfort 5. anxiety/depression Each dimension has 5 levels: no problems, slight problems, moderate problems, severe problems and extreme problems. The patient is asked to indicate his/her health state by ticking the box next to the most appropriate statement in each of the five dimensions.	6
Short Form-12 (SF-12) (281)	Patient-reported outcome measurement instrument. Assessing the following domains: 1. physical functioning 2. role-physical 3. bodily pain 4. general health 5. vitality 6. social functioning 7. role-emotional 8. mental Health	5

Name	Description of OMIs including definitions	Frequency of use
Short Form-36 (SF-36) (165)	Patient-reported outcome measurement instrument. Assessing the following domains: 1. physical functioning 2. role-physical 3. bodily pain 4. general health 5. vitality 6. social functioning 7. role-emotional 8. mental Health	17
Short Form-6 Dimensions (SF-6D) (359)	Patient-reported outcome measurement instrument. Assessing the following domains: 1. physical functioning 2. role limitations 3. social functioning 4. pain 5. mental health 6. vitality	1
Sickness Impact Profile (SIP) (202,203)	Patient-reported outcome measurement instrument to assess perceived health status. The full-length SIP consists of 136 items within 12 domains: 1. sleep and rest 2. eating 3. work 4. home management 5. recreation and pastimes 6. ambulation 7. mobility 8. body care and movement 9. social interaction 10. alertness behaviour 11. emotional behaviour 12. communication	5
Veterans Affairs System of Rating	Physician/technician reported outcome measurement instrument used to assess the level of disability for calculation of disability compensation. Each body system is assessed separately for the level of disability, and a combined score is generated.	2

Name	Description of OMIs including definitions	Frequency of use
Disabilities (360)		
Veterans RAND 12 Item Health Survey (VR-12) (331)	Patient-reported outcome measurement instrument assesses domains: 1. general health perceptions 2. physical functioning 3. role physical 4. role emotional 5. bodily pain 6. vitality/mental health 7. social functioning 8. change physical 9. change emotional	1
4. Delivery of care outcome measurement instruments (32)		
Satisfaction outcome measurement instruments		
Definitions of satisfaction	1. All patients were asked to evaluate their satisfaction with the function of the lower leg, the cosmetic appearance and overall outcome at final follow-up on a 10-point rating scale, with 0 indicating highest satisfaction and 10 indicating maximum dissatisfaction. The patients were additionally asked to rate the function of the affected lower extremity in percent with the contralateral uninjured side serving as a 100 % reference.	1
The Patient Satisfaction Questionnaire Short Form (PSQ-18) (361)	Patient-reported outcome measurement instrument assessing satisfaction in the following domains: 1. general satisfaction 2. technical quality 3. interpersonal manner 4. communication 5. financial aspects 6. time spent with doctor 7. accessibility and convenience	1
Visual Analogue Scale for satisfaction (362)	Patient-reported outcome measurement instruments assessing satisfaction on a continuous scale (0-100mm). Novel score only used in citing study.	1
4. Resource use outcome measurement instruments		

Name	Description of OMIs including definitions	Frequency of use
1. Economic outcome measurement instruments (35)		
Definitions of cost	1. Cost utility analysis 2. Health care system costs (direct health care costs) and costs for productivity losses (indirect health care costs). 3. The cost calculations represent a weighted average of actual expenses for similar entities, during a previous period, indexed to current time. 4. The analysis of surgical costs was based on operative time (including anaesthetic time), theatre staff present (grade, discipline and number) and consumables (all drugs administered, dressings, sutures, etc.) 5. Unit cost data will be obtained from national databases such as the BNF and PSSRU Costs of Health and Social Care (20). Where these are not available, the unit cost will be estimated in consultation with the UHCW finance department. The cost-consequences fol- lowing discharge, including NHS costs and patients' out-of-pocket expenses, will be recorded via a short questionnaire which will be administered at 3, 6, 9 and 12 months post-surgery. Patient self-reported information on service use has been shown to be accurate in terms of the intensity of use of different services. 6. Standard approaches developed for all METRC studies. 7. Cost of treating patients based on Patient-Level Information Costing Systems (PLICS) data. 8. Unit cost data were obtained from national databases such as the BNF24 and Personal Social Services Research Unit (PSSRU)'s Unit Costs of Health and Social Care 2012.25 When these were not available, the unit cost was estimated in consultation with the University Hospitals Coventry and Warwickshire (UHCW) NHS Trust finance department. The cost–consequences following hospital discharge, including NHS costs and patients' out-of-pocket expenses, were estimated using questions included within a questionnaire sent to participants at 3, 6, 9 and 12 months post randomisation. Patient self-reported information on service use has previously been shown to be accurate in terms of the intensity of use of different services. 9. Hospital facility bills for each patient's graft surgery admission were requested from participating centers. Billed charges were converted to cost through application of Medicare cost-to-charge ratios. Professional fees for the surgeon and anesthesiologist were based on Medicare 2016 national average payment for the associated graft surgery procedures. 10. Real income received for service provision as determined per HRG remuneration.	10
2. Need for intervention outcome measurement instruments (36)		
Definitions of reoperation	1. All unplanned operations deemed clinically important.	10

Name	Description of OMIs including definitions	Frequency of use
	2. Composite of all subsequent operative procedures to treat an infection, a wound healing problem, or a nonunion within 1 year of the initial surgical intervention 3. Re-operation is defined as a surgery that occurs subsequent to the initial procedure. This composite endpoint of re-operation will include a narrow spectrum of patient-important procedures: irrigation and debridement for infection, revision and closure for wound dehiscence, wound coverage procedures for infected or necrotic wounds, bone grafts or implant exchange procedures for established nonunion in patients with postoperative fracture gaps less than 1 cm, intramedullary nail dynamizations in the operating room, and fasciotomies for compartment syndrome. 4. An operation to revise or augment fracture fixation after arriving to a Level V facility. 5. The third evaluation factor of the psychosocial evolution of the patients was represented by the number of later readmissions for secondary surgical interventions. 6. Reoperation was defined as at least one surgical procedure following the index procedure. 7. Metal work exchange or reinsertion, joint fusion, bone resection and bone grafting) in addition to the routine. 8. The secondary surgical procedure rate included any reported secondary surgical procedure related to the ankle fracture. This also included partial and complete hardware removals. 9. Composite, all-cause reoperation within 1 year of definitive skeletal stabilization, excluding bedside irrigation and debridement for superficial pin tract infections, or planned ex-fix removal.	
5. Adverse events outcome measurement instruments		
1. Adverse events or effects (38)		
Definitions of complications	1. Orthopedic complications were defined as local cellulitis, wound infections, infections documented by delayed wound culture, osteomyelitis, non-union or malunion, and secondary amputation. Infections of primary amputation sites were included, whereas infections of pin sites remote from the wounds were excluded. 2. Early postoperative complications were defined as any 1 or more of the following having occurred within 6 months from surgical reconstruction: hematoma, wound infection, deep venous thrombosis, thromboembolism, partial flap loss, complete flap loss, continued osteomyelitis, and progression to amputation occurring within the first 6 months after the injury. 3. This is a composite measure defined as the occurrence within 2 weeks of injury of one or both of significant soft tissue necrosis developing after the initial surgery, or significant wound infection. Significant soft tissue necrosis will be determined based upon	18

Name	Description of OMIs including definitions	Frequency of use
	the amount of tissue surgically debrided after the initial surgery. Minimal trimming of skin edges removing no more than a few millimeters of tissue to clean the surface of a wound which was not obviously necrotic will be considered normal surgical practice and will not be scored as indicating 'significant necrosis'. ‣ Wound infection occurring during the acute phase will be assessed via review of data based upon those used in the USA Centre for Disease Control guide- lines for assessing surgical wound infections.43 ‣ The final adjudication on any cases where the presence of infection or necrosis is equivocal will be determined via review of available clinical data, photos and X-rays by clinical adjudicators not involved in the patient's care and blinded to the identity and location of the patient, and the allocation to HBO or no-HBO group. 4. Primary study outcome is defined as having a major complication that results in either: (1) operative treatment during the index hospitalization; (2) rehospitalization during the 12 months after injury (involving operative or nonoperative treatment of the complication); or (3) same day surgery during the 12 months after injury. Major limb complications include 7 predefined occurrences: infection, flap failure, amputation, non-union, malunion, loss of reduction, or hardware failure as diagnosed by the treating surgeon. 5. Complications were subclassified into problems, obstacles and sequelae [14]. Problems did not require surgical interventions, while obstacles needed surgical revisions to be resolved. 6. Postoperative complications were determined by noting any return trips to the operating room. Complications encountered included deep infection, heterotopic ossification/arthro- fibrosis, nonunion, and prominent hardware requiring removal. 7. Complications included acute respiratory distress syndrome (ARDS), pneumonia, deep venous thrombosis, deep surgical site infections (DSSIs), myocardial infarction occurring within 30 days of injury, organ/space surgical site infection, superficial surgical site infection, stroke/cerebral vascular accident, cardiac arrest requiring cardiopulmonary resuscitation, wound disruption, sepsis, and overall/any complication. 8. We recorded complications requiring reoperation. 9. Pseudoarthrosis, chronic osteitis and angular deformities of over 10 degrees 10. All complications and surgical interventions related to the open fracture will be recorded. 11. Neurovascular injury be- cause of frame application, mechanical frame failure as evident by pin, clamp, or bar breakage, pin tract osteomyelitis, and septic arthritis because of intra-articular pin placement.	

Name	Description of OMIs including definitions	Frequency of use
	12. Pins within 1 inch of the fracture site,17 loss of fracture reduction,9 deep pin overpenetration □26 mm,18 soft-tissue pin placement (no cortical purchase), and intra-articular pin placement defined as pins within 14 mm of the tibial plateau or 10 mm of the tibial plafond. 13. Complication subtypes were coded as established in the HCUP CCS manual. 14. Assessment of complications like muscle contractures, joint subluxation, axial deviation, neurological or vascular insult, premature consolidation, delayed consolidation, refracture and pin-site infection were done at each follow up visit and were managed accordingly. 15. Complications are defined as issues that required further treatment or surgery after frame removal. 16. Major complications were defined as any flap loss, return to operating room, amputation, or death. 17. Complication subtypes were coded as established in the HCUP CCS manual. 18. All complications and further surgical interventions related to the open-fracture wound or treatment of the wound were recorded using multiple approaches. Complications were documented at routine follow-up appointments, were self-reported by patients or were notified as adverse events (AEs) or serious adverse events (SAEs) (see Approval for main trial). All participants were invited for clinical review and a radiograph at 12 months, as per routine practice after this type of injury. If a participant had not returned a 12-month postal questionnaire, this was completed in clinic.	
Definitions of flap complications	1. Defined as any flap- related adverse outcome requiring a return to the operating room. This included infection, dehiscence, necrosis, and thrombosis of the flap or its anastomosis, if applicable. Infection was defined as any infection in, adjacent to, or beneath the flap, to include osteomyelitis. Because nonunion of open fractures can be related to many variables that are unrelated to coverage, such as bone loss and soft-tissue stripping, it was not considered a flap-related complication in this study. 2. Partial flap loss was considered when debridement occurred for partial flap necrosis. 3. Total flaps loss required complete removal of the free-flap. 4. partial flap necrosis that required a return to the operating room for debridement but did not require a revision coverage procedure. 5. Flap failure was defined as any flap with tissue necrosis secondary to microvascular thrombosis, ischaemia, and/or infection.	15

Name	Description of OMIs including definitions	Frequency of use
	6. Including: split skin graft, secondary suturing, fasciocutaneous flap to cover necrosed flap. 7. Total flap loss, partial flap loss, or return to the operating room in the postoperative period for impending flap failure. 8. Deep infection with positive intraoperative bone cultures, radiographic changes consistent with osteomyelitis, or clinical documentation of operative findings consistent with osteomyelitis. 9. Flap take-back was defined as any free- flap complication which required the return to theatre during the same inpatient stay. 10. Total flap failure was defined as flap compromise requiring complete debridement during the index hospitalization. Partial flap failure was defined as those requiring additional surgical procedure(s) related to wound breakdown or need for flap debridement during the first 3 months after free flap coverage. Secondary outcomes included operative take- backs and success rates, as well as arterial and venous complications. 11. Total flap failure was defined as flap compromise requiring complete debridement during the index hospitalization. 12. Flap failure was defined as total or partial necrosis of the transferred tissue. This complication always requires return to theatre for excision of the necrotic tissue. 13. Total or partial necrosis of the transferred tissue. 14. Intraoperative flap thrombosis was defined as recurrent venous or arterial thrombosis occurring during the primary flap procedure. Postoperative flap thrombosis was defined as any thrombotic event requiring emergent take-back for flap salvage following the conclusion of the primary flap procedure. Take-backs for the planned debridement. 15. Partial flap failure was defined as those requiring additional surgical procedure(s) related to wound breakdown or need for flap debridement during the first 3 months after free-flap coverage.	

8.19 Appendix 19. Outcome statements presented at the healthcare professional SDG.

Outcome area	Outcome domain (COMET Taxonomy of Outcomes number)	Outcome Statements
Death	**1. Mortality/ survival**	1. Death is an important outcome to measure when recovering from open lower limb fracture.
	2. Blood and lymphatic system outcomes	2. Diagnosis of venous thromboembolism is an important outcome to measure when recovering from open lower limb fracture.
Physio-logical / clinical	**9. General outcomes**	3. Quality of sleep is an important outcome to measure when recovering from open lower limb fracture. 4. Tiredness and fatigue is an important outcome to measure when recovering from open lower limb fracture. 5. Absence of systemic infection is an important outcome to measure when recovering from open lower limb fracture.
	15. Musculo-skeletal and connective tissue outcomes	**Complication outcomes** 6. Complications following treatment is an important outcome to measure when recovering from open lower limb fracture. 7. Hardware or implant failure is an important outcome to measure when recovering from open lower limb fracture. 8. External fixator pin site loosening is an important outcome to measure when recovering from open lower limb fracture. 9. Complications resulting from muscle flaps or grafts is an important outcome to measure when recovering from open lower limb fracture.

		10. Time in an external fixator is an important outcome to measure when recovering from open lower limb fracture. 11. Amputation is an important outcome to measure when recovering from open lower limb fracture. **Bone outcomes** 12. Bone union is an important outcome to measure when recovering from open lower limb fracture. 13. Malunion, alignment and rotational deformity is an important outcome to measure when recovering from open lower limb fracture. 14. Non-union is an important outcome to measure when recovering from open lower limb fracture. 15. Osteonecrosis is an important outcome to measure when recovering from open lower limb fracture. 16. Pseudoarthrosis is an important outcome to measure when recovering from open lower limb fracture. 17. Compartment syndrome is an important outcome to measure when recovering from open lower limb fracture. **Infection outcomes** 18. Deep infection is an important outcome to measure when recovering from open lower limb fracture. 19. Flap infection is an important outcome to measure when recovering from open lower limb fracture. 20. Osteomyelitis is an important outcome to measure when recovering from open lower limb fracture. 21. Pin site infection is an important outcome to measure when recovering from open lower limb fracture. 22. Septic arthritis is an important outcome to measure when recovering from open lower limb fracture. 23. Superficial or wound infection is an important outcome to measure when recovering from open lower limb fracture. 24. Leg or bone shortening is an important outcome to measure when recovering from open lower limb fracture.

25. Microbiological culture results are an important outcome to measure when recovering from open lower limb fracture.
26. Sensation loss is an important outcome to measure when recovering from open lower limb fracture.
27. Muscle weakness is an important outcome to measure when recovering from open lower limb fracture.
28. Over sensitivity is an important outcome to measure when recovering from open lower limb fracture.
29. Development of post-traumatic osteoarthritis is an important outcome to measure when recovering from open lower limb fracture.

Pain outcomes

30. Pain is an important outcome to measure when recovering from open lower limb fracture.
31. Ache is an important outcome to measure when recovering from open lower limb fracture.
32. Post-operative pain is an important outcome to measure when recovering from open lower limb fracture.
33. Pain on walking is an important outcome to measure when recovering from open lower limb fracture.
34. Medication use for pain is an important outcome to measure when recovering from open lower limb fracture.

Plastic surgery outcomes

35. Muscle flap or skin graft failure or survival is an important outcome to measure when recovering from open lower limb fracture.
36. Muscle flap or skin graft necrosis is an important outcome to measure when recovering from open lower limb fracture.

Reoperation outcomes

37. Number or reoperations, revision surgeries or surgical procedures is an important outcome to measure when recovering from open lower limb fracture.
38. Number of debridements is an important outcome to measure when recovering from open lower limb fracture.

		39. Swelling is an important outcome to measure when recovering from open lower limb fracture.
		Wound outcomes
		40. Type of wound closure is an important outcome to measure when recovering from open lower limb fracture.
		41. Wound dehiscence (reopening) is an important outcome to measure when recovering from open lower limb fracture.
		42. Wound necrosis (skin breakdown) is an important outcome to measure when recovering from open lower limb fracture.
	19. Renal and urinary outcomes	43. Acute Kidney Injury is an important outcome to measure when recovering from open lower limb fracture.
		44. Development of renal failure is an important outcome to measure when recovering from open lower limb fracture.
Life impact	**Functioning**	
	25. Physical functioning	45. Ability to climb stairs is an important outcome to measure when recovering from open lower limb fracture.
		46. Ability to do activities of daily living is an important outcome to measure when recovering from open lower limb fracture.
		47. Ability to kneel is an important outcome to measure when recovering from open lower limb fracture.
		48. Ability to balance is an important outcome to measure when recovering from open lower limb fracture.
		49. Ability to be independent is an important outcome to measure when recovering from open lower limb fracture.
		50. Ability to drive is an important outcome to measure when recovering from open lower limb fracture.
		51. Walking, gait and mobility is an important outcome to measure when recovering from open lower limb fracture.
		52. Ability to fully weight bear is an important outcome to measure when recovering from open lower limb fracture.
		53. Ability to do gardening and DIY is an important outcome to measure when recovering from open lower limb fracture.

		54. Ability to be able to do self and personal care is an important outcome to measure when recovering from open lower limb fracture. 55. Ability to enjoy sex is an important outcome to measure when recovering from open lower limb fracture. 56. Ability to partake in sports and exercise is an important outcome to measure when recovering from open lower limb fracture. 57. Ability to comfortably wear shoes is an important outcome to measure when recovering from open lower limb fracture. **Function by anatomical area** 58. Lower limb function is an important outcome to measure when recovering from open lower limb fracture. 59. Ankle function is an important outcome to measure when recovering from open lower limb fracture. 60. Foot function is an important outcome to measure when recovering from open lower limb fracture. 61. Knee function is an important outcome to measure when recovering from open lower limb fracture. 62. Shoulder function is an important outcome to measure when recovering from open lower limb fracture. 63. Range of movement and joint stiffness is an important outcome to measure when recovering from open lower limb fracture. **Range of movement outcomes** 64. Ankle range of movement is an important outcome to measure when recovering from open lower limb fracture. 65. Knee range of movement is an important outcome to measure when recovering from open lower limb fracture.
	26. Social functioning	66. Ability to participate in social events is an important outcome to measure when recovering from open lower limb fracture.

		67. Ability to maintain and develop relationships is an important outcome to measure when recovering from open lower limb fracture.
		68. Not having to rely on other people is an important outcome to measure when recovering from open lower limb fracture.
	27. Role functioning	69. Being able to care for other people and animals is an important outcome to measure when recovering from open lower limb fracture.
		70. Being able to work or return to work is an important outcome to measure when recovering from open lower limb fracture.
		71. Return to work or active duty (military) is an important outcome to measure when recovering from open lower limb fracture.
	28. Emotional functioning/ wellbeing	72. Ability to accept the event and life change is an important outcome to measure when recovering from open lower limb fracture.
		73. Appearance outcome measures
		74. Appearance of lower limb e.g. scars, flaps and swelling is an important outcome to measure when recovering from open lower limb fracture.
		75. General appearance e.g. putting on weight is an important outcome to measure when recovering from open lower limb fracture.
		76. Donor site appearance is an important outcome to measure when recovering from open lower limb fracture.
		77. Appearance of lower limb tattoos following injury is an important outcome to measure when recovering from open lower limb fracture.
		78. Maintaining a feeling of dignity is an important outcome to measure when recovering from open lower limb fracture.
		79. Having emotional strength is an important outcome to measure when recovering from open lower limb fracture.

		80. Having clear expectations and views on the future with lack of uncertainty is an important outcome to measure when recovering from open lower limb fracture. 81. Living in fear e.g. fear of falling or going outside and fear for the future is an important outcome to measure when recovering from open lower limb fracture. 82. Feelings of disablement, being damaged or broken is an important outcome to measure when recovering from open lower limb fracture. 83. Feelings of giving up and hopelessness is an important outcome to measure when recovering from open lower limb fracture. 84. Feeling of loss is an important outcome to measure when recovering from open lower limb fracture. 85. Feelings of struggle or fighting against the body is an important outcome to measure when recovering from open lower limb fracture. 86. Feeling of frustration and anger is an important outcome to measure when recovering from open lower limb fracture. 87. Feelings of hopefulness, positivity and determination is an important outcome to measure when recovering from open lower limb fracture. 88. Isolation, loneliness and lack of emotional support is an important outcome to measure when recovering from open lower limb fracture. 89. Loss of control and feeling of limitation is an important outcome to measure when recovering from open lower limb fracture. 90. Low mood is an important outcome to measure when recovering from open lower limb fracture. 91. Ability to move on and feeling of getting life back is an important outcome to measure when recovering from open lower limb fracture.

		92. Experience of flash backs to the traumatic event is an important outcome to measure when recovering from open lower limb fracture. 93. Feelings of self-identity and body wholeness is an important outcome to measure when recovering from open lower limb fracture. 94. Being anxious or stressed is an important outcome to measure when recovering from open lower limb fracture.
	29. Cognitive functioning	95. Change in outlook, behaviour and attitude towards life is an important outcome to measure when recovering from open lower limb fracture. 96. Being mentally exhausted is an important outcome to measure when recovering from open lower limb fracture.
	30. Global quality of life	97. Quality of life is an important outcome to measure when recovering from open lower limb fracture.
	31. Perceived health status	98. Percentage of perceived loss of function is an important outcome to measure when recovering from open lower limb fracture. 99. A subjective assessment of success of intervention is an important outcome to measure when recovering from open lower limb fracture.
	32. Delivery of care	100. Communication of healthcare professionals to patients is an important outcome to measure when recovering from open lower limb fracture. 101. The non-clinical hospital experience e.g. food, ward environment, etc. is an important outcome to measure when recovering from open lower limb fracture. 102. Help adapting to the home environment e.g. occupational therapy interventions is an important outcome to measure when recovering from open lower limb fracture. 103. Satisfaction with care received is an important outcome to measure when recovering from open lower limb fracture.

		104. Delivery of physiotherapy and rehabilitation is an important outcome to measure when recovering from open lower limb fracture. 105. Tolerability and acceptability of surgical intervention e.g. external fixator, is an important outcome to measure when recovering from open lower limb fracture.
	33. Personal circum-stances	106. Change in lifestyle is an important outcome to measure when recovering from open lower limb fracture. 107. Being able to use disabled facilities e.g. disabled parking is an important outcome to measure when recovering from open lower limb fracture. 108. Being compensated financially for injury is an important outcome to measure when recovering from open lower limb fracture. 109. Personal cost of treatment and care following injury is an important outcome to measure when recovering from open lower limb fracture. 110. Effect of injury on personal finances is an important outcome to measure when recovering from open lower limb fracture.
Resource use	**34. Economic**	111. Cost to healthcare provider is an important outcome to measure when recovering from open lower limb fracture.
	35. Hospital	112. Number of hospital re-admissions is an important outcome to measure when recovering from open lower limb fracture. 113. Length of hospital stay is an important outcome to measure when recovering from open lower limb fracture. 114. Length of Intensive Care Unit stay is an important outcome to measure when recovering from open lower limb fracture. 115. Number of Emergency Department attendances is an important outcome to measure when recovering from open lower limb fracture.

		116. Number of outpatient appointments is an important outcome to measure when recovering from open lower limb fracture. 117. Number of Primary Care visits is an important outcome to measure when recovering from open lower limb fracture.
	36. Need for intervention	none
	37. Societal/ carer burden	none
Adverse events	**38. Adverse events/ effects**	118. Number of adverse events is an important outcome to measure when recovering from open lower limb fracture. 119. Side effects of pain medication is an important outcome to measure when recovering from open lower limb fracture. 120. Discomfort from blood taking and cannula insertion is an important outcome to measure when recovering from open lower limb fracture. 121. Poor experience during anaesthesia is an important outcome to measure when recovering from open lower limb fracture.

Total number of outcome statements: 121

8.20 Appendix 20. Outcomes and outcome statements presented at the patient SDG.

Outcome area	Outcome domain (COMET Taxonomy of Outcomes number)	Outcome Statements
Life impact	**Functioning**	
	25. Physical functioning	1. Ability to climb stairs * Ability to climb stairs should be measured when recovering from open lower limb fracture. ……. 2. Ability to do activities of daily living Ability to do activities of daily living should be measured when recovering from open lower limb fracture. ……. 3. Ability to kneel Ability to kneel should be measured when recovering from open lower limb fracture. ……. 4. Ability to balance Ability to balance should be measured when recovering from open lower limb fracture. ……. 5. Ability to be independent * Ability to be independent should be measured when recovering from open lower limb fracture. ……. 6. Ability to drive

Ability to drive should be measured when recovering from open lower limb fracture.

…….

7. Walking, gait and mobility

Walking, gait and mobility should be measured when recovering from open lower limb fracture.

…….

8. Ability to do gardening and DIY

Ability to do gardening and DIY should be measured when recovering from open lower limb fracture.

…….

9. Ability to be able to do self and personal care

Ability to be able to do self and personal care should be measured when recovering from open lower limb fracture.

…….

10. Ability to have intimate relationships

Ability to have intimate relationships should be measured when recovering from open lower limb fracture.

…….

11. Ability to partake in exercise

Ability to partake in exercise should be measured when recovering from open lower limb fracture.

…….

12. Ability to comfortably wear shoes and clothes of your choice

Ability to comfortably wear shoes and clothes of your choice should be measured when recovering from open lower limb fracture.

…….

13. Lower limb function

Lower limb function should be measured when recovering from open lower limb fracture.

		…….
		14. Range of movement
		Range of movement should be measured when recovering from open lower limb fracture.
		…….
		15. Joint stiffness
		Joint stiffness should be measured when recovering from open lower limb fracture.
	26. Social functioning	16. Ability to participate in social events
		Ability to participate in social events should be measured when recovering from open lower limb fracture.
		…….
		17. Ability to start, maintain and develop relationships
		Ability to start, maintain and develop relationships should be measured when recovering from open lower limb fracture.
		…….
		18. Maintaining a level of independence
		Maintaining a level of independence should be measured when recovering from open lower limb fracture.
	27. Role functioning	19. Being able to care for other people and animals
		Being able to care for other people and animals should be measured when recovering from open lower limb fracture.
		…….
		20. Being able to work, return to work or active duty (military)
		Being able to work, return to work or active duty (military) should be measured when recovering from open lower limb fracture.
		…….

		21. Being able to return to life roles (e.g. caring, work, military duty) Being able to return to life roles (e.g. caring, work, military duty) should be measured when recovering from open lower limb fracture.
	28. Emotional functioning/ wellbeing	**Appearance outcomes** 22. Appearance of lower limb e.g. scars, flaps and swelling Appearance of lower limb e.g. scars, flaps and swelling should be measured when recovering from open lower limb fracture. ……. 23. General appearance e.g. changing shape or weight General appearance e.g. changing shape or weight should be measured when recovering from open lower limb fracture. ……. 24. Feelings of self-identity and body wholeness Feelings of self-identity and body wholeness should be measured when recovering from open lower limb fracture. ……. **Depression outcomes** 25. Feelings of disablement, being damaged or broken Feelings of disablement, being damaged or broken should be measured when recovering from open lower limb fracture. ……. 26. Feelings of giving up and hopelessness Feelings of giving up and hopelessness should be measured when recovering from open lower limb fracture. ……. 27. Feeling of loss Feeling of loss should be measured when recovering from open lower limb fracture.

	…….
	28. Feeling of frustration and anger
	Feeling of frustration and anger should be measured when recovering from open lower limb fracture.
	…….
	29. Feelings of hopefulness, positivity and determination
	Feelings of hopefulness, positivity and determination should be measured when recovering from open lower limb fracture.
	…….
	30. Isolation, loneliness and lack of emotional support
	Isolation, loneliness and lack of emotional support should be measured when recovering from open lower limb fracture.
	…….
	31. Low mood
	Low mood should be measured when recovering from open lower limb fracture.
	…….
	32. Ability to move on and feeling of getting life back
	Ability to move on and feeling of getting life back should be measured when recovering from open lower limb fracture.
	…….
	Anxiety outcomes
	33. Having clear expectations and views on the future with lack of uncertainty
	Having clear expectations and views on the future with lack of uncertainty should be measured when recovering from open lower limb fracture.
	…….
	34. Tolerance of uncertainty and living in fear e.g. fear of falling or going outside and fear for the future

Tolerance of uncertainty and living in fear e.g. fear of falling or going outside and fear for the future should be measured when recovering from open lower limb fracture.

…….

35. Being anxious or stressed

Being anxious or stressed should be measured when recovering from open lower limb fracture.

…….

36. Loss of confidence or control and feeling of limitation

Loss of confidence or control and feeling of limitation should be measured when recovering from open lower limb fracture.

…….

Post-Traumatic Stress Outcomes

37. Experience of flashbacks to the traumatic event

Experience of flashbacks to the traumatic event should be measured when recovering from open lower limb fracture.

…….

Resilience and acceptance outcomes

38. Having emotional strength

Having emotional strength should be measured when recovering from open lower limb fracture.

…….

39. Ability to accept the event and life change

Ability to accept the event and life change should be measured when recovering from open lower limb fracture.

…….

40. Feelings of struggle or fighting against the body

Feelings of struggle or fighting against the body should be measured when recovering from open lower limb fracture.

		…….
		Satisfaction with care outcomes
		41. Maintaining a feeling of dignity Maintaining a feeling of dignity should be measured when recovering from open lower limb fracture.
	29. Cognitive functioning	42. Lack of concentration and focus Lack of concentration and focus be measured when recovering from open lower limb fracture.
Physio-logical / clinical	**2. Blood and lymphatic system outcomes**	43. Venous Thromboembolism (blood clots in the legs or lungs) Diagnosis of venous thromboembolism should be measured when recovering from open lower limb fracture.
		…….
	9. General outcomes	44. Sleep and fatigue Sleep and fatigue should be measured when recovering from open lower limb fracture.
		…….
	15. Musculo-skeletal and connective tissue outcomes	**Complication outcomes**
		45. Complications Complications following treatment should be measured when recovering from open lower limb fracture.
		…….
		46. Metalwork failure Metalwork failure should be measured when recovering from open lower limb fracture.

…….

47. Complications resulting from soft tissue (muscle flaps or grafts)

Complications resulting from soft tissue (muscle flaps or grafts) should be measured when recovering from open lower limb fracture.

…….

48. Amputation

Amputation should be measured when recovering from open lower limb fracture.

…….

Bone outcomes

49. Bone healing

Bone healing should be measured when recovering from open lower limb fracture.

…….

50. Malunion, alignment and rotational deformity

Malunion, alignment and rotational deformity should be measured when recovering from open lower limb fracture. (discuss with surgeons)

…….

Infection outcomes

51. Deep infection

Deep infection should be measured when recovering from open lower limb fracture.

…….

52. Surface infection

Surface infection should be measured when recovering from open lower limb fracture.

…….

53. Leg or bone shortening

		Leg or bone shortening should be measured when recovering from open lower limb fracture. ……. 54. Change in sensation Change in sensation should be measured hen recovering from open lower limb fracture. ……. 55. Muscle weakness Muscle weakness should be measured when recovering from open lower limb fracture. **Pain outcomes** 56. Pain or discomfort Pain or discomfort should be measured when recovering from open lower limb fracture. ……. **Reoperation outcomes** 57. Unplanned return to the operating theatre Unplanned return to the operating theatre should be measured when recovering from open lower limb fracture.
	30. Global quality of life	58. Quality of life Quality of life should be measured when recovering from open lower limb fracture.
	31. Perceived health status	59. Percentage of perceived loss of function Percentage of perceived loss of function should be measured when recovering from open lower limb fracture. ……. 60. Degree of perceived loss of general health and wellbeing

		Degree of perceived loss of general health and wellbeing should be measured when recovering from open lower limb fracture.
	32. Delivery of care	61. Quality of communication of healthcare professionals to patients Quality of communication of healthcare professionals to patients should be measured when recovering from open lower limb fracture. ……. 62. Satisfaction with care Satisfaction with care should be measured when recovering from open lower limb fracture. ……. 63. Tolerability and acceptability of surgical intervention e.g. external fixator Tolerability and acceptability of surgical intervention e.g. external fixator, should be measured when recovering from open lower limb fracture.
	33. Personal circumstances	64. Change in lifestyle Change in lifestyle should be measured when recovering from open lower limb fracture. ……. 65. Being able to use disabled facilities e.g. disabled parking Being able to use disabled facilities e.g. disabled parking should be measured when recovering from open lower limb fracture. ……. 66. Being compensated financially for injury Being compensated financially for injury should be measured when recovering from open lower limb fracture.

		…… 67. Personal cost of treatment and care following injury Personal cost of treatment and care following injury should be measured when recovering from open lower limb fracture. …… 68. Effect of injury on personal finances Effect of injury on personal finances should be measured when recovering from open lower limb fracture.
Resource use	**34. Economic**	69. Cost to healthcare provider Cost to healthcare provider should be measured when recovering from open lower limb fracture.
	35. Hospital	70. Number of unplanned hospital re-admissions Number of unplanned hospital re-admissions should be measured when recovering from open lower limb fracture. …… 71. Length of hospital stay Length of hospital stay should be measured when recovering from open lower limb fracture. …… 72. Number of outpatient appointments Number of outpatient appointments should be measured when recovering from open lower limb fracture. …… 73. Number of primary care appointments Number of Primary Care visits should be measured when recovering from open lower limb fracture.

	36. Need for intervention	none
	37. Societal/ carer burden	None
Adverse events	**38. Adverse events/ effects**	74. Number of adverse events Number of adverse events should be measured when recovering from open lower limb fracture. ……. 75. Side effects of medication Side effects of medication should be measured when recovering from open lower limb fracture. ……. 76. Poor experience during anaesthesia Poor experience during anaesthesia should be measured when recovering from open lower limb fracture.
Death	**1. Mortality/ survival**	77. Survival Survival should be measured when recovering from open lower limb fracture.

Total number of outcome statements: 77

8.21 Appendix 21. Outcomes presented to the Study Management Group in the order recommended at the SDGs.

Core area	Outcome domain (COMET Taxonomy of Outcomes number)	Outcome Statements	Evidence of audit, trustworthiness and accountability in the Thematic Analysis and development of outcomes.
Life impact	**Functioning** **25. Physical functioning**	1. Ability to do activities of daily living	Patients often described problems being able to do taken for granted things they could do before their injuries, for example making a cup of tea, cooking and climbing stairs. This outcome links to self and personal care, dependence and dressing among others. Following the patient SDG ability to climb was felt to be encompassed by activities of daily living and was dropped. Four studies identified in Chapter 2 reported activities of daily living as an outcome in the systematic review. "I mean I've had to get cleaners in for the house and you know I couldn't sort of… I couldn't make a cup of tea… well I could make a cup of tea but I had to, sort of, put it in stages." "I didn't have to climb any stairs as obviously I wouldn't have been able to…"

			"I could walk with a frame but you can't carry anything, you can't cook for yourself, I could only shower because you can't get your dressing wet and little things, stupid things. When you want a cup of tea at night you can't because it's downstairs and you can't carry the tea upstairs"
		2. Ability to kneel	A number of patients expressed at interview that they were unable to, or had pain when kneeling down. For example, this interfered with patient's ability to play with children, practicing CPR, using the washing machine and working in trades. Patient: "As I was saying, kneeling is about the only thing now that I can't do." Interviewer: "Is that something you would like to get back to how it was?" Patient: "Oh yes I'd love to."
		3. Ability to balance	Loss of balance was a recurring theme in patient interviews affecting confidence and mobility. "I waddle, I… I walk like a penguin it's the only way I can balance"
		4. Ability to be independent	Ability to be independent was a strong theme discussed both within patient interviews and in the SDG. Being dependent on other people was closely linked to a loss of dignity and self and personal care. "So, in hospital the main thing was that loss of independence, having young girls wiping your bum and all those things" Patients really struggled with loss of independence:

			"It was my independence and you're there, you're there. I thought about topping myself because it's like I've been independent all my life, there wasn't a lot else I could do."
		5. Ability to drive	In the interviews and at the SDGs patients identified that the ability to drive again was part of their recovery process which linked strongly to regaining independence. "I do use my car a lot, I don't live that far from Sainsburys and I could walk to Sainsburys and carry things back but I can't do that anymore, I have to drive there.
		6. Walking, gait and mobility	Walking, gait and mobility was highlighted by patients as a crucial stage in their early recovery. Learning to walk again with normal gait or to mobilise in a wheelchair was essential to patients feeling that they were getting their life back: "So, I suppose learning to walk and putting weight on my foot was the hardest thing, getting that toe facing forwards, just getting back into normal life."
		7. Ability to be able to dress and do self and personal care	Ability to be able to dress and do self and personal care was identified by patients in interviews as key part of recovery and this linked to activities of daily living, dependence and maintaining dignity. At the patient SDG, it was felt that ability to dress should be added the self and personal care outcome theme, this outcome was thought to be important enough to be stand alone and not part of activities of daily living. "I never did use the commode from about five weeks after the accident was the first time she took me over and I never used it. I pulled myself up the stairs, I was determined I wasn't using it. I'm not having somebody wiping up after me." "I didn't always get myself as clean as I wanted but at least I'd done it."

		8. Ability to have intimate relationships	Ability to have intimate relationships was explored at interview and was discussed at the patient SDG. This centered around the inability to get comfortable and a loss of confidence. "I can't get comfortable you know because we don't have sex because every single time I move there's something"
		9. Ability to exercise	Ability to start exercising again was identified by patients as a step in the journey back to normal life. This includes any types of fitness activity and sports. A measure of return to sport or physical exercise was reported 7 times in research papers included in the systematic review. "as part of rehab I started… mmm… running quite regularly… mmm…" "I did try playing football… mmm… when I started running again but… mmm… sort of the sharp turning and that was just a bit painful on my ankle…and just kind of stopped doing that really."
		10. Ability to comfortably wear shoes and clothes of your choice	The ability to comfortably wear shoes and clothes of your choice was discussed by patients during recovery at the patient SDG and linked to a feeling of regaining normality. "Not being able to wear normal shoes is frustrating, I could put a normal shoe on my right foot but I couldn't put a normal shoe on my left foot"
		11. Lower limb function	Patients at the SDG felt that they would like to quantify their improvement in lower limb function during their recovery. A measure of lower limb function was reported 88 times in research papers included in the systematic review.

		12. Range of movement	Problems with or improvements in range of movement particularly the knees, ankles and toes were identified by patients during their recovery. Range of movement linked closely to stiffness and mobility more generally. Range of movement or joint stiffness was reported 25, 22 and 25 times broadly and specifically for the knee and ankle respectively in research papers included in the systematic review. "I can bend my knee to about 45 less than what it should go." "I'd say my ankles a bit stiff now and again in the mornings"
	26. Social functioning	13. Ability to participate in social events	Patients described difficulties meeting with friends, attending and engaging in family events. A measure of social participation was reported in 3 papers in the systematic review. "I'd go out with ladies who lunch once a month and… mmm… and I'd go to the library a lot, I'd go to me friends… I can't do any of that now they all have to come here…" "my grandson who was 2 could walk faster than me, I couldn't keep up with him and that's why I couldn't go out walking with them which was another frustration I felt." Social events that involved participation in sport was also identified as an area of difficulty. "Yeah I do socialise yeah, yeah socialise yeah. Just nothing that involves running? Physically no, no no… it's not like running and kicking a ball and stuff, I can go and sit and talk to people and it's no problem at all."

		14. Ability to start, maintain and develop relationships	Starting relationships with new people following injury e.g. new romantic relationships or developing relationships e.g. with grandchildren was identified by patients as an area of difficulty during recovery. "So how do you feel about that, the fact that you can't play with your grandchildren? It's not pain, but I can't play with them, it's if you try to kneel down to do something on the carpet it just feels awkward." Maintaining a marriage was also highlighted as an important area during recovery. "So many marriages break up because of accidents because of the strain it puts on relationships."
	27. Role functioning	15. Being able to care for other people and animals	Patients discussed frustrations being unable to continue their roles as carers both for other people and for animals. "My son, you know, I couldn't have my son because I couldn't take him to school the next day…" "I still suffer quite a bit with aches and pains and things like that but I'm back walking my dogs and things like that and I can go out on my own and probably walk a good few miles now."

		16. Being able to return to life roles (e.g. caring, work, military duty)	Being able to return to life roles (e.g. caring, work, military duty) was identified by patients as a central part of recovery and return to normal life. Return to employment was measured in 17 papers and return to active military duty was measured in 2 papers in the systematic review. "being off… off work as nice as it sounds it's just that being sat there and having nothing to do and not being able to do anything I think is… was the hardest… mmm… and just the sense of boredom and its just frustration really"
	28. Emotional functioning/ wellbeing	17. Appearance of lower limb e.g. scars, flaps and swelling	Appearance of lower limb e.g. scars, flaps and swelling was identified as an area of importance during recovery by patients at interview and in discussion groups. This linked to feelings of body wholeness and feeling uncomfortable wearing certain clothing. A measure of cosmetic outcome was reported in 6 research papers in the systematic review. "visibility I mean when they first took it out it was like a big crater but you'd… but you'd never notice it was there now." "a considerable lump where they put the muscle in from my back etc and there's a scar that runs up to just below my knee and yes so it's not a thing of beauty to look at in appearance but I don't look at it, well I do every morning because I cream it every day but apart from that I don't look at it very much."
		18. General appearance e.g. changing shape or weight	General appearance e.g. changing shape or weight was highlighted in patient interviews as an important and separate outcome to the appearance of the injury site. Some patients felt they gained weight, or their body changed shape as a result of their injury and its treatment.

			"I'm fatter which is quite depressing. The weight doesn't do the rest of me any good but it's one of those things and it couldn't really be avoided. I've put on about two and half/three stone in two years."
		19. Feelings of self-identity and body wholeness	Feelings of loss of identity and one's body no longer feeling whole was discussed in patient interviews. This linked to feelings of limitation in what patients felt they could do or wear and feelings of loss. "I mean what do you do, you sit down and do nothing and I'm not that kind of person, do you try and be the person you were before and you can't be because you are 95% of what you used to be but it's just that 5% area that causes you 100% of the problems."
		20. Feelings of disablement, being damaged or broken	"It's an injury that yes its healed, its scarred but it's still going to affect me on a daily basis. I'm never going to be 100% healed if that's the right thing to say. Sometimes I'm a bit frustrated when I've got bend down or kneel down for something."
		21. Feelings of giving up and hopelessness	"You try and be positive, my wife says 'you can do it, think positive', it's alright for people to say it but when you're constantly trying to be positive when sometimes you just want to lay down and cry. 'I've had enough', not to kill yourself but you just think 'I can't be bothered today."
		22. Feeling of loss	Feelings of lost opportunities, time and function were frequently discussed by patient at interview. "because my son's a bit older now, he's fourteen now, I mean it's not like I would take him to the park so I missed out on all that sort of stuff… mmm…"

			"Horrid, it's changed my life a lot. It's changed my life, I've lost so much."
		23. Feelings of frustration and anger	Patients at interview explained that at times they felt frustrated and angry with their situation. This linked to emotional fragility and feelings of helplessness. "incredibly frustrating in the beginning and I found myself gritting my teeth without even realising it and I was so angry really. I'd get really irritable for no reason at all."
		24. Feelings of hopefulness, positivity and determination	Patients described feelings of positivity and using a positive attitude to help their recovery. Some mention that determination to get better was a significant element of their recovery. "I don't want to get depressed, so I just think 'well it could've been worse… could've been a lot worse, could've been both legs!' and there's a lot of people out there worse than me so I just get on with it."
		25. Isolation, loneliness and lack of emotional support	"there are carers but they're not here 24/7 because you don't need them. They're not here for you mentally but physically."
		26. Low mood	Low mood was discussed by patients at interview which strongly linked to depression and anxiety. One paper reported mood in the systematic review. "sometimes you just feel low shall we say but not quite depressed." "err, there was periods of obviously low mood and depression after the, after the accident."
		27. Ability to move on and feeling of getting life back	"since the accident there's you know positives of, um, my girlfriend and I got married sort of last September and we had a baby we had a son sort of, so life's carried on those are the good bits."

		28. Having clear expectations and views on the future with lack of uncertainty	"I worry about what's in the future for me because everybody says your mobility is going to get worse."
		29. Tolerance of uncertainty and living in fear e.g. fear of falling or going outside and fear for the future	Patient: "the big thing was that uncertainty and that's what was the hardest part for me, it was the not knowing. I wasn't looking for anyone to make me a promise or an outcome but I still find it hard to explain, it's a very dark place to be almost." Interviewer: "Without any future?" Patient: "Yes or an uncertain future."
		30. Being anxious or stressed	Stress was reported in four studies in the systematic review. "I find now that I don't tend to worry so much about things anymore. Sometimes I do but the majority of time I don't because it just pales into insignificance."
		31. Loss of confidence or control and feeling of limitation	"It's more… it's more the fact that I can't just go and do something that I maybe want to I think that's the harder element of it… mmm… not just sports it's just…" "No control and just the uncertainty of, err, obviously never having broken a bone in my life for something like this to happen!"
		32. Experience of flashbacks to the traumatic event	Post-traumatic stress was reported in one paper included in the systematic review.

			Patients describe remembering their accidents as if 'they were yesterday' and reporting traumatic flashbacks. These feelings linked to feelings of confusion, trying to make sense of their situation and being low in mood. "There were days when all I could think about was what had happened in the past with the crash and as you would expect it ended up like it was yesterday but I have to say I don't remember it as often as I used to." Patient: "I still get flash backs from time to time, ET: "Of the accident or the operation? Patient: "No of the accident it was only last week that I seemed that I was re-living it again and it got me up and I seem to have had more dreams than I ever did." "PTSD Post Traumatic Stress, err, not being able to watch anything, err, at all, mmm, violent on TV, mmm, of any nature and just really sort of withdrawn into myself and, mmm, just trying to make sense of it all really."
		33. Emotional vulnerability, volatility and fragility	"If I watched something on the TV and I found myself empathising with people who had been injured and things like that which is something I've never experienced before, it was a range of emotions really that I'd probably not experienced that were actually brought out by the whole thing and that was something I'd never experienced and I found myself tearful and things like that."

			This outcome was changed from ‘having emotional strength’ following second focus group.
		34. Ability to accept the event and life change	Ability to accept the event and life change was regularly discussed by patients at interview as an import part of the recovery process. “You’ve got to accept it and I’ve had times when I haven’t been able to accept it in the last two years, many times.” “always feel that I did come to terms with it anyway so it’s something I’ve kind of accepted, whether that’s true or not I don’t know but it’s always felt like something that I kind of went okay this has happened let’s move with it.”
		35. Feelings of struggle or fighting against the body	A patient discussed at interview a feeling of struggle against his body and his surroundings to feel normal. “As you say its perception, people look at you and say you’re getting on great aren’t you. All you really just want to say to them is every day I struggle and some days you just want to sit and cry your eyes out, its difficult if you’re on your own because you think to yourself man up.”
		36. Maintaining a feeling of dignity	Maintaining a feeling of dignity was discussed by patients at interview which tended to focus on toileting and having to use mobility aids. “It’s your dignity, I mean the last person who wiped my arse was my mum and that’s it or my dad but not being a grown man in a bed pan because I couldn’t get out of bed you see.”

	29. Cognitive functioning	37. Lack of concentration and focus	Patients discussed at interview feeling that they had a shorter attention span and more likely to become mentally tired when thinking about tasks. "The pain is the biggest issue because it physically drags you down and will mentally wipe you out and I hate being mentally tired. I'd rather be physically tired than mentally tired."
Physio-logical / clinical	**2. Blood and lymphatic system outcomes**	38. Venous Thromboembolism (blood clots in the legs or lungs)	Venous thromboembolism was reported in 10 papers included in the systematic review.
	9. General outcomes	39. Sleep and fatigue	Patients regularly discussed difficulty sleeping which was often related to pain. Patients also described ongoing fatigue during recovery. "I was tired every day so just like seeing one person would pretty much exhaust me anyway so yeah it's weird I thought 'how am I getting so tired when all I'm doing is laying here?"

	15. Musculo-skeletal and connective tissue outcomes	40. Complications	Complications of treatment was reported in 71 papers included in the systematic review and in one paper as a primary outcome. Complications were often reported simply as 'complications' with some studies being more specific, e.g. complications from external fixator, perioperative complications, wound complications etc.

		41. Metalwork failure	Metalwork or implant failure was reported in 8 papers in the systematic review.
		42. Complications resulting from soft tissue (muscle flaps or grafts)	Complications related to soft tissue surgery (muscle flaps and grafts) were reported in 5 papers as a primary outcome and 79 as a secondary outcome in the systematic review. Flap survival was reported in 4 papers as a primary outcome and reported 47 times as a secondary outcome in the systematic review.
		43. Amputation	Amputation was reported in 7 papers as a primary outcome measure and in 58 papers as a secondary outcome measure. Patients often considered keeping their leg as being lucky or fortunate, the sentiment, 'it could be worse, I could have lost my leg' was expressed by a number of patients. A patient also expressed that if he knew how much pain his foot would cause at the time of the injury he would have asked for an amputation. "Physically, I'm really pleased that I've still got my leg and if I'd have stopped at Lincoln they were going to take it off." "I was lucky not to have lost my leg really." "I'm not complaining I could've ended up with no foot couldn't I so you've got to look on the bright side of it!" "I've always said to people all along that if you can sort the pain out I can live with the disability and as I said, on the day if they'd have given me a choice and said there's a very

			good chance you will be in tremendous pain for the rest of your life do you want to keep your leg. With the pain I was in that night I would have said take it off."
		44. Bone healing	Bone union outcome theme was changed to bone healing at the patient SDG. Bone healing was reported as a primary outcome in 13 papers and as a secondary outcome in 191 papers in the systematic review. Failure of bone healing (bone non-union) was reported as a primary outcome measure in 1 paper and as a secondary outcome in 33 papers.
		45. Malunion, alignment and rotational deformity	Malunion, alignment and rotation deformity was reported as a secondary outcome in 62 papers in the systematic review
		46. Deep infection	Deep infection was reported as a primary outcome in 10 papers and as a secondary outcome in 60 papers in the systematic review.
		47. Surface infection	Superficial or wound infection was reported as a primary outcome in one paper and as a secondary outcome in 32 papers in the systematic review. Pin site infection was reported as a primary outcome in one paper and as a secondary outcome in 32 papers in the systematic review. Flap infection was reported as a secondary outcome in two papers in the systematic review.
		48. Leg or bone shortening	Leg or bone shortening was reported as a secondary outcome in 25 papers in the systematic review.
		49. Change in sensation	Change in sensation including numbness, loss of sensation and increased sensation to pain was discussed by patients during their recovery. A measure of sensation was made in 6 papers in the systematic review.

			"there was this sort of numbness in my right leg, but it didn't bother me that much and it didn't affect my walking that much whereas now it does."
		50. Muscle weakness	Muscle weakness or muscle power was measured in 2 papers in the systematic review.
		51. Pain or discomfort	Patients regularly discussed problems with pain and discomfort during their recovery. Pain was reported as a secondary outcome in 34 papers in the systematic review. "I've been on a pain management course and that was basically just stop thinking what you're doing and it what's caused your problem. I know what's causing the problem: walking, they said avoid it well I can't avoid walking." "The pain is the biggest issue because it physically drags you down and will mentally wipe you out" "No there is no hard and fast cure for it as far as I can tell, we did discuss cutting it off because of the pain that I was in after the operations. It was really quite bad some days, some days I couldn't even walk because the tendons and ligaments down the back of my leg which run behind the knee were just cramped up and tight and would be like electrically pulsed painful and I would have a day or two of that and think what the hell have I done, it's was almost like somebody had got in there and stretched and torn it or something like that and so that was worrying about how long that would last for and if it was going to be like that forever but like I said he did put me on pregabalin which did the trick really, reset the brain and way to go"

		52. Unplanned return to the operating theatre	Many papers in the systematic review reported reoperation outcomes in different ways. Following SDGs, it was agreed that unplanned return to the operating theatre would be most relevant to patients. Reoperation was reported as a primary outcome in 5 papers and as a secondary outcome in 15 papers in the systematic review. Number of operations was reported as a secondary outcome in 44 papers in the systematic review. Number of debridements was reported as a secondary outcome in 6 papers in the systematic review.
Life Impact	**30. Global quality of life**	53. Quality of life	Quality of life was reported as an outcome in 32 papers included in the systematic review.
	31. Perceived health status	54. Percentage of perceived loss of function	Patients, when talking about recovery often describe their function as a perceived percentage of what they remember their physical function being prior to their injury. "Yes but I've still got it and I can use it, I've got a lot of use back in it, not all of it. I've lost about 30%." "I think I've got about 40-50% use back of the ankle and that's good enough to do the things I want to do"
		55. Degree of perceived loss of general health and wellbeing	Patients often described in loose terms how much their general health and wellbeing compares to what they can remember before their injury. Two studies identified in the systematic review reported a subjective assessment of success of the intervention. "I know I'll never be 100%"

	32. Delivery of care	56. Quality of communication of healthcare professionals to patients	Quality of communication of healthcare professionals to patients was identified as an area of importance in interview. Patients at SDG felt this outcome should be kept. "Yeah but I did find there was definitely a communication breakdown between the, the bone people and the skin, skin flap people."
		57. Satisfaction with care	Patient satisfaction and satisfaction with treatment was reported in the systematic review of the literature three and two times respectively. Patients discussed the quality of their care, hospital food and environment, occupational therapy input, hospital visits, and their experience of physiotherapy services in the interviews linking to their overall satisfaction with care. "Two or three of the District Nurses were really not up to my standard even so in the end I said don't bother coming any more. When we used to come up to the plastic clinic the nurses up there were brilliant, they showed my wife what to do, they gave us some advice and we came back and did it ourselves which was excellent." "I had to go… mmm… twice a week probably two months to the [hospital] to have the dressing changed… mmm… which was a bit of a pain!" "It was either salad or bread and butter but I wanted a ham salad sandwich, oh no we can't do that, we can do you a ham salad and we can give you bread and butter, well why can't you do it for me and I said I'd do it myself. It's silly things, you know what I mean. I could

			have a ham sandwich with two or three slices of bread and make it myself but yes I didn't eat for seven days. I had about three or four biscuit's, digestives."
		58. Tolerability and acceptability of surgical intervention e.g. external fixator	Tolerability and acceptability of surgical intervention was identified as a concept that may be important in recovery for example living with an external frame on your leg. "I think that was probably the lowest point for me because its quite a large piece of equipment and there's not a lot you can really do when it's on. Even getting dressed was a problem and things like that and so I became quite reliant on my wife to help through the day."
	33. Personal circumstances	59. Change in lifestyle	Patients discussed the broad reaching change recovering from an OLLF brought to their lives. Aspects of wider lifestyle change were coded under this outcome theme. "I don't know how many months I slept downstairs and we turned one of the rooms downstairs into a bedroom" "Really for the first two or three months I just sat on the sofa…" "I was kind of housebound quite a bit and didn't really go out and maybe slept too much, but I wouldn't say that I suffered during it the hardest part."
		60. Being compensated financially for injury	The search for compensation and the litigation process was highlighted from patient interviews as being a significate step in the patient recovery journey. Patients did not feel

			like they could emotionally move on until this was settled. However, it was a common complain that the process is lengthy. "Now that the insurance is all settled, I feel like my life is settled a little bit anyway, and as I said I think it's time for us to get on and move on."
		61. Personal cost of treatment and care following injury	Personal cost of treatment and care following injury was discussed by patients at interview. This focussed around the added costs of buying specific shoes or aids in the recovery period. "Well the expense, a pair of trainers if they're adapted with the rockers in for £250.00, a pair of shoes I've had three pairs of shoes at £350.00 each."
		62. Effect of injury on personal finances	Effect of injury on personal finances was discussed by patients at interview. Many explained what a significant negative impact their injury had both their finances and that of their family. "My wife had to go back to work because we weren't getting any payments from the insurance to start off with and so she had to carry on working and so my OT sourced a second-hand scooter." "There was obviously a financial strain on the family and obviously I felt that myself but although at the time nobody would say that because obviously who could say that to him, he's got enough to deal with and I think it took me quite a while to come to terms with that."

Resource use	**34. Economic**	63. Cost to healthcare provider	Cost (economic analysis) of treating patients with open lower limb fractures was reported as a primary outcome in 8 studies and as a secondary outcome in 16 papers included in the systematic review.
	35. Hospital	64. Number of unplanned hospital re-admissions	Number of unplanned hospital re-admissions was reported in 5 papers in the systematic review.
		65. Length of hospital stay	Length of hospital stay was reported in 52 papers included in the systematic review.
		66. Number of outpatient appointments	Number of outpatient appointments was reported in 5 papers included in the systematic review.
		67. Number of Primary Care visits	Number of Primary Care visits was reported in 1 paper included in the systematic review.
	36. Need for intervention	none	
	37. Societal/ carer burden	none	
Adverse events	**38. Adverse events/effects**	68. Number of adverse events	Number of adverse events was reported in 5 papers included in the systematic review.
		69. Side effects of medication	Side effects of medication was discussed in patient interviews. This particularly focused on taking morphine-based pain killers.

			"The only downside of it was that I had a horrible, horrible headache from taking the tablets and it felt like my teeth were going to fall out of my head which was another side effect really." "I had the morphine thing every so often and that's a bad thing as well, I think it gives you nightmares. I was seeing things and every so often had pain and that's another weird thing, morphine is … I didn't like morphine."
		70. Poor experience during anaesthesia	Poor experience during anaesthesia was discussed by patients at interview, this included feeling awake during a procedure and having an unpleasant experience in recovery. Patient: "mmm, err, I woke up while I was being operated on" Interviewer: "Oh no that's terrible!" Patient: "yes it was yeah, I woke up and I saw someone above me and then I looked down and just saw blood everywhere."
Death	**1. Mortality/ survival**	71. Survival	Survival (death or mortality) was reported in 21 papers included in the systematic review.

Total number of outcome statements: 71

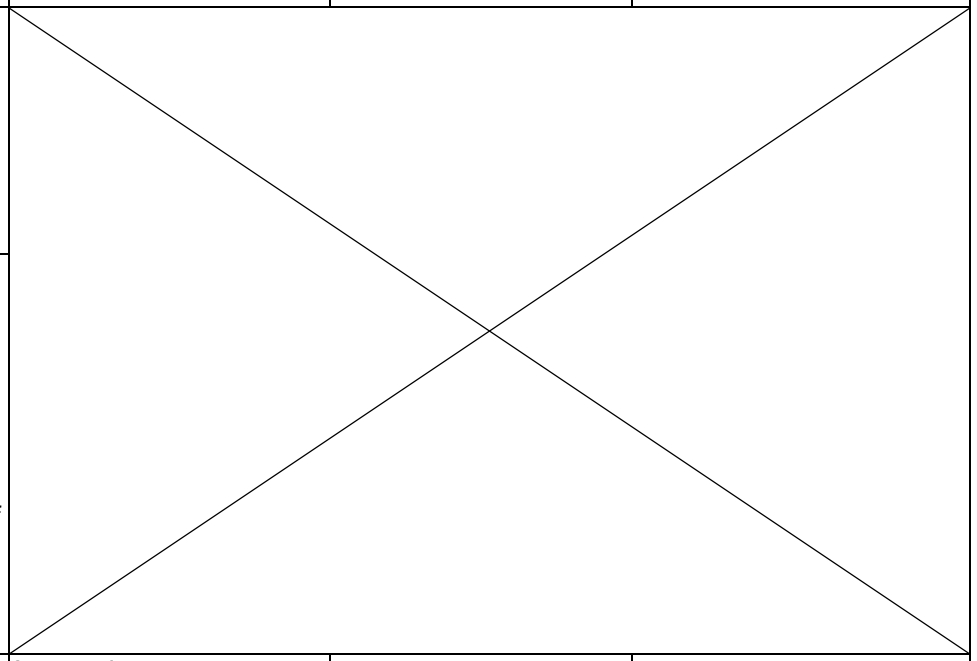
8.22 Appendix 22. Progression of outcome themes and subthemes from Thematic Analysis through discussion at SDGs to the final list of outcome themes taken to the Delphi survey.

Outcome themes categorised by the COMET Taxonomy of Outcomes core area and outcome domain (outcome domain number)	Number of systematic review codes	Primary outcome codes	Secondary outcome codes	Outcome statements presented at the healthcare professional SDG (SDG1)	Outcomes presented at the patient SDG (SDG2)	Outcomes presented to the Study Management Group (SMG)	Outcomes approved for Delphi survey round 1
1. Death							
Mortality/survival (1)							
Death	21	1	20	Death is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Death changed to Survival.*	Survival	→	Survival
2. Physiological or clinical							
Blood and lymphatic system outcomes (2)							

Venous thromboembolism	10	0	10	Diagnosis of venous thromboembolism is an important outcome to measure when recovering from open lower limb fracture.	Venous Thromboembolism (blood clots in the legs or lungs)	→	Venous thromboembolism (blood clot in legs or lungs)
General outcomes (9)							
Sleep	0	0	0	Quality of sleep is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Outcome joined with fatigue as it was felt that there was significant concept overlap.*	Sleep and fatigue *SDG2: Participants recognised sleep as important, comparing it to being worse after the injury than looking after a 2-year-old. Although they did recognise that it may not be important enough to become a core outcome.*	→	Sleep and fatigue
Systemic sepsis or bacteraemia	3	0	3	Absence of systemic infection is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Dropped due to only being reported in only 3 studies.*			Number of unplanned hospital re-admissions[1]
Tiredness and fatigue	0	0	0	Tiredness and fatigue is an important outcome to measure when recovering from open lower limb fracture.			Length of hospital stay[1]

[1] Outcome previously categorised under COMET Taxonomy of Outcomes core area: Resource use, outcome domain: Hospital. Moved general outcomes domain following SMG1.

				SDG1: Combined with sleep as above.			
						Number of outpatient appointments[1]	
						Number of Primary Care visits[1]	
Musculoskeletal and connective tissue outcomes (15)							
Adverse events of orthopaedic intervention	5	2	3	*SDG1: Dropped due adverse events core area below*			
Complications and post-operative complications	71	1	70	Complications following treatment is an important outcome to measure when recovering from open lower limb fracture. Complications resulting from muscle flaps or grafts is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Soft tissue complication thought to be a specific and serious complication justifying inclusion as a separate outcome theme.*	Complications Complications resulting from soft tissue (muscle flaps or grafts)	Complications *SMG1: Dropped due to overlap with 'number of adverse events' outcome below.*	Complications resulting from soft tissue (muscle flaps or grafts)
Hardware or implant failure	12	0	12	Hardware or implant failure is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Implant term dropped, feeling term could be associated with aesthetic surgery e.g. breast implant.*	Metalwork failure *SDG2: Participants recognised metalwork failure as important. One patient recounted his experience of needing an additional surgery for a*		Metalwork failure

					'snapped' piece of metalwork.		
Pin site loosening	3	1	2	External fixator pin site loosening is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Outcome dropped due to cover of concept by 'metalwork failure outcome'*			
Time in external fixator	3	0	3	Time in an external fixator is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Dropped as felt to be too specific with sufficient coverage of concept in other outcome themes, e.g.* 'Tolerability and acceptability of surgical intervention e.g. external fixator, is an important outcome to measure when recovering from open lower limb fracture'.			
Amputation	77	8	69	Amputation is an important outcome to measure when recovering from open lower limb fracture.	Amputation *SDG2: All participants agreed that amputation is a very important outcome theme. It was also recognised that the term amputation is very broad. There are many types of amputation which have big effects on your eventual function, e.g. below knee*		Amputation

					vs through knee vs above knee. It was also discussed that an amputation may be a good option for some people.		
Bone	2	0	2	Bone union is an important outcome to measure when recovering from open lower limb fracture. *SDG1: 'union' dropped in favour of 'healing' as felt to be more intuitive for patients.*		→	
Bone union or healing	265	15	250		Bone healing		Bone healing
Malunion or alignment	77	0	77	Malunion, alignment and rotational deformity is an important outcome to measure when recovering from open lower limb fracture.	Malunion, alignment and rotational deformity	→	Malunion, alignment and rotational deformity
Non-union	53	2	51	Non-union is an important outcome to measure when recovering from open lower limb fracture. *SDG1: outcome dropped as from a patient perspective bone union/healing and non-union/non-healing are the same concept.*			
Osteonecrosis	5	1	4	Osteonecrosis is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Too specific and infrequently reported in the literature, can be covered by adverse events core area below.*			
Pseudoarthrosis	2	0	2	Pseudoarthrosis is an important outcome to measure when recovering from open lower limb fracture.			

				SDG1: As above.			
Compartment syndrome	17	0	17	Compartment syndrome is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Felt that the consequences of a compartment syndrome would be picked up in other outcome themes, e.g. appearance and walking, gait and mobility.*			
Infection	157	27	130				
Deep infection	88	14	74	Deep infection is an important outcome to measure when recovering from open lower limb fracture. *SDG1: from a clinical point of view the distinction between deep and superficial infection is important and does effect practice. So is important to differentiate between the two rather than having an broad 'infection' outcome theme.*	Deep infection	→	Deep infection
Flap infection	2	0	2	Flap infection is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Covered in surface infection*			
Osteomyelitis	48	6	42	Osteomyelitis is an important outcome to measure when recovering from open lower limb fracture.			

				SDG1: Covered in deep infection			
Pin site infection	30	2	28	Pin site infection is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Covered in surface infection*			
Septic arthritis	5	4	1	Septic arthritis is an important outcome to measure when recovering from open lower limb fracture. *SDG1: dropped due to infrequency of reporting.*			
Superficial or wound infection	41	1	40	Superficial or wound infection is an important outcome to measure when recovering from open lower limb fracture. *SDG1: changed to 'surface infection', superficial infection felt to imply infection may be trivial.*	Surface infection	→	Surface infection
Laboratory tests	4	0	4				
Leg length or leg shortening	25	0	25	Leg or bone shortening is an important outcome to measure when recovering from open lower limb fracture.	Leg or bone shortening	→	Leg or bone shortening
Loss of height	0	0	0				
Microbiology cultures	17	1	16	Microbiological culture results are an important outcome to measure when recovering from open lower limb fracture. *SDG1: Dropped as covered by the deep/surface infection outcome*			
Wound cultures	13	1	12				

				themes. Felt that the culture result is not important to the patient.			
Numbness and loss of sensation	3	0	3	Sensation loss is an important outcome to measure when recovering from open lower limb fracture.	Change in sensation *SDG2: there was some debate about taking this outcome theme out. However, patients did present personal accounts of how their sensation had changed. One patient who had an amputation talked about trying to desensitise his stump using 'chilli cream'.*	→	Change in sensation
Sensory or motor impairment	17	1	16	Muscle weakness is an important outcome to measure when recovering from open lower limb fracture.	Muscle weakness *SDG2: Participants felt that this is well covered in the 'walking, gait and mobility' outcome theme. However, they kept it is as they recalled personal accounts of having to build up strength in specific muscles in their injured limbs.*	→	Muscle weakness
Osteoarthritis	4	0	4	Development of post-traumatic osteoarthritis is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Dropped due to the symptoms overlapping with pain and range of movement outcome themes.*			

Over sensitivity of sensation	0	0	0	Over sensitivity is an important outcome to measure when recovering from open lower limb fracture. *SDG1: it was felt that this was not an intuitive outcome, difficult to define and overlapped with pain so was dropped.*			
Pain or discomfort	48	1	47	Pain is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Join pian and discomfort to create an overarching pain outcome theme, 'pain or discomfort'.* Ache is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Ache dropped as participants felt that ache was on the same spectrum as pain and can be described as discomfort which may be a better term to use as its more general.* Post-operative pain is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants felt that this outcome is an important part of the treatment experience, but would be adequately covered by one outcome theme; 'pain and discomfort'. There was also a*	Pain or discomfort	→	Pain or discomfort

				consensus opinion that post-op pain is an expected event after an operation making it an unnecessary standalone outcome theme for consideration in the COS.			
				Pain on walking is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Adequately covered by a pain or discomfort outcome.*			
Medication use for pain	1	0	1	Medication use for pain is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Dropped as covered later in the adverse events core area.*			
Plastics intervention e.g. flap or graft	2	0	2	Muscle flap or skin graft failure or survival is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants felt this would be encompassed by adverse events core area and 'unplanned return to the operating theatre' outcome.*			
Adverse event or complication of graft or flap	18	1	17	Muscle flap or skin graft necrosis is an important outcome to measure when recovering from open lower limb fracture. *SDG1: As above.*			
Flap failure or survival	51	4	47				
Graft or flap necrosis	10	0	10				

Reoperations	21	5	16	Number or reoperations, revision surgeries or surgical procedures is an important outcome to measure when recovering from open lower limb fracture. *SDG1: encompassed by* 'Unplanned return to the operating theatre' outcome.	Unplanned return to the operating theatre *SDG2: Patients identified that this was an important marker of complication during recovery and recounted their own storeys where discharge decisions had gone wrong.*	→	Unplanned return to the operating theatre
Number of debridements	7	0	7	Number of debridements is an important outcome to measure when recovering from open lower limb fracture. *SDG1: encompassed by* 'Unplanned return to the operating theatre' outcome.			
Number of operations	62	1	61				
Shaking or fasciculations	0	0	0				
Swelling	2	0	2	Swelling is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants felt swelling would be adequately covered by functioning outcomes*			
Wound	3	0	3				
Wound closure and dehiscence	7	1	6	Type of wound closure is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants did not feel this represented an outcome.*			

				Wound dehiscence (reopening) is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants felt that this would be covered in the 'unplanned return to the operating theatre' outcome.*	
Wound healing	43	2	41		
Wound necrosis	14	1	13	Wound necrosis (skin breakdown) is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants felt that this would be covered in the 'number of adverse events' outcome or 'unplanned return to the operating theatre' outcome.*	
Renal and urinary outcomes (19)					
Acute Kidney Injury	4	2	2	Acute Kidney Injury is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Not a highly reported outcome for OLLF, not mentioned in patient interviews so decision to drop.*	
Renal failure	1	0	1	Development of renal failure is an important outcome to measure when recovering from open lower limb fracture.	

				SDG1: As above.			
3. Life impact							
Physical functioning (25)							
Ability to climb stairs	2	0	2	Ability to climb stairs is an important outcome to measure when recovering from open lower limb fracture.	Ability to climb stairs *SDG2: Participants felt it was adequately covered by activities of daily living.*		
Ability to do activities of daily living	4	0	4	Ability to do activities of daily living is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants felt that this was an important outcome but wanted a clearer definition of what activities of daily living may include. It was discussed that if selected as a core outcome this would be identified when choosing an appropriate measurement instrument.*		Ability to do activities of daily living	Ability to do activities of daily living
Cleaning and tidying	0	0	0		Ability to do activities of daily living		
Ability to find a comfortable position	0	0	0				
Ability to kneel	0	0	0	Ability to kneel is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Kneeling felt to be an essential part of patients functioning, e.g. builders,*	Ability to kneel *SDG2: Participants thought kneeling was very important.*	→	Ability to kneel

				paramedics doing CPR and playing with children were examples given in patient interviews.			
Balance	0	0	0	Ability to balance is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Balance was felt to be an important part of recovery and this was expressed at interview.*	Ability to balance *SDG2: Participants felt balance is important as it effects walking, exercise, e.g. keeping a football up, as well as other normal life activities.*	→	Ability to balance
Dependence	0	0	0	Ability to be independent is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Recognised as an important broad reaching outcome theme that links to others around participation and emotional wellbeing.*	Ability to be independent *SDG2: Participants felt this outcome themes also related strongly to mental health*	→	Ability to be independent
Disability	3	1	2				
Driving	0	0	0	Ability to drive is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Driving caused some discussion about whether to keep or not. Participants agreed it should be kept after descriptions of patients valuing it as important in the interviews.*	Ability to drive *SDG2: Driving recognised as very important, not only a key part of some people's employment but also central to their independence.*	→	Ability to drive
Function - lower limb functional and general physical function	88	8	80	Lower limb function is an important outcome to measure when recovering from open lower limb fracture.	Lower limb function *SDG1: Participants decided not to distinguish*	→ *SDG2: Participants happy to keep lower limb*	Lower limb function

Ankle function	16	0	16	Ankle function is an important outcome to measure when recovering from open lower limb fracture.	*between anatomical areas of the lower limb when measuring function as the anatomical characteristics of peoples OLLF are different*	*function broad and bot breaking up into anatomical areas of lower limb functioning.*	
Foot function	7	0	7	Foot function is an important outcome to measure when recovering from open lower limb fracture.			
Knee function	12	0	12	Knee function is an important outcome to measure when recovering from open lower limb fracture.			
Shoulder function	1	0	1	Shoulder function is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Dropped as less relevant for OLLF. Shoulder pain from using crutches is more an adverse event.*			
Gait, walking and mobility	29	3	26	Walking, gait and mobility is an important outcome to measure when recovering from open lower limb fracture.	Walking, gait and mobility	→	Walking, gait and mobility
Awareness and difficulty walking on uneven ground	0	0	0				
Weight bearing	2	0	2	Ability to fully weight bear is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Dropped as encompassed by 'walking gait and mobility'*			
Weight bearing status and time to weight bear	14	0	14				

Gardening and DIY	0	0	0	Ability to do gardening and DIY is an important outcome to measure when recovering from open lower limb fracture. *SDG1. Participants thought that this could be merged with 'activities of daily living' however they wanted to let the patients decide. A note was taken to discuss at SDG2.*	Ability to do gardening and DIY *SDG2: Patients agreed that this outcome can be merged with 'activities of daily living'. Not an essential activity, more of a hobby.*		
Movement, range of movement and stiffness	25	0	25	Range of movement and joint stiffness is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Range of movement and joint stiffness were thought to be different outcome concepts e.g. joint stiffness is often described in patients with arthropathies while range of movement may not be as important as function for example in that context. Therefore, the two outcome concepts were split as separate themes*	Joint stiffness *SDG2: Participants didn't feel 'joint stiffness' was important enough to justify keeping it as a standalone outcome theme. They felt it ties in to 'walking, gait and mobility' as well and 'range of movement'.*		
Ankle range of movement	22	0	22	Ankle range of movement is an important outcome to measure when recovering from open lower limb fracture. *SDG1: As per the lower limb functioning outcome themes, a decision was made not top split by anatomical area.*	Range of movement	→	Range of movement

Knee range of movement	25	0	25	Knee range of movement is an important outcome to measure when recovering from open lower limb fracture. *SDG1: As above.*			
Self and personal care	0	0	0	Ability to be able to do self and personal care is an important outcome to measure when recovering from open lower limb fracture. *SDG1" Participants felt that this was an important outcome theme and should be kept as it encompasses activities like toileting and washing more specifically than 'activities of daily living'.*	Ability to be able to do self and personal care *SDG2: Added the dressing to this outcome theme heading. Participants described the ability to start dressing for themselves as a key stage in their recovery representing a large step towards independent living again. This was felt to be important enough to be a standalone outcome themes and not merged with 'activities of daily living'.*	Ability to be able to dress and do self and personal care	Ability to be able to dress and do self and personal care
Sex	0	0	0	Ability to enjoy sex is an important outcome to measure when recovering from open lower limb fracture. *SDG1: outcome term changed from sex to intimacy. Although only discussed once in the interviews, the outcome theme was kept as it may have been underrepresented by patients.*	Ability to have intimate relationships SDG2: Participants though that 'ability to have intimate relationships' is important. This outcome theme was also linked to the importance of being able to kneel.	→	Ability to have intimate relationships

Sports, exercise and fitness	7	0	7	Ability to partake in sports and exercise is an important outcome to measure when recovering from open lower limb fracture. *SDG1: sports dropped as it may put off older people from scoring the outcome, the term exercise represents the concept more broadly.*	Ability to partake in exercise *SDG2: wording changed to 'ability' rather than 'partake'. Made more sense to the participants.*	Ability to exercise	Ability to exercise
Wearing shoes	1	0	1	Ability to comfortably wear shoes is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Changed to include the term comfortably to indicate the outcome is more about being able to wear shoes as a function rather than for appearance. Clothes also added to outcome theme.*	Ability to comfortably wear shoes and clothes of your choice *SDG2: Participants discussed need to by new trainers and not being able to wear the right clothes at work,*	→	Ability to comfortably wear shoes and clothes of your choice
Social functioning (26)							
Participation	3	0	3	Ability to participate in social events is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants agreed that this theme heading represents an important component of social functioning.*	Ability to participate in social events SDG2: This was recognised as important by participants who discussed events in life they could not join in with. This related to mental wellbeing.	→	Ability to participate in social events
Relationships	0	0	0	Ability to maintain and develop relationships is an important outcome to measure when recovering from open lower limb fracture.	Ability to start, maintain and develop relationships	→	Ability to start, maintain and develop relationships

				SDG1: Participants felt it was helpful to have a broad relationship outcome theme. The addition of the word 'start' was added to encompass difficulties that may be encountered making new relationships, e.g. starting intimate relationships.			
Reliance on others	1	0	1	Not having to rely on other people is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Outcome theme wording changed to encompass people who may not have been fully independent before their injuries to emphasise the importance of maintaining their level of independence pre-injury, e.g. the elderly fragility OLLF population.*	Maintaining a level of independence *SDG2: Dropped as participants felt it overlapped with 'ability to be independent' in the physical functioning outcome domain.*		
Role functioning (27)							
Care for others and animals	0	0	0	Being able to care for other people and animals is an important outcome to measure when recovering from open lower limb fracture.	Being able to care for other people and animals	→	Being able to care for other people and/or animals
Work and employment	1	0	1	Being able to work or return to work is an important outcome to measure when recovering from open lower limb fracture.	Being able to work, return to work or active duty (military) *SDG2: Participants decided to change 'return to work or active duty' to 'return to life roles' this*	Being able to return to life roles (e.g. caring, work, military duty)	Being able to return to life roles (e.g. caring, work, military duty)
Return to work or duty	16	2	14	Return to work or active duty (military) is an important outcome to measure when recovering from open lower limb fracture.			

				SDG1: Participants felt that all three role functioning outcomes could be combined but decided to only combine the two work/employment/duty outcome themes at this stage. It thought best to let the patients decide in SDG2 whether they wanted to combine all three outcome themes in the outcome theme 'return to life roles'.	*was because they thought it would be more specific, i.e. you may return to work or the military but not in the same role as before. They also decided to keep 'being able to care for other people and animals separate, as, for example, you may not be able to return to your previous work role but can still look after your children. They identified this outcome theme as 'essential'.*		
Emotional functioning and wellbeing (28)							
Acceptance of event and change	0	0	0	Ability to accept the event and life change is an important outcome to measure when recovering from open lower limb fracture. *SDG1: It was felt that this outcome theme linked closely with depression and could therefore be covered to some extent in the 'mood' outcome theme. However, it was decided not to drop it at this point.*	Ability to accept the event and life change[5]	→	Ability to accept the event and life change[5]
Appearance	5	0	5	Appearance of lower limb e.g. scars, flaps and swelling is an important outcome to measure when recovering from open lower limb fracture.	Appearance of lower limb e.g. scars, flaps and swelling[1] *SDG2: Participants did not feel that appearance in itself was important, they*	→	Appearance of lower limb e.g. scars, flaps and swelling[1]

				SDG1: This outcome theme was kept as a standalone appearance outcome theme as the direct appearance of the injured lower limb was felt be important to many patients after OLLF. It also encompasses specific appearance issues patients mentioned including swelling and flap appearance.	*felt the issue lays with feeling different and being accepted by society. However, they did concede that they were all male and a woman may feel differently, so decided to keep the appearance outcome themes.*		
				General appearance e.g. putting on weight is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Outcome theme heading changed to include changing shape as well as weight gain to encompass strength or muscle loss which men are often more concerned about and weight gain which women are often more concerned about. It was also thought that 'donor site appearance' and 'tattoos' could be dropped and represented by this outcome theme.*	General appearance e.g. changing shape or weight[1] *SDG2: As above.*	General appearance e.g. changing shape or weight[1] *SMG: Outcome theme title changed to 'change in body shape or weight' to be more specific an outcome theme.*	Change in body shape or weight[1]
Donor site appearance	1	0	1	Donor site appearance is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Dropped as encompassed by general appearance.*			
Tattoos	0	0	0	Appearance of lower limb tattoos following injury is an important outcome to measure when recovering from open lower limb fracture.			

				SDG1: Dropped as encompassed by general appearance.			
Dignity	0	0	0	Maintaining a feeling of dignity is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Dignity felt to be justified as a separate outcome to dependence and was recognised as potentially a key area of importance for older patients.*	Maintaining a feeling of dignity[6]	→	Maintaining a feeling of dignity[6]
Emotional fragility	0	0	0	Having emotional strength is an important outcome to measure when recovering from open lower limb fracture. *SDG1: It was felt that this outcome theme is very closely linked to feelings commonly associated with depression and an argument was made on this basis to drop it. However, the feeling of inability to cope with emotions and emotional breakdowns were commonly described in narratives of recovery. On that basis it was decided to keep the outcome and change the theme heading to 'having emotional strength'.*	Having emotional strength *SDG2: Participants opted to change the outcome theme heading to include vulnerability, volatility and fragility which was thought to better represent the concepts the outcome is trying to capture from the lived experiences of patient dealing with emotional struggle including unexpected and unwanted extreme emotional outbursts at times during recovery. They felt that this outcome is also closely related to, and manifests as a consequence of feelings of uncertainty.*	Emotional vulnerability, volatility and fragility[5]	Emotional vulnerability, volatility and fragility[5]
Expectations, uncertainty and views on the future	0	0	0	Having clear expectations and views on the future with lack of		→	

Uncertainty	0	0	0	uncertainty is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants felt that this outcome theme tries to capture the patient need for a clear treatment plan and good idea of what their final recovery outcome may look like.*	Having clear expectations and views on the future with lack of uncertainty[3] SDG2: Participants related to this outcome theme.		Having clear expectations and views on the future with lack of uncertainty
Fear and fear for the future	0	0	0	Living in fear e.g. fear of falling or going outside and fear for the future is an important outcome to measure when recovering from open lower limb fracture. *SDG1: This outcome theme heading was changed to include 'tolerance of uncertainty' as it was felt that this was a more clearly defined psychological concept which relates to a person's emotional state including their mood. i.e. people in lower mood states do not have as much tolerance to deal with uncertainties in life.*	Tolerance of uncertainty and living in fear e.g. fear of falling or going outside and fear for the future[3] *SDG2: Participants also related to this outcome theme.* *"that's quite a good actually". One patient talked about becoming very risk adverse and scared to leave the house, which got to the point that he decided to see a clinical psychologist.*	→	Tolerance of uncertainty and living in fear e.g. fear of falling or going outside and fear for the future[3]
Feeling of being disabled, damaged or brokenness	0	0	0	Feelings of disablement, being damaged or broken is an important outcome to measure when recovering from open lower limb fracture.	Feelings of disablement, being damaged or broken[2]	→	Feelings of disablement, being damaged or broken[2]
Feeling of giving up or hopelessness	0	0	0	Feelings of giving up and hopelessness is an important outcome to measure when recovering from open lower limb fracture.	Feelings of giving up and hopelessness[2] *SDG2: Participants also related this outcome to*	→	Feelings of giving up and hopelessness[2]

					feelings of uselessness and argued they were the same thing.		
Feeling of loss	0	0	0	Feeling of loss is an important outcome to measure when recovering from open lower limb fracture.	Feeling of loss[2]	→	Feeling of loss[2]
Feeling of stolen youth, energy or fitness	0	0	0	Feelings of struggle or fighting against the body is an important outcome to measure when recovering from open lower limb fracture.		→	
Feeling of struggle or fighting	0	0	0		Feelings of struggle or fighting against the body[5]		Feelings of struggle or fighting against the body[5]
Frustration and anger	0	0	0	Feeling of frustration and anger is an important outcome to measure when recovering from open lower limb fracture.	Feeling of frustration and anger[2] *SDG2: Participants identified with this outcome and talked about their experiences dealing with the compensation process. One patient talked about his feeling after the two people he felt were responsible for his injury won a lottery syndicate which elicited strong feeling of frustration.*	→	Feelings of frustration and anger[2]
Grateful and thankfulness	0	0	0	Feelings of hopefulness, positivity and determination is an important outcome to measure when recovering from open lower limb fracture.		→	
Hopefulness, positivity and determination	0	0	0		Feelings of hopefulness, positivity and determination[2]		Feelings of hopefulness, positivity and determination[2]

Isolation, loneliness and lack of support[2]	0	0	0	Isolation, loneliness and lack of emotional support is an important outcome to measure when recovering from open lower limb fracture.	Isolation, loneliness and lack of emotional support[2]	→	Isolation, loneliness and lack of emotional support
Loss of control and limitation	0	0	0	Loss of control and feeling of limitation is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants felt the word 'confidence' should appear here as patients may more easily identify with confidence over the 'fear for the future' outcome detailed above. Patients may not consider themselves afraid but rather lacking their previous confidence doing activities such as sports etc.*	Loss of confidence or control and feeling of limitation[3]	→	Loss of confidence or control and feeling of limitation[3]
Mood	1	0	1	Low mood is an important outcome to measure when recovering from open lower limb fracture.	Low mood[2]	→	Low mood[2]
Moving on and getting life back	0	0	0	Ability to move on and feeling of getting life back is an important outcome to measure when recovering from open lower limb fracture.	Ability to move on and feeling of getting life back[2]	→	Ability to move on and feeling of getting life back[2]
Psychological status	0	0	0	Experience of flashbacks to the traumatic event is an important outcome to measure when recovering from open lower limb fracture.	Experience of flashbacks to the traumatic event[4]	→	Experience of flashbacks to the traumatic event[4]
Sense of helping others	0	0	0				

Sense of self, identity and body wholeness	0	0	0	Feelings of self-identity and body wholeness is an important outcome to measure when recovering from open lower limb fracture.	Feelings of self-identity and body wholeness[2] *SDG2: Some participants did not identify with this outcome theme, "that's a bit deep for me". And some did. It was agreed that this theme is related to how severe the OLLF is. The more severe the more chance that a person may feel a loss of identity and their body no longer being recognised as theirs anymore.*	→	Feelings of self-identity and body wholeness[2]
Worry and anxiety	1	0	1	Being anxious or stressed is an important outcome to measure when recovering from open lower limb fracture.		→	
Fear of falling over	0	0	0				
Stress	3	1	2		Being anxious or stressed[3]		Being anxious or stressed[3]

Emotional functioning and wellbeing outcomes subcategorisation

The emotional functioning and wellbeing outcome themes were discussed at length at the professional and patient Structured Discussion Groups (SDG) where arguments were made to keep the granularity of the different outcome themes or merge them into overarching headings recognised from a psychological perspective. A Trauma Psychologist attended the professional SDG. It was noted that the outcome themes could be grouped by overarching themes used in the field of clinical psychology in trauma. Going forward to patient SDG and beyond the emotional wellbeing and outcome themes were grouped as below (superscript on the above emotional functioning and wellbeing outcome themes represents the outcome groups they were subsequently categories to).

1 - Appearance outcomes

2 - Depression outcomes

3 - Anxiety outcomes

4 - Post-Traumatic Stress Outcomes

5 - Resilience and acceptance outcomes ***6 - Satisfaction with care outcomes***							
Cognitive functioning (29)							
Change in behaviour and attitude	0	0	0	Change in outlook, behaviour and attitude towards life is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants agreed to merge this outcome with mental exhaustion below to better encompass cognitive function.*	Lack of concentration and focus	→	Lack of concentration and focus
Mental exhaustion	0	0	0	Being mentally exhausted is an important outcome to measure when recovering from open lower limb fracture. *SDG1: As above merged to 'lack of concentration and focus'. This outcome better represents mental agility and speed of thinking or lack thereof.*			
Global quality of life (30)							
Quality of life	32	0	32	Quality of life is an important outcome to measure when recovering from open lower limb fracture. *SDG1: All agreed quality of life is an important outcome theme.*	Quality of life	→	Quality of life

Perceived health status (31)							
Percentage perceived loss of function	0	0	0	Percentage of perceived loss of function is an important outcome to measure when recovering from open lower limb fracture.	Percentage of perceived loss of function	Percentage of perceived loss of function *SMG: Decided to drop the term 'percentage' in favour of 'degree' to be more intuitive. It was felt that perceived health status would be better suited to general health rather than also being included specifically for lower limb function.*	Degree of perceived loss of general health and wellbeing
Subjective assessment of success	2	0	2	A subjective assessment of success of intervention is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants suggested changing wording to 'general health and wellbeing' to better capture the concept loss of other elements of health not directly related to the injured limb.*	Degree of perceived loss of general health and wellbeing	Degree of perceived loss of general health and wellbeing *SMG: As above.*	
Delivery of care (32)							
Communication	1	0	1	Communication of healthcare professionals to patients is an important outcome to measure when recovering from open lower limb fracture.	Quality of communication of healthcare professionals to patients	→	Quality of communication of healthcare professionals to patients

				SDG1: Participants didn't entirely agree this should be an outcome but felt that it should be discussed with the patients.	*SDG2: Patients felt that this outcome theme is important enough from their experiences to be kept in for the Delphi survey.*		
hospital food and environment eg non-clinical hospital care	0	0	0	The non-clinical hospital experience e.g. food, ward environment, etc. is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants didn't feel that this represented an outcome in of itself, more a standard of care. It was recognised that this would overlap with patient satisfaction.*			
Hospital visits	0	0	0				
Occupational therapy - house alterations	0	0	0	Help adapting to the home environment e.g. occupational therapy interventions is an important outcome to measure when recovering from open lower limb fracture. *SDG1: As above.*			
Patient satisfaction	5	0	5	Satisfaction with care received is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants felt that this was an important outcome and potentially covers many of the outcome themes in the delivery of care domain.*	Satisfaction with care *SDG2: Participants felt that this outcome theme was perhaps too broad but decided to retain it for the Delphi survey. Patients expressed strong feelings of satisfaction around input from their trauma nurse specialists.*	→	Satisfaction with care

Quality of care	0	0	0				
Rehab and physio	0	0	0	Delivery of physiotherapy and rehabilitation is an important outcome to measure when recovering from open lower limb fracture. *SDG1: As per 'Hospital food nd environment outcome'*			
Tolerability and acceptability of intervention eg exfix vs nail vs plate	0	0	0	Tolerability and acceptability of surgical intervention e.g. external fixator, is an important outcome to measure when recovering from open lower limb fracture. *SDG1: It was felt that this should be kept at this stage as the 'time in external fixator 'outcome theme was dropped. There was a discussion around not dropping to many outcome themes at this stage in the research as there is more validity in dropping themes as the Delphi Stage due to a wider audience.*	Tolerability and acceptability of surgical intervention e.g. external fixator	→	Tolerability and acceptability of surgical intervention e.g. external fixator
Personal circumstances (33)							
Change in lifestyle	0	0	0	Change in lifestyle is an important outcome to measure when recovering from open lower limb fracture. *SDG1: There was a feeling that 'change in lifestyle could encompass the below three outcome themes. However, at this stage in the project it was decided*	Change in lifestyle	→	Change in lifestyle

				to keep them as separate outcome themes			
Having access to a disabled badge	0	0	0	Being able to use disabled facilities e.g. disabled parking is an important outcome to measure when recovering from open lower limb fracture.	Being able to use disabled facilities e.g. disabled parking. *SDG2: Participants did not feel that this was an essential outcome to measure in their recovery.*		
Insurance and financial compensation	0	0	0	Being compensated financially for injury is an important outcome to measure when recovering from open lower limb fracture. *SDG1: This outcome theme was contentious as it is something that would be difficult to measure in a trial. However, many patients described getting through the compensation litigation process as a key element of moving forward with life and gaining a level of acceptance.*	Being compensated financially for injury	→	Being compensated financially for injury
Need to plan around, or adapt to disability	0	0	0				
Personal cost of treatment and care	0	0	0	Personal cost of treatment and care following injury is an important outcome to measure when recovering from open lower limb fracture. *SDG1: this was recognised as being important to patients and so kept for SDG2 discussion.*	Personal cost of treatment and care following injury	→	Personal cost of treatment and care following injury

Personal finances	0	0	0	Effect of injury on personal finances is an important outcome to measure when recovering from open lower limb fracture. SDG1: As above.	Effect of injury on personal finances	→	Effect of injury on personal finances
4. Resource use							
Economic (34)							
Cost	24	8	16	Cost to healthcare provider is an important outcome to measure when recovering from open lower limb fracture.	Cost to healthcare provider	Cost to healthcare provider *SMG: This decided as out of scope for the aims of this COS project*	☒
Hospital (35)							
Hospital re-admission	5	0	5	Number of hospital re-admissions is an important outcome to measure when recovering from open lower limb fracture.	Number of unplanned hospital re-admissions	Number of unplanned hospital re-admissions[2]	*See general outcomes*
Length of hospital stay	52	0	52	Length of hospital stay is an important outcome to measure when recovering from open lower limb fracture.	Length of hospital stay	Length of hospital stay[2]	*See general outcomes*

[2] Outcome moved to general outcome domain following SMG meeting.

Length of ICU stay	6	0	6	Length of Intensive Care Unit stay is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants felt that this wasn't a useful measure in the context of long-term recovery from OLLF.*			
Number of emergency department attendances	1	0	1	Number of Emergency Department attendances is an important outcome to measure when recovering from open lower limb fracture. *SDG1: Participants could drop this as it would be better captured by the outcome theme 'hospital re-admission' and 'unplanned return to the operating theatre'*			
Number of outpatient appointments	5	0	5	Number of outpatient appointments is an important outcome to measure when recovering from open lower limb fracture.	Number of outpatient appointments	Number of outpatient appointments[2]	*See general outcomes*
Number of primary care encounters	1	0	1	Number of Primary Care visits is an important outcome to measure when recovering from open lower limb fracture.	Number of Primary Care appointments	Number of Primary Care visits[2]	*See general outcomes*
Need for intervention (36)							
No outcome themes identified in this outcome domain							
Social or career burden (37)							
No outcome themes identified in this outcome domain							
5. Adverse events							

Adverse events or effects (38)							
Adverse events	5	0	5	Number of adverse events is an important outcome to measure when recovering from open lower limb fracture. SDG1: Decided to retain this outcome theme, but expected that this will need further defining if accepted as a core outcome.	Number of adverse events	→	Number of adverse events
Anaesthesia	0	0	0	Poor experience during anaesthesia is an important outcome to measure when recovering from open lower limb fracture.	Poor experience during anaesthesia	→	Poor experience during anaesthesia
Phlebotomy	0	0	0	Discomfort from blood taking and cannula insertion is an important outcome to measure when recovering from open lower limb fracture. *SDG1: This was removed as it was not felt be a useful outcome theme as there is phlebotomy is essential for the practice of modern medicine.*	✕	✕	✕
Side effects of analgesia	0	0	0	Side effects of pain medication is an important outcome to measure when recovering from open lower limb fracture.	Side effects of medication	→	Side effects of medication
Number of outcome statements/themes			**150**	**121**	**77**	**71**	**68**

8.23 Appendix 23. Patient Delphi survey invitation email template.

Page 1

CO-OLLF

Core Outcomes for Open Lower Limb Fractures Study

Click Here To Start Delphi Survey

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CO-OLLF

(Core Outcomes for research on Open Lower Limb Fractures)

Research Study Participant Reply Slip

Thank you for reading the study information sheet

- If you are interested in taking part in this study, please indicate which of the three separate parts you would like to participate in by ticking the relevant box below and providing your contact details:

Tick box	Description of study components
	A discussion group (we need up to 10 people for this, both patients and healthcare professionals- although please note the groups will be separate) This is a chance to tell us your views about statements that we believe summarise important outcomes to patients recovering from an open lower limb fracture (OLLF). You will need to [illegible] We will [illegible] your permission to make an audio recording of the [illegible]ing (this is [illegible]research purposes only).
	An online survey (we need a minimum of 30 people for this) We will invite you to do a survey online. We will ask you to rate on a scale of 1-9 how important you feel different outcomes are when recovering from an OLLF, based on your own experience. The survey consists of 3 rounds, each of which will take a maximum of 30 minutes to complete.
	Two consensus meetings (we need a minimum of 10 patients for this) We will invite you to come to one or two all-day meetings. Other patients, healthcare professionals including surgeons, doctors, nurses, physiotherapists, and [illegible] At the first meeting, we will discuss the outcomes which people have told us are important in the online survey. After discussion, we will decide which outcomes we all think must be used in future research studies. We will vote on these. At the second meeting, we will discuss measuring outcomes. We will explain some of the possible ways to measure these. We will then invite you to help choose how we should measure the outcomes which we decided (at meeting 1) are important. We will ask your permission to make an audio-visual recording of these meetings (for research purposes only).

Page 2

Dear <<First Name>>,

My name is Alex Aquilina and I am a Trauma and Orthopaedic Surgeon currently undertaking a PhD at the University of Oxford.

You may remember that you completed a research study reply slip (see above) where you said you would be happy to take part in an online Delphi Survey as part of the Core Outcomes for Open Lower Limb Fractures (CO-OLLF) Study.

Thank you very much for offering to take part in this research your views on which outcomes are most important when recovering from open lower limb fracture are very important to us. Your contributions will help improve how we undertake research in the future, and we hope will ultimately improve patient care.

The survey consists of 2 rounds will take no longer than 5-10 minutes each to complete. The first round is now open and will close in approximately 2 weeks. I would be delighted if you could complete the survey at your earliest convenience.

If you would like further information on the study please click here.

Please don't hesitate to get back to me with any questions or queries either by email or call my mobile, number below.

Best wishes and kind regards,

Dr Alex Aquilina

Click Here To Start Delphi Survey

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8.24 Appendix 24. Professionals Delphi survey invitation email template

Page 1

CO-OLLF

Core Outcomes for Open Lower Limb Fractures Study

Click Here To Start Delphi Survey

We want to know the most important outcomes to measure for patients recovering from open lower limb fractures. In order to gain a consensus, the views of patients and healthcare professionals will be collected using a survey.

As a healthcare professional involved in the care of patients with open lower limb fracture we would like to invite you to take part in this process.

The survey consists of 2 rounds and will take no longer than 5-10 minutes each to complete. The first round is now open and will close in approximately 2 weeks. You are asked to score outcomes that have been developed from in depth interviews with patients and from a systematic review of outcomes used in published literature on open lower limb fractures. In the second round we will ask you to re-evaluate your scores in order to gain a consensus across different stakeholder groups. I would be delighted if you could complete the survey within 2 weeks.

This project is supported by the Orthopaedic Trauma Society Membership and the Trauma, Audit and Research Network. In addition, Major Trauma Centre lead clinicians identified the need for a set or core outcomes for open lower limb fracture as a major area of research need at the National Open Fracture Summit in Newcastle last year.
Your contributions will help improve how we undertake research in the future, and we hope will ultimately lead to improvements patient care.

Page 2

My name is Alex Aquilina and I am a Trauma and Orthopaedic Surgical trainee and this research project is being undertaken as part of my PhD at the University of Oxford supervised by Prof Matt Costa, Prof Xavier Griffin, Dr Liz Tutton and Prof Ray Fitzpatrick.

If you would like further information on the study please click here.

Please don't hesitate to get back to me with any questions or queries.

Best wishes,

Dr Alex Aquilina

Click Here To Start Delphi Survey

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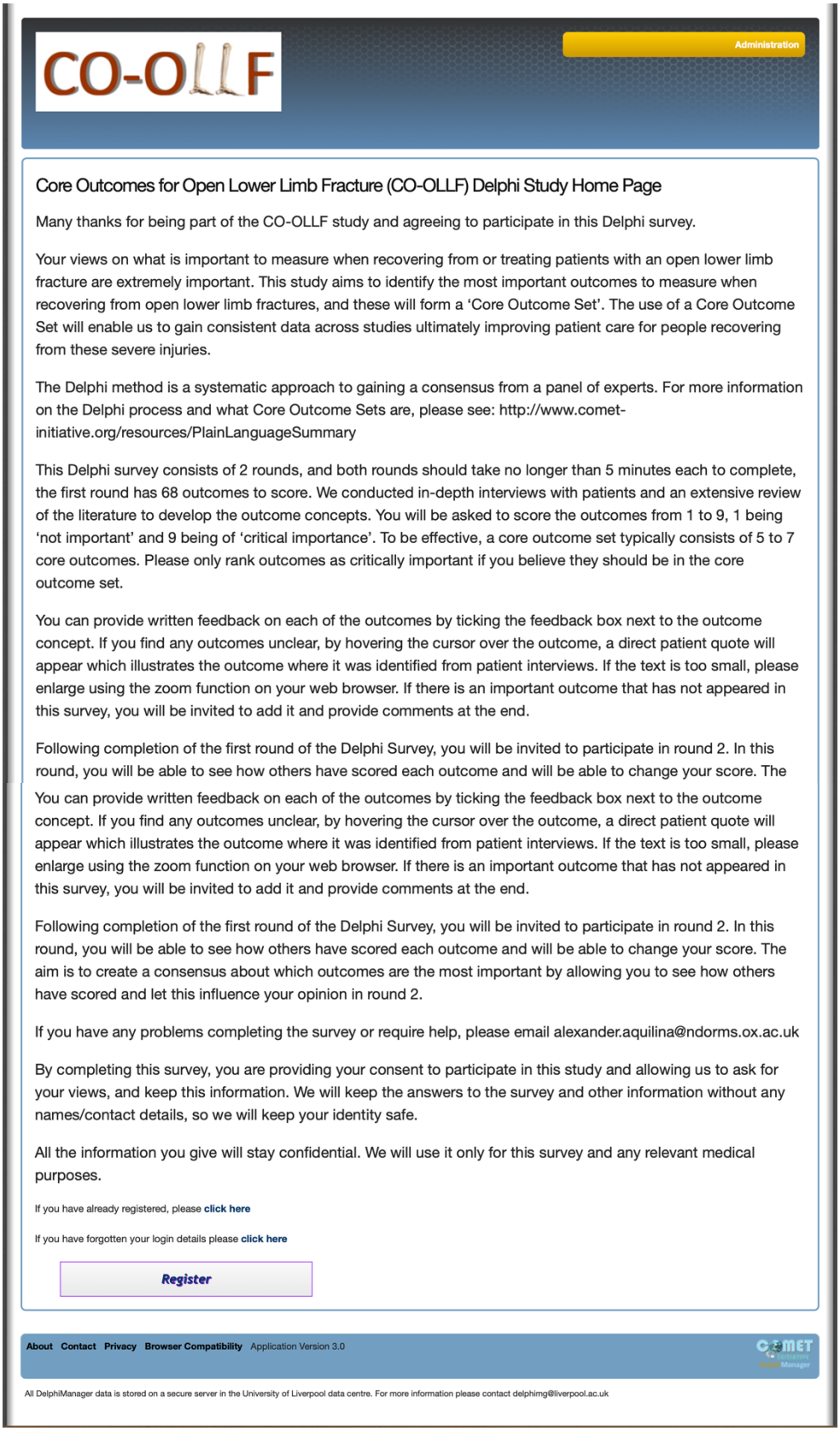
Oxford Trauma

COMET INITIATIVE

8.25 Appendix 25. CO-OLLF Delphi survey registration page



CO-OLLF

Administration

Core Outcomes for Open Lower Limb Fracture (CO-OLLF) Delphi Study Home Page

Many thanks for being part of the CO-OLLF study and agreeing to participate in this Delphi survey.

Your views on what is important to measure when recovering from or treating patients with an open lower limb fracture are extremely important. This study aims to identify the most important outcomes to measure when recovering from open lower limb fractures, and these will form a 'Core Outcome Set'. The use of a Core Outcome Set will enable us to gain consistent data across studies ultimately improving patient care for people recovering from these severe injuries.

The Delphi method is a systematic approach to gaining a consensus from a panel of experts. For more information on the Delphi process and what Core Outcome Sets are, please see: http://www.comet-initiative.org/resources/PlainLanguageSummary

This Delphi survey consists of 2 rounds, and both rounds should take no longer than 5 minutes each to complete, the first round has 68 outcomes to score. We conducted in-depth interviews with patients and an extensive review of the literature to develop the outcome concepts. You will be asked to score the outcomes from 1 to 9, 1 being 'not important' and 9 being of 'critical importance'. To be effective, a core outcome set typically consists of 5 to 7 core outcomes. Please only rank outcomes as critically important if you believe they should be in the core outcome set.

You can provide written feedback on each of the outcomes by ticking the feedback box next to the outcome concept. If you find any outcomes unclear, by hovering the cursor over the outcome, a direct patient quote will appear which illustrates the outcome where it was identified from patient interviews. If the text is too small, please enlarge using the zoom function on your web browser. If there is an important outcome that has not appeared in this survey, you will be invited to add it and provide comments at the end.

Following completion of the first round of the Delphi Survey, you will be invited to participate in round 2. In this round, you will be able to see how others have scored each outcome and will be able to change your score. The

You can provide written feedback on each of the outcomes by ticking the feedback box next to the outcome concept. If you find any outcomes unclear, by hovering the cursor over the outcome, a direct patient quote will appear which illustrates the outcome where it was identified from patient interviews. If the text is too small, please enlarge using the zoom function on your web browser. If there is an important outcome that has not appeared in this survey, you will be invited to add it and provide comments at the end.

Following completion of the first round of the Delphi Survey, you will be invited to participate in round 2. In this round, you will be able to see how others have scored each outcome and will be able to change your score. The aim is to create a consensus about which outcomes are the most important by allowing you to see how others have scored and let this influence your opinion in round 2.

If you have any problems completing the survey or require help, please email alexander.aquilina@ndorms.ox.ac.uk

By completing this survey, you are providing your consent to participate in this study and allowing us to ask for your views, and keep this information. We will keep the answers to the survey and other information without any names/contact details, so we will keep your identity safe.

All the information you give will stay confidential. We will use it only for this survey and any relevant medical purposes.

If you have already registered, please **click here**

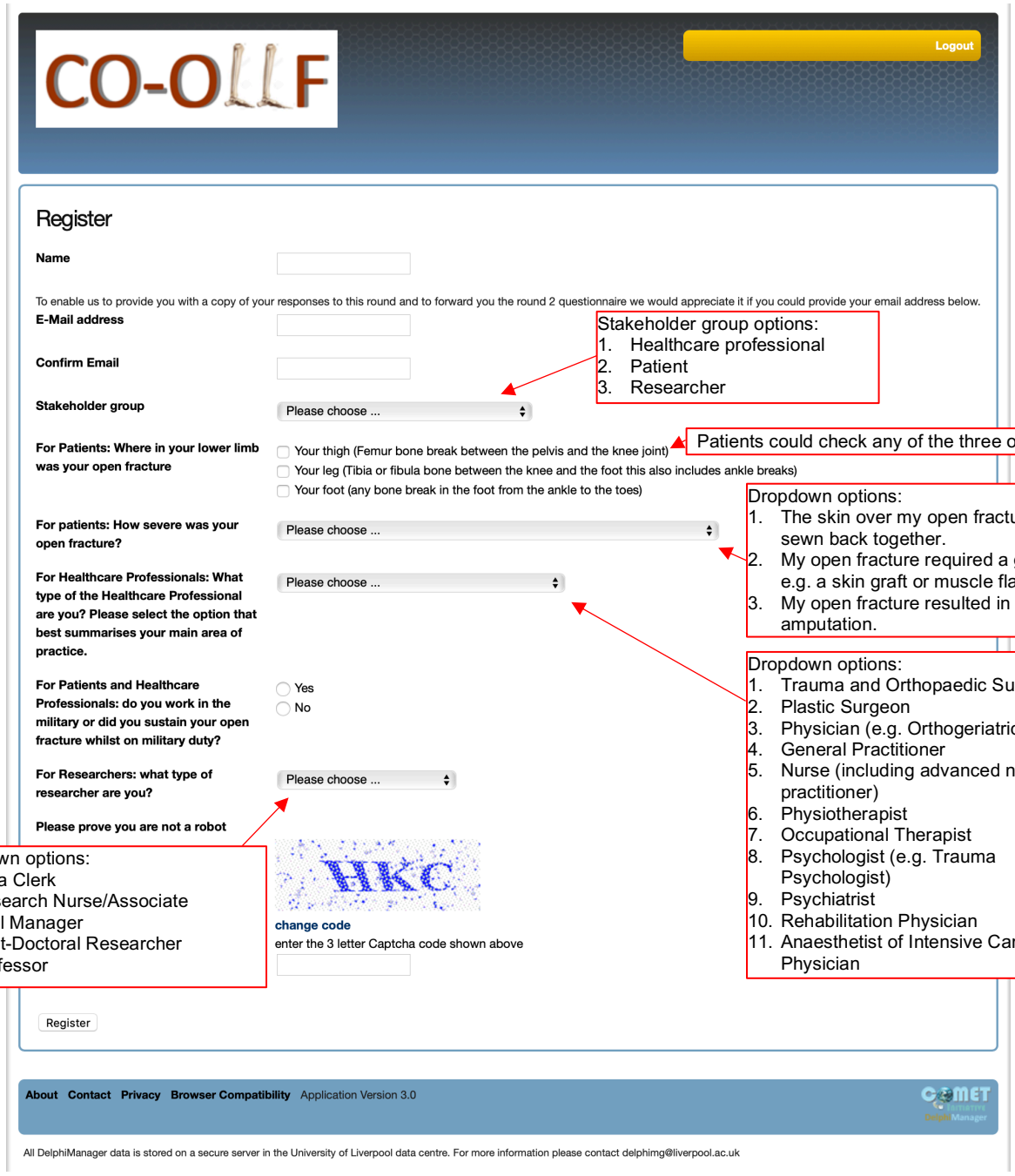
If you have forgotten your login details please **click here**

Register

About **Contact** **Privacy** **Browser Compatibility** Application Version 3.0

All DelphiManager data is stored on a secure server in the University of Liverpool data centre. For more information please contact delphimg@liverpool.ac.uk

8.26 Appendix 26. CO-OLLF Delphi survey registration form



Dropdown box options displayed in red boxes

8.27 Appendix 27. Outcomes in the order they appeared in the Delphi survey with patient quote descriptors.

Core area and Outcome Domain (outcome domain number)	Outcome	Patient quote descriptor
Physical functioning	1. Ability to do activities of daily living	
	2. Ability to kneel	
	3. Ability to balance	
	4. Ability to be independent	
	5. Ability to drive	
	6. Walking, gait and mobility	
	7. Ability to be able to dress and do self and personal care	
	8. Ability to have intimate relationships	
	9. Ability to exercise	
	10. Ability to comfortably wear shoes and clothes of your choice	
	11. Lower limb function	
	12. Range of movement	
Social functioning	13. Ability to participate in social events	
	14. Ability to start, maintain and develop relationships	
Role functioning	15. Being able to care for other people and/or animals	
	16. Being able to return to life roles (e.g. caring, work, military duty)	
Emotional functioning and wellbeing	17. Appearance of lower limb e.g. scars, flaps and swelling	“a considerable lump where they put the muscle in from my back etc and there’s a scar that runs up to just below my knee and yes so it’s not a thing of beauty to

Core area and Outcome Domain (outcome domain number)	Outcome	Patient quote descriptor
		look at in appearance but I don't look at it, well I do every morning because I cream it every day but apart from that I don't look at it very much."
	18. Change in body shape or weight	"I'm fatter which is quite depressing. The weight doesn't do the rest of me any good but it's one of those things and it couldn't really be avoided. I've put on about two and half/three stone in two years."
	19. Feelings of self-identity and body wholeness	"I mean what do you do, you sit down and do nothing and I'm not that kind of person, do you try and be the person you were before and you can't be because you are 95% of what you used to be but it's just that 5% area that causes you 100% of the problems."
	20. Feelings of disablement, being damaged or broken	"It's an injury that yes its healed, its scarred but it's still going to affect me on a daily basis. I'm never going to be 100% healed if that's the right thing to say. Sometimes I'm a bit frustrated when I bend down or kneel down for something."
	21. Feelings of giving up and hopelessness	"You try and be positive, my wife says, 'you can do it, think positive', it's alright for people to say it but when you're constantly trying to be positive when sometimes you just want to lay down and cry. 'I've had enough', not to kill yourself but you just think 'I can't be bothered today."
	22. Feeling of loss	"because my son's a bit older now, he's fourteen now, I mean it's not like I would take him to the park so I missed out on all that sort of stuff… mmm…" "Horrid, it's changed my life a lot. It's changed my life, I've lost so much."
	23. Feelings of frustration and anger	"incredibly frustrating in the beginning and I found myself gritting my teeth without even realising it and I was so angry really. I'd get really irritable for no reason at all."
	24. Feelings of hopefulness, positivity and determination	"I don't want to get depressed, so I just think 'well it could've been worse… could've been a lot worse, could've been both legs!' and there's a lot of people out there worse than me so I just get on with it."
	25. Isolation, loneliness and lack of emotional support	"there are carers but they're not here 24/7 because you don't need them. They're not here for you mentally but physically."

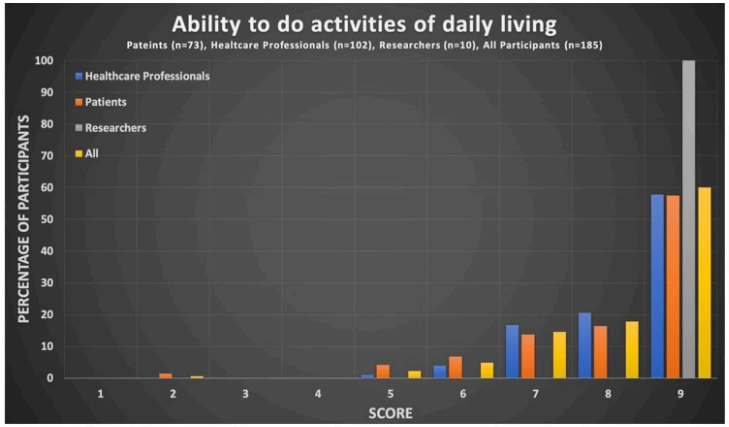
Core area and Outcome Domain (outcome domain number)	Outcome	Patient quote descriptor
	26. Low mood	"sometimes you just feel low shall we say but not quite depressed." "err, there was periods of obviously low mood and depression after the, after the accident."
	27. Ability to move on and feeling of getting life back	"since the accident there's you know positives of, um, my girlfriend and I got married sort of last September and we had a baby we had a son sort of, so life's carried on those are the good bits."
	28. Having clear expectations and views on the future with lack of uncertainty	"I worry about what's in the future for me because everybody says your mobility is going to get worse."
	29. Tolerance of uncertainty and living in fear e.g. fear of falling or going outside and fear for the future	Patient: "the big thing was that uncertainty and that's what was the hardest part for me, it was the not knowing. I wasn't looking for anyone to make me a promise or an outcome but I still find it hard to explain, it's a very dark place to be almost." Interviewer: "Without any future?" Patient: "Yes or an uncertain future."
	30. Being anxious or stressed	I find now that I don't tend to worry so much about things anymore. Sometimes I do but the majority of time I don't because it just pales into insignificance."
	31. Loss of confidence or control and feeling of limitation	"Yeah I'd say… mmm… [pause] yeah much better… it… it… it… you… you just get used to… you know your limitations so you learn to live with them limitations… err… because if you stopped and thought about what I could do and what I can't do now you… it is as it is…there's nothing you can do about it"
	32. Experience of flashbacks to the traumatic event	
	33. Emotional vulnerability, volatility and fragility.	"If I watched something on the TV and I found myself empathising with people who had been injured and things like that which is something I've never experienced before, it was a range of emotions really that I'd probably not experienced that were actually brought out by the whole thing and that was something I'd never experienced and I found myself tearful and things like that."
	34. Ability to accept the event and life change	"You've got to accept it and I've had times when I haven't been able to accept it in the last two years, many times."

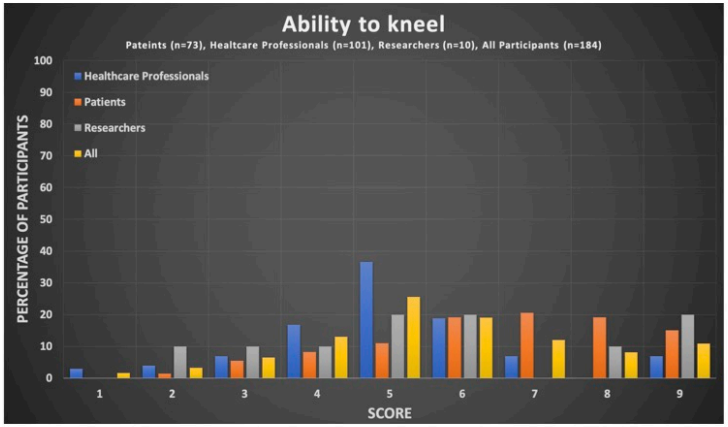
Core area and Outcome Domain (outcome domain number)	Outcome	Patient quote descriptor
	35. Feelings of struggle or fighting against the body	"My wife said to me why are you always fighting, it just seems I'm battling against the world at the moment. I don't need to, but I think you're trying to be somebody that you're not, putting the world to right because you had an injustice done against you."
	36. Maintaining a feeling of dignity	"It's your dignity, I mean the last person who wiped my arse was my mum and that's it or my dad but not being a grown man in a bed pan because I couldn't get out of bed you see."
Cognitive functioning	37. Lack of concentration and focus	"The pain is the biggest issue because it physically drags you down and will mentally wipe you out and I hate being mentally tired. I'd rather be physically tired than mentally tired."
Blood and lymphatic system outcomes	38. Venous thromboembolism (blood clot in legs or lungs)	
General outcomes	39. Sleep and fatigue	"I was tired every day so just like seeing one person would pretty much exhaust me anyway so yeah it's weird I thought 'how am I getting so tired when all I'm doing is laying here?"
	40. Number of unplanned hospital re-admissions	
	41. Length of hospital stay	
	42. Number of outpatient appointments	
	43. Number of Primary Care visits	
Musculoskeletal and connective tissue outcomes	44. Metalwork failure	
	45. Complications resulting from soft tissue (muscle flaps or grafts)	
	46. Amputation	
	47. Bone healing	
	48. Malunion, alignment and rotational deformity	

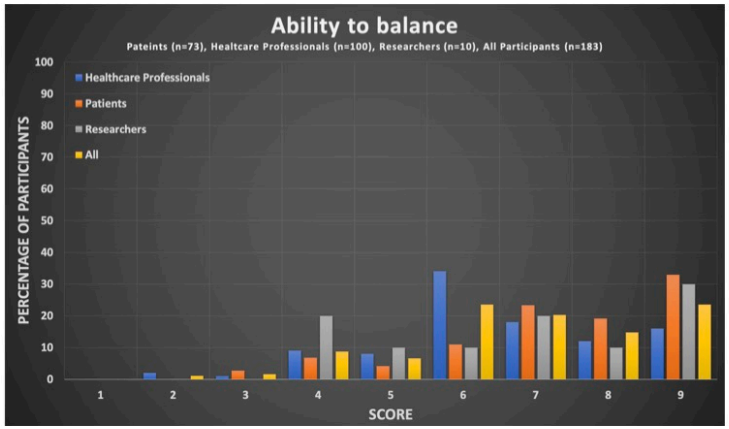
Core area and Outcome Domain (outcome domain number)	Outcome	Patient quote descriptor
	49. Deep infection	
	50. Surface infection	
	51. Leg or bone shortening	
	52. Change in sensation	
	53. Muscle weakness	
	54. Pain or discomfort	
	55. Unplanned return to the operating theatre	
Global quality of life	56. Quality of life	
Perceived health status	57. Degree of perceived loss of general health and wellbeing	
Delivery of care	58. Quality of communication of healthcare professionals to patients	
	59. Satisfaction with care	
	60. Tolerability and acceptability of surgical intervention e.g. external fixator	"I think that was probably the lowest point for me because it's quite a large piece of equipment and there's not a lot you can really do when it's on. Even getting dressed was a problem and things like that and so I became quite reliant on my wife to help through the day."
Personal circumstances	61. Change in lifestyle	
	62. Being compensated financially for injury	
	63. Personal cost of treatment and care following injury	
	64. Effect of injury on personal finances	
Adverse events and effects	65. Number of adverse events	
	66. Side effects of medication	
	67. Poor experience during anaesthesia	

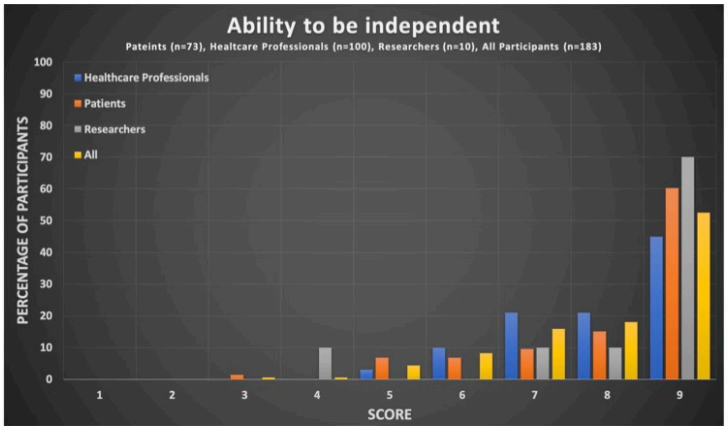
Core area and Outcome Domain (outcome domain number)	Outcome	Patient quote descriptor
Mortality	68.Survival	
Musculoskeletal and connective tissue outcomes	69. Chronic pain (added following Delphi survey round 1)	
General outcomes	70.Length of stay (Super Spell) (added following Delphi survey round 1)	

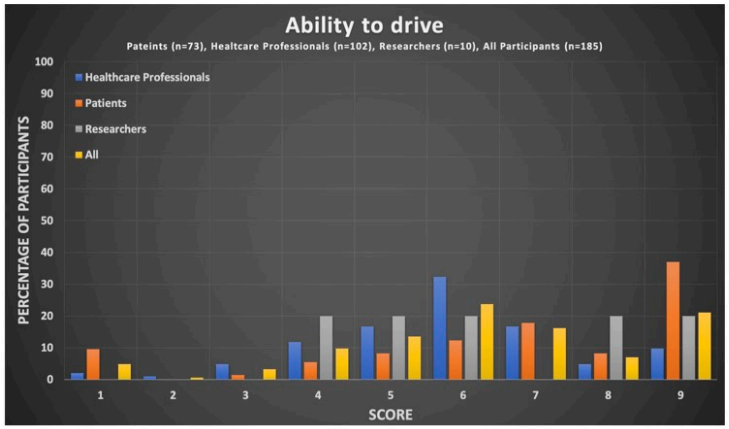
8.28 Appendix 28. Bar charts of Delphi survey round 1 results added to Delphi survey round 2.

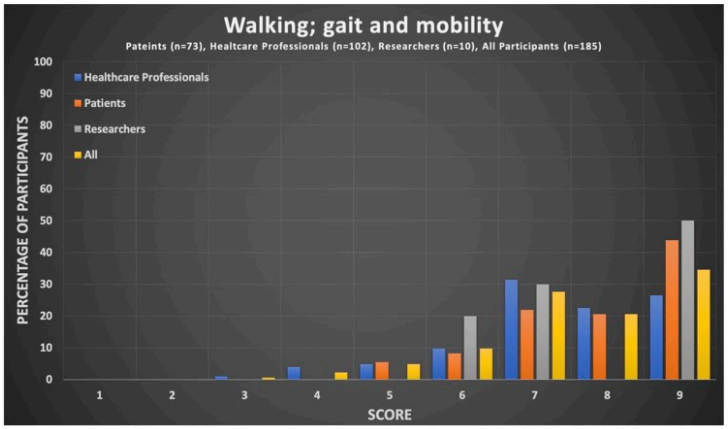


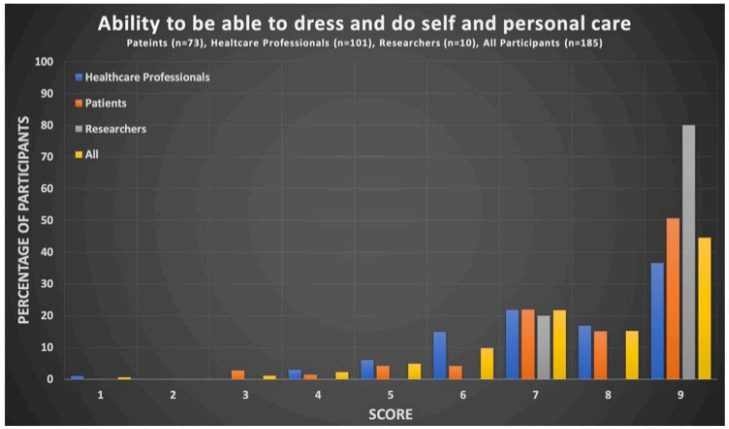


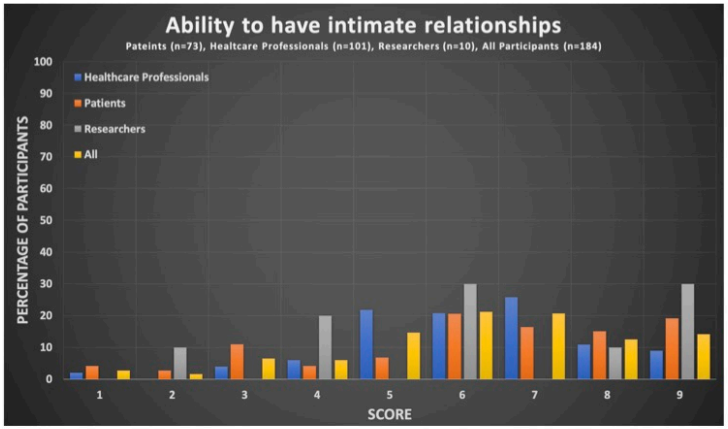


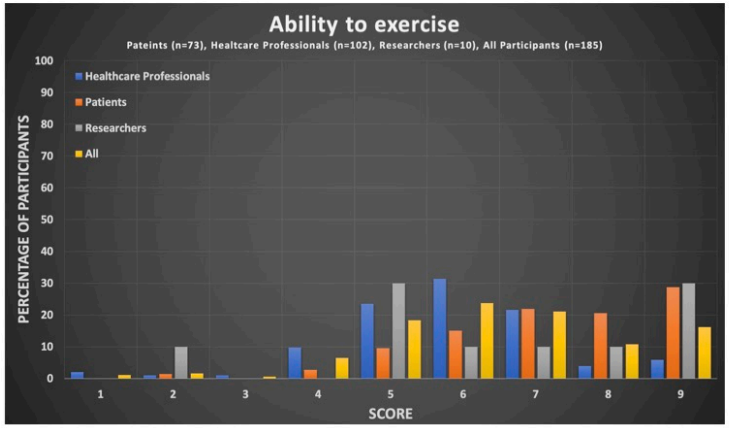



Ability to drive
Pateints (n=73), Healtcare Professionals (n=102), Researchers (n=10), All Participants (n=185)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

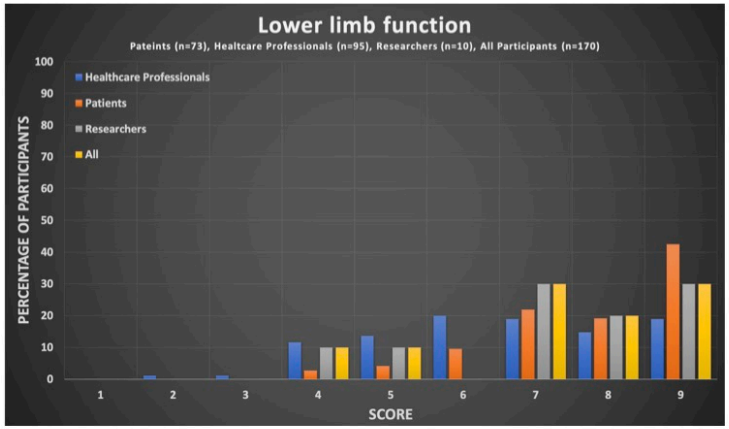

Walking; gait and mobility
Pateints (n=73), Healtcare Professionals (n=102), Researchers (n=10), All Participants (n=185)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

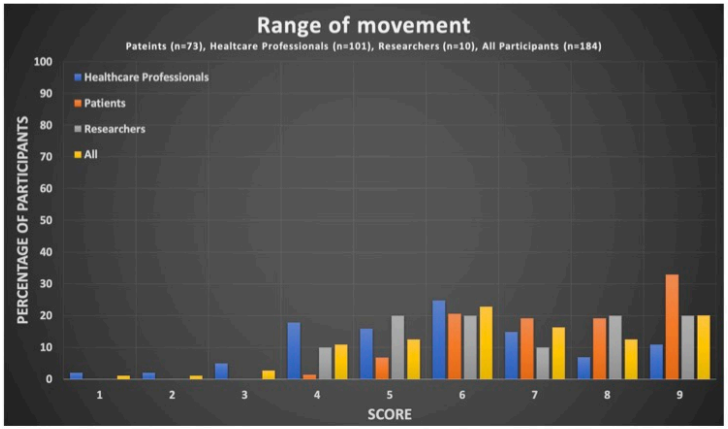

Ability to be able to dress and do self and personal care
Pateints (n=73), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=185)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

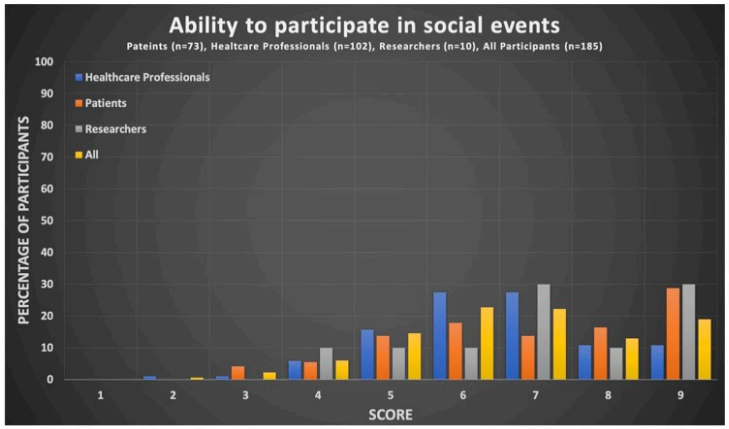

Ability to have intimate relationships
Pateints (n=73), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=184)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE


Ability to exercise
Pateints (n=73), Healtcare Professionals (n=102), Researchers (n=10), All Participants (n=185)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

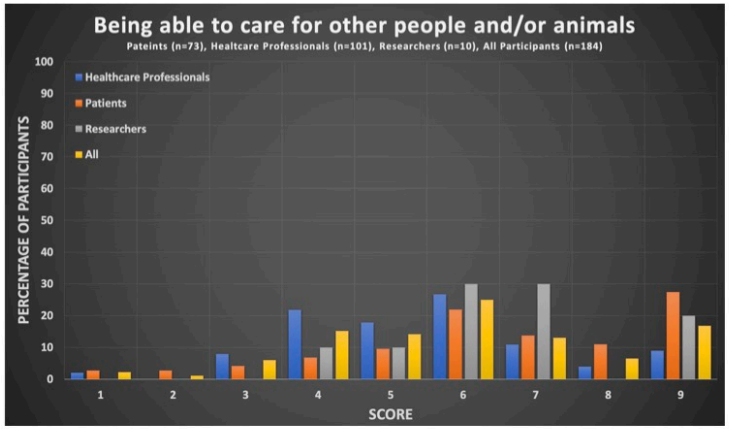
Ability to comfortably wear shoes and clothes of your choice
Pateints (n=73), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=184)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

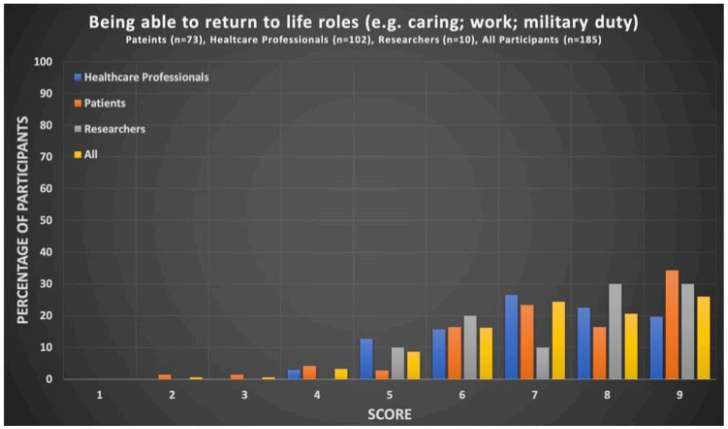

Lower limb function
Pateints (n=73), Healtcare Professionals (n=95), Researchers (n=10), All Participants (n=170)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

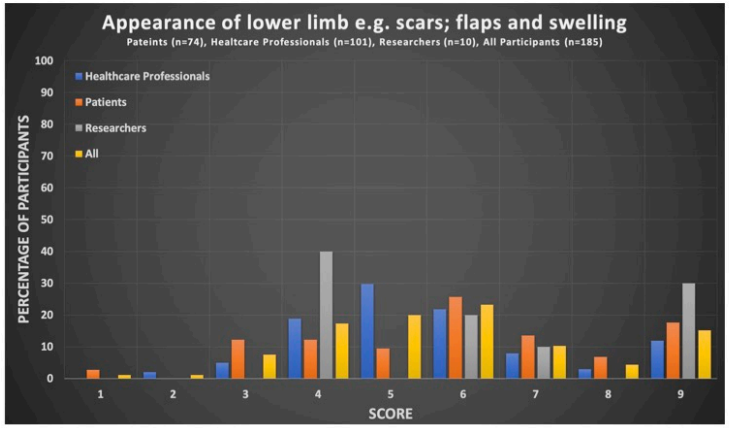

Range of movement
Pateints (n=73), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=184)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE


Ability to participate in social events
Pateints (n=73), Healtcare Professionals (n=102), Researchers (n=10), All Participants (n=185)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

Ability to start; maintain and develop relationships
Pateints (n=73), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=184)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

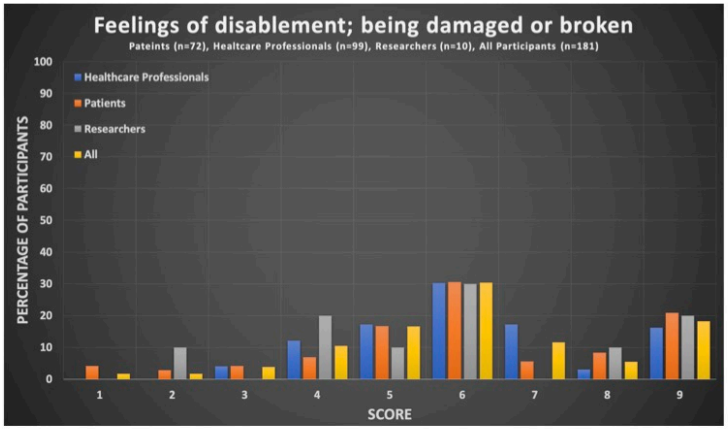

Being able to care for other people and/or animals
Pateints (n=73), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=184)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

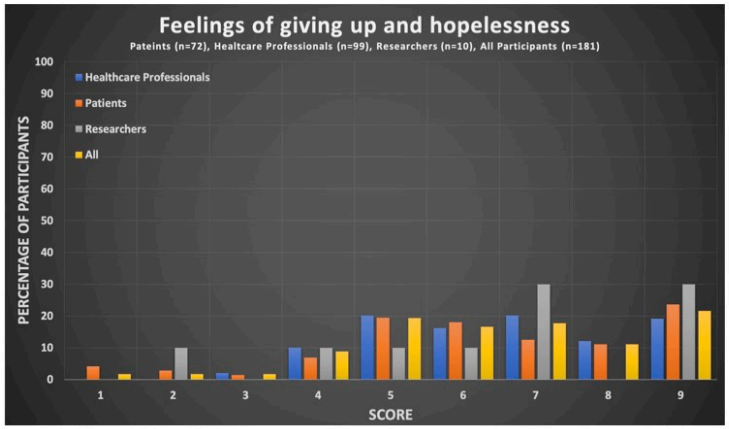

Being able to return to life roles (e.g. caring; work; military duty)
Pateints (n=73), Healtcare Professionals (n=102), Researchers (n=10), All Participants (n=185)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

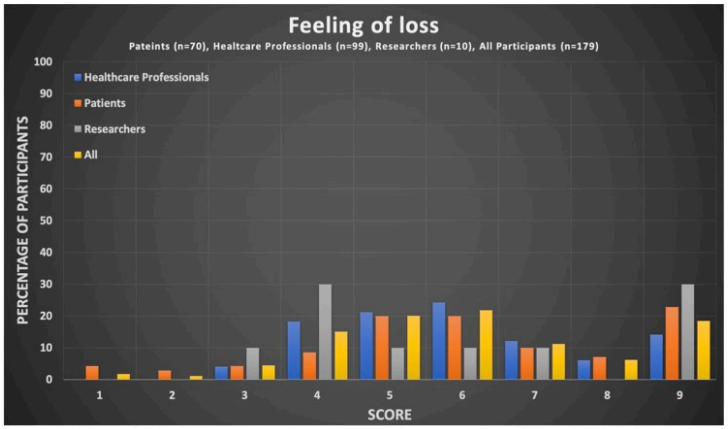

Appearance of lower limb e.g. scars; flaps and swelling
Pateints (n=74), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=185)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

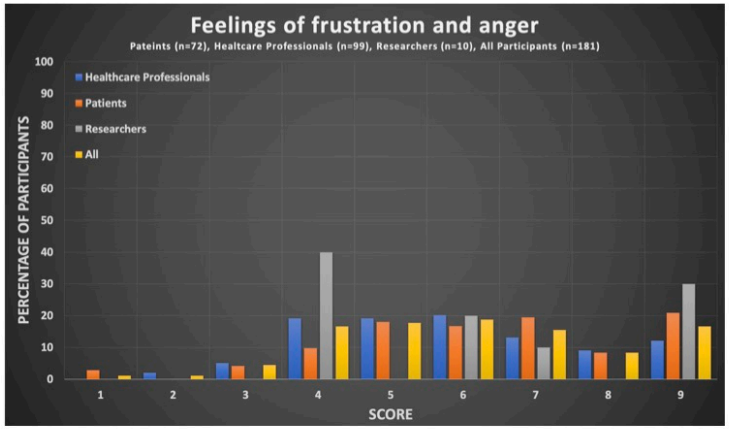
Change in body shape or weight
Pateints (n=74), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=185)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

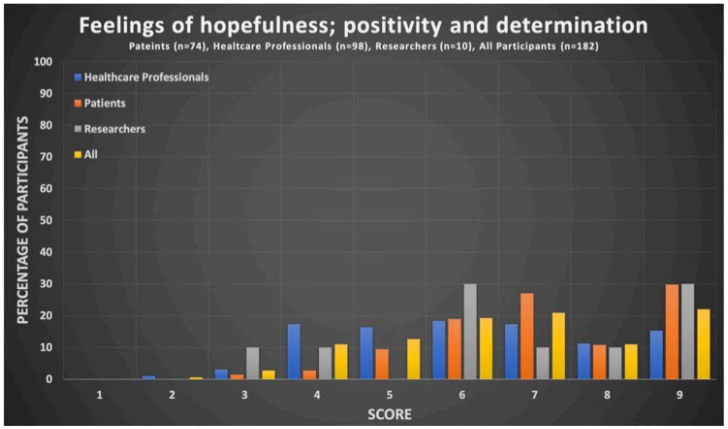
Feelings of self-identity and body wholeness
Pateints (n=73), Healtcare Professionals (n=99), Researchers (n=10), All Participants (n=182)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

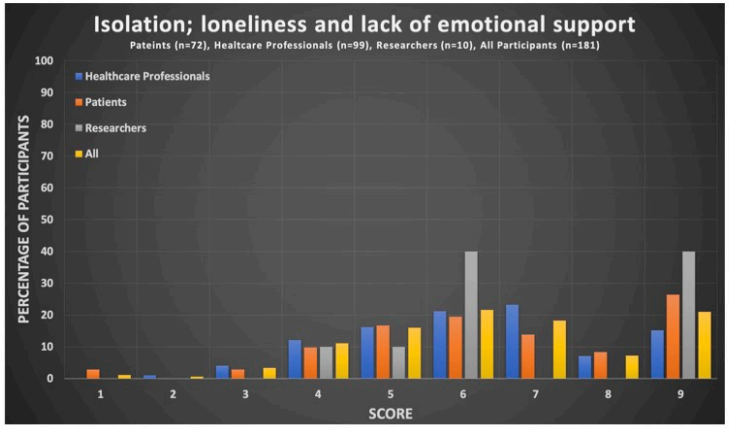

Feelings of disablement; being damaged or broken
Pateints (n=72), Healtcare Professionals (n=99), Researchers (n=10), All Participants (n=181)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

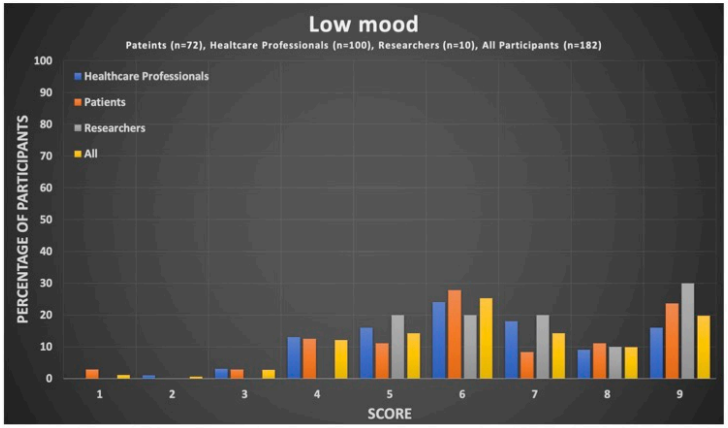

Feelings of giving up and hopelessness
Pateints (n=72), Healtcare Professionals (n=99), Researchers (n=10), All Participants (n=181)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

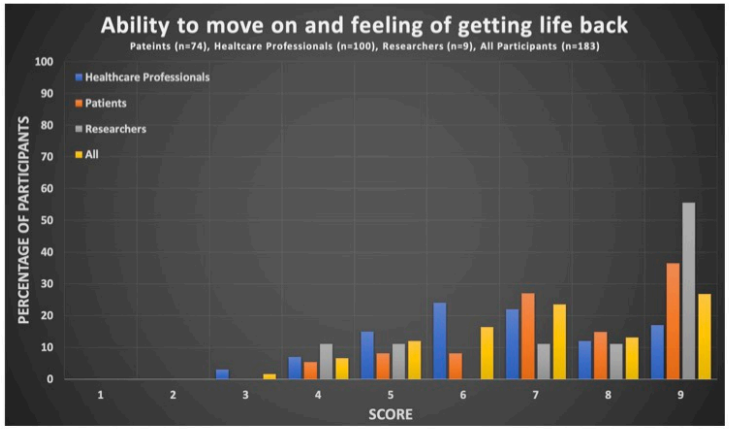

Feeling of loss
Pateints (n=70), Healtcare Professionals (n=99), Researchers (n=10), All Participants (n=179)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

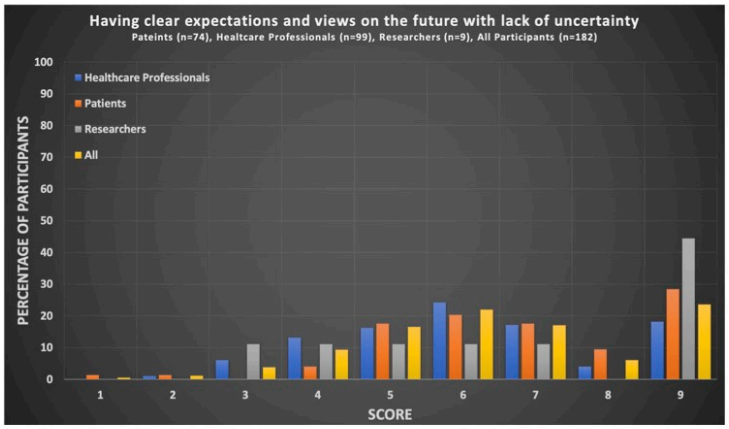

Feelings of frustration and anger
Pateints (n=72), Healtcare Professionals (n=99), Researchers (n=10), All Participants (n=181)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

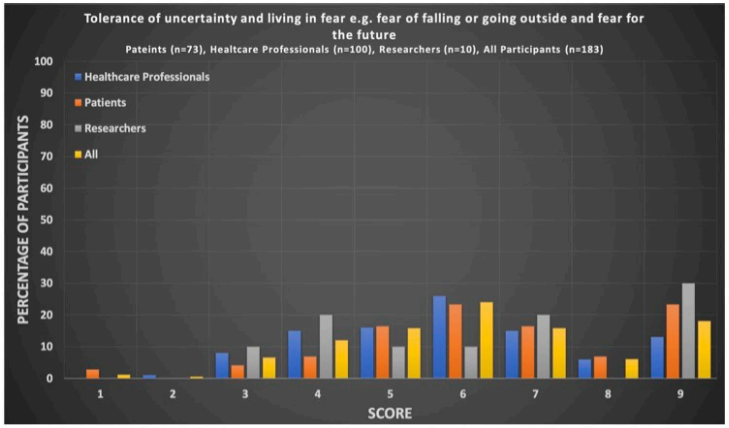

Feelings of hopefulness; positivity and determination
Pateints (n=74), Healtcare Professionals (n=98), Researchers (n=10), All Participants (n=182)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

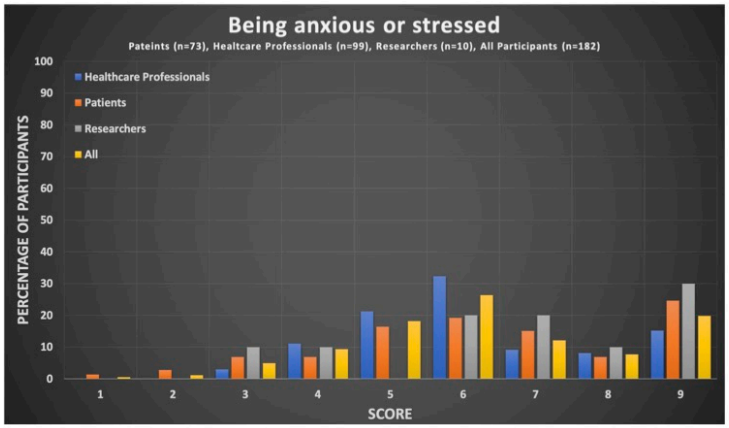

Isolation; loneliness and lack of emotional support
Pateints (n=72), Healtcare Professionals (n=99), Researchers (n=10), All Participants (n=181)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

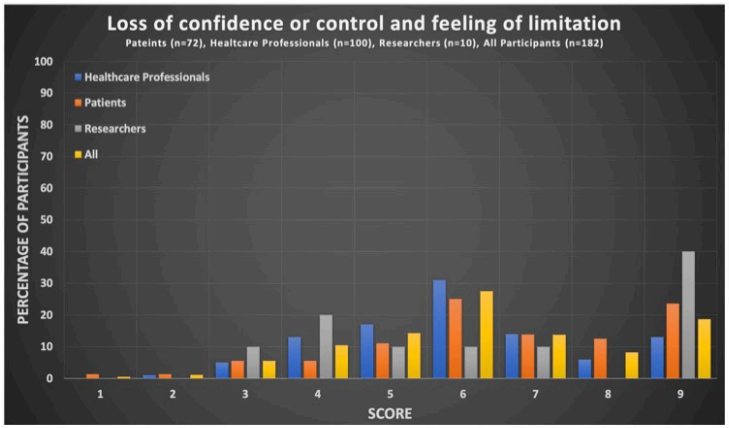

Low mood
Pateints (n=72), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=182)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

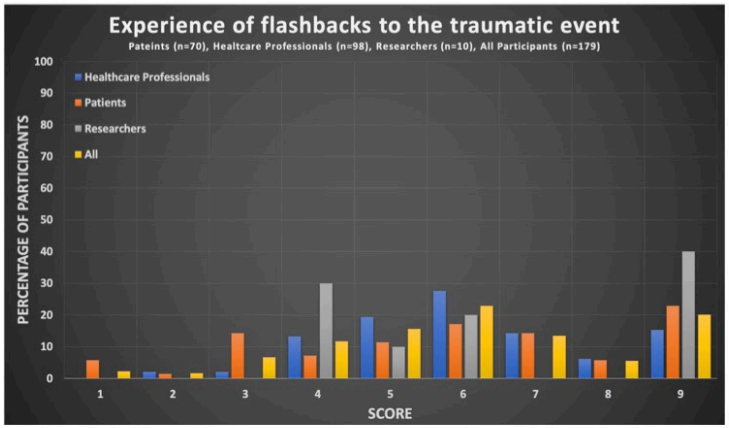

Ability to move on and feeling of getting life back
Pateints (n=74), Healtcare Professionals (n=100), Researchers (n=9), All Participants (n=183)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

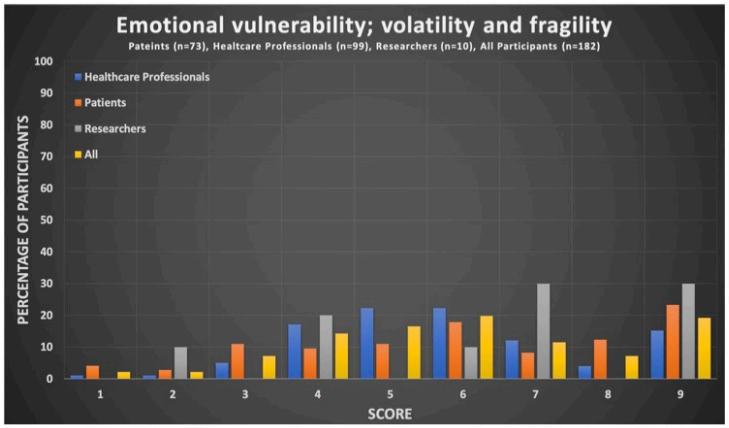

Having clear expectations and views on the future with lack of uncertainty
Pateints (n=74), Healtcare Professionals (n=99), Researchers (n=9), All Participants (n=182)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE


Tolerance of uncertainty and living in fear e.g. fear of falling or going outside and fear for the future
Pateints (n=73), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=183)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

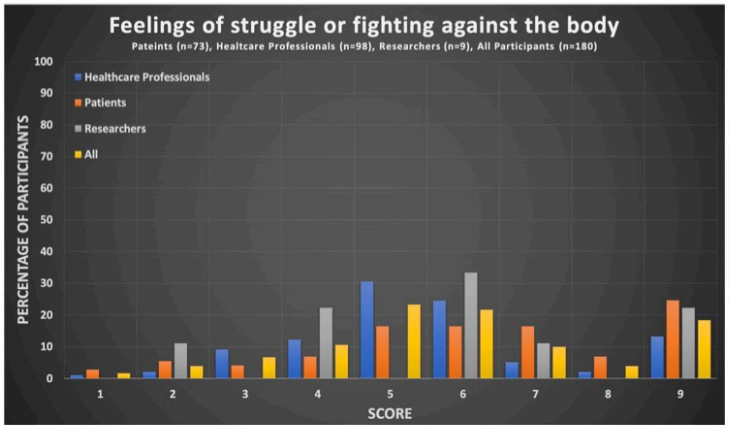

Being anxious or stressed
Pateints (n=73), Healtcare Professionals (n=99), Researchers (n=10), All Participants (n=182)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

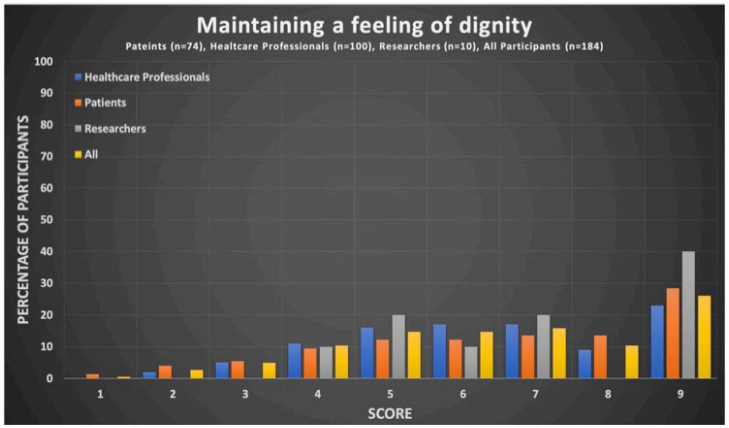

Loss of confidence or control and feeling of limitation
Pateints (n=72), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=182)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

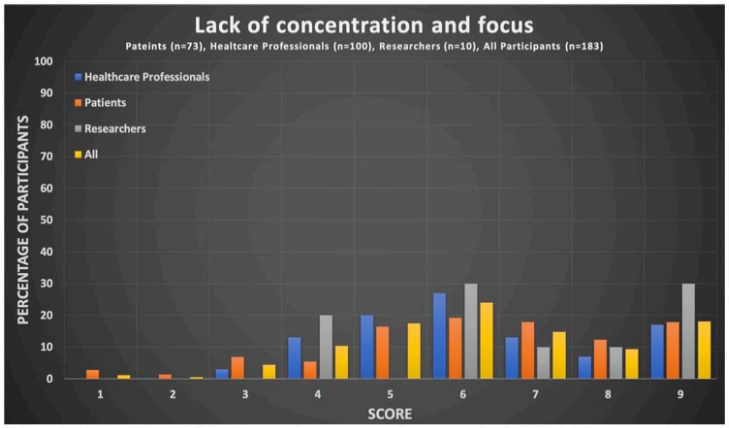

Experience of flashbacks to the traumatic event
Pateints (n=70), Healtcare Professionals (n=98), Researchers (n=10), All Participants (n=179)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

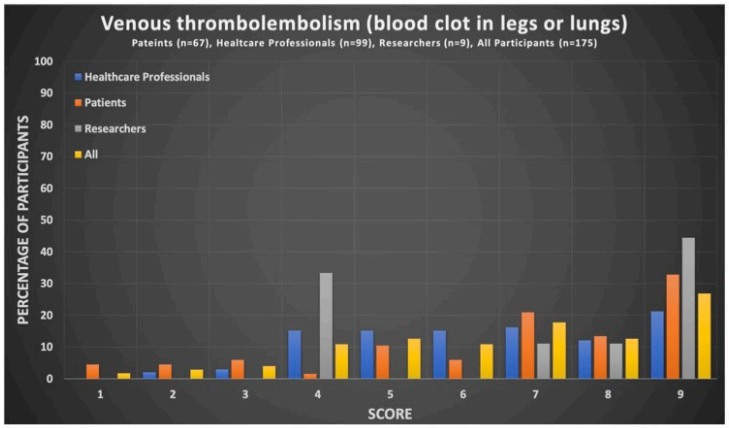

Emotional vulnerability; volatility and fragility
Pateints (n=73), Healtcare Professionals (n=99), Researchers (n=10), All Participants (n=182)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

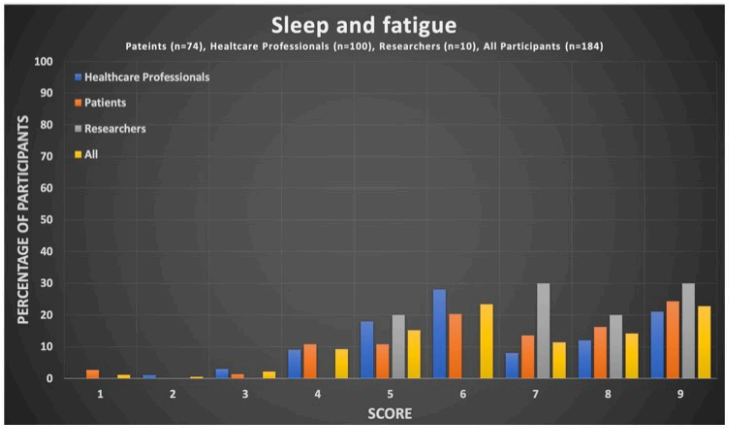
Ability to accept the event and life change
Pateints (n=73), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=183)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

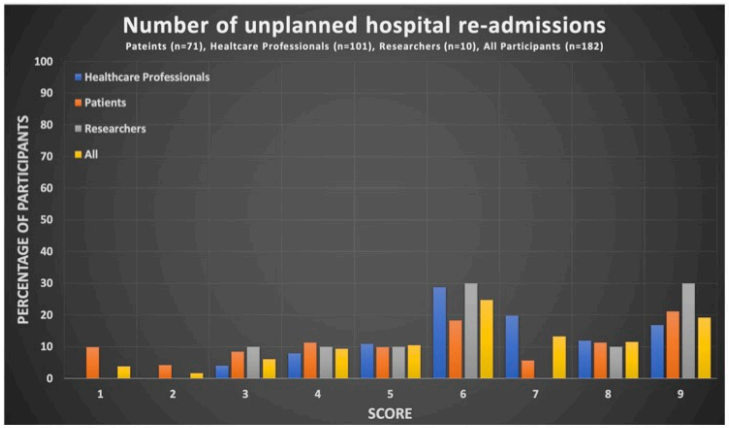

Feelings of struggle or fighting against the body
Pateints (n=73), Healtcare Professionals (n=98), Researchers (n=9), All Participants (n=180)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

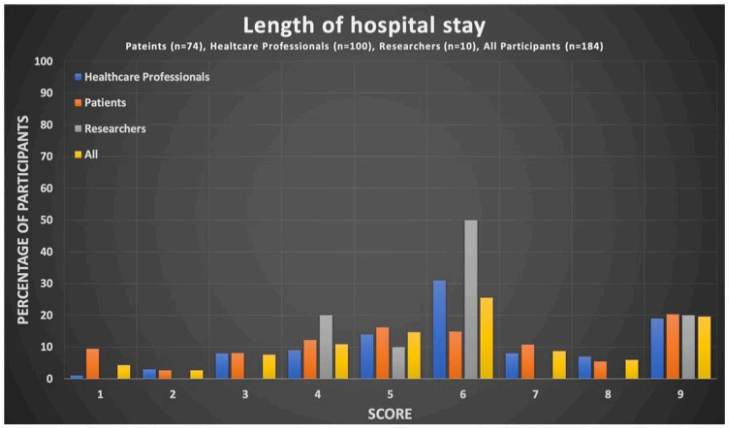

Maintaining a feeling of dignity
Pateints (n=74), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=184)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

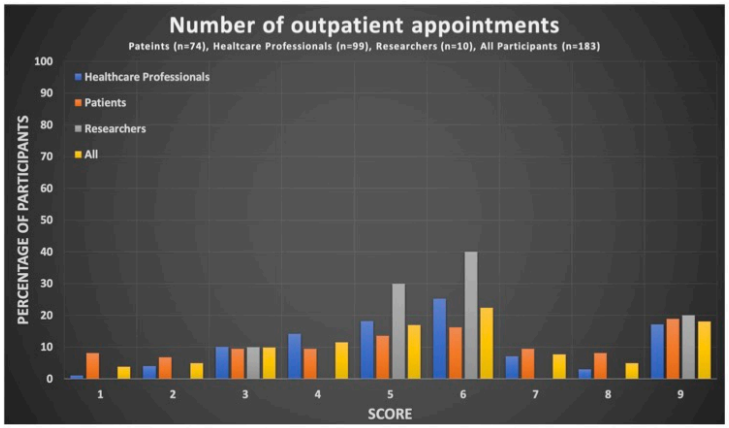

Lack of concentration and focus
Pateints (n=73), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=183)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

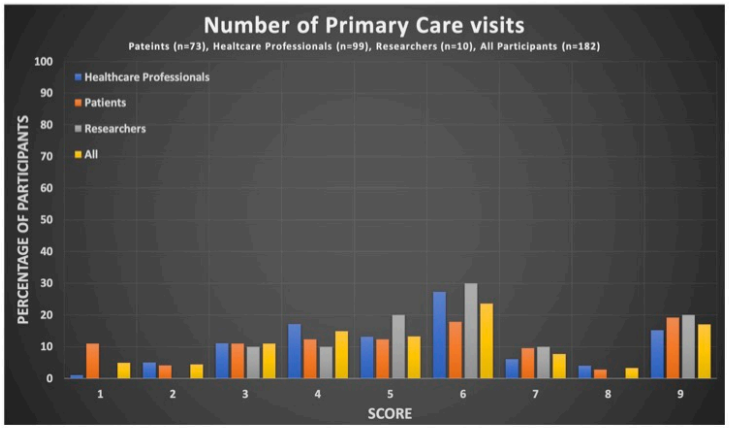

Venous thrombolembolism (blood clot in legs or lungs)
Pateints (n=67), Healtcare Professionals (n=99), Researchers (n=9), All Participants (n=175)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

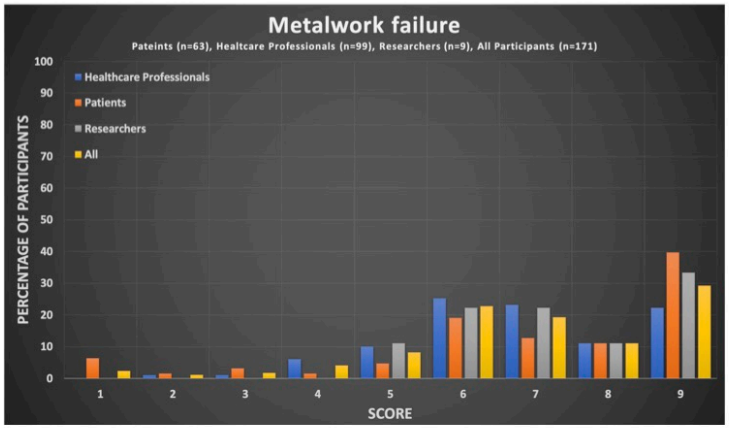

Sleep and fatigue
Pateints (n=74), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=184)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

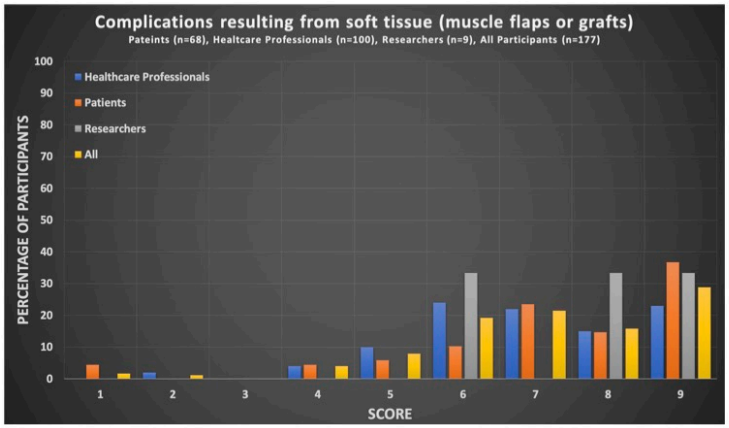

Number of unplanned hospital re-admissions
Pateints (n=71), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=182)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

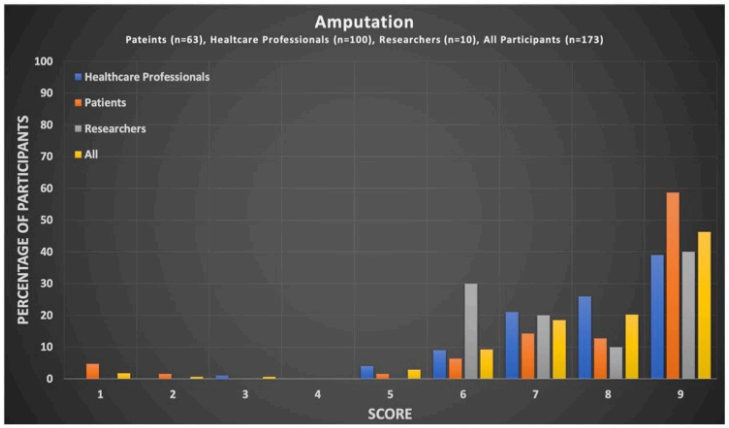

Length of hospital stay
Pateints (n=74), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=184)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

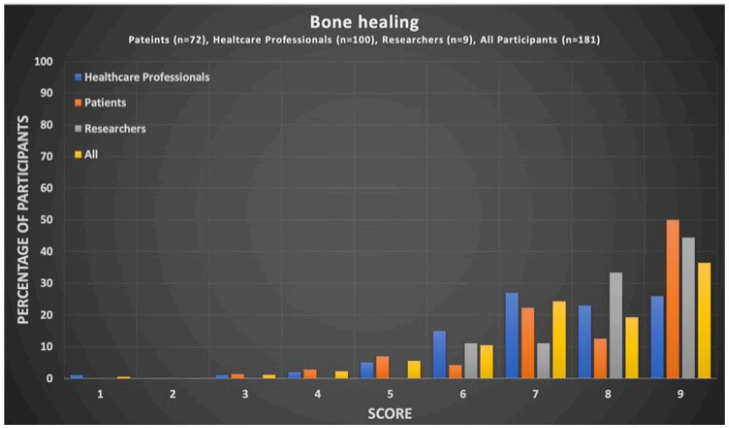

Number of outpatient appointments
Pateints (n=74), Healtcare Professionals (n=99), Researchers (n=10), All Participants (n=183)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

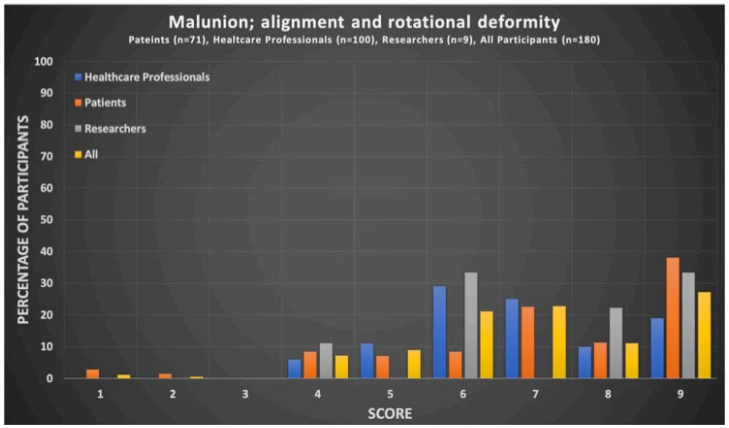

Number of Primary Care visits
Pateints (n=73), Healtcare Professionals (n=99), Researchers (n=10), All Participants (n=182)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

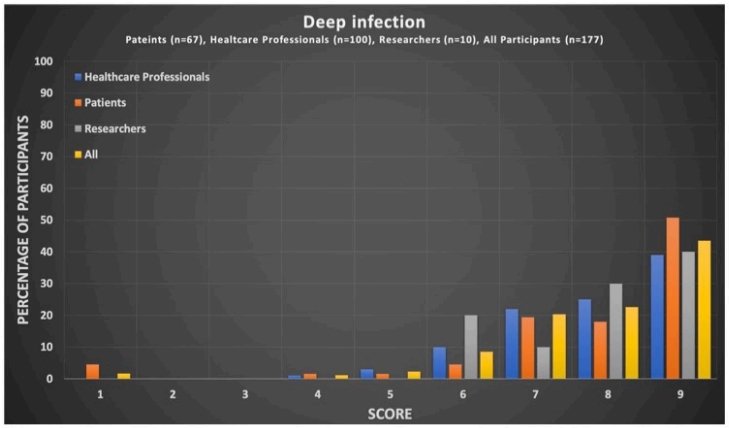

Metalwork failure
Pateints (n=63), Healtcare Professionals (n=99), Researchers (n=9), All Participants (n=171)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

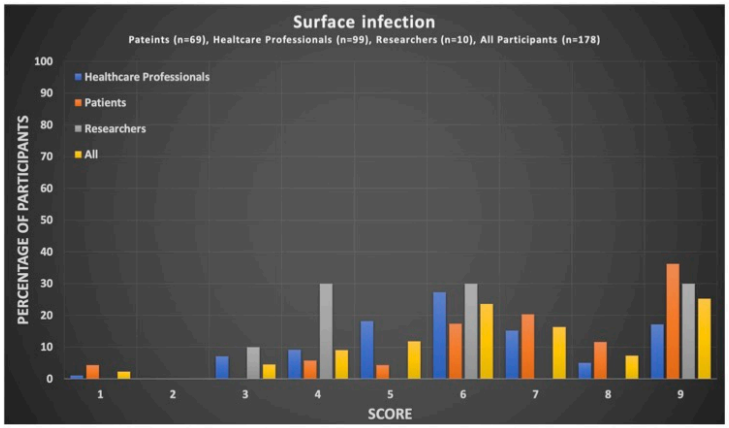

Complications resulting from soft tissue (muscle flaps or grafts)
Pateints (n=68), Healtcare Professionals (n=100), Researchers (n=9), All Participants (n=177)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

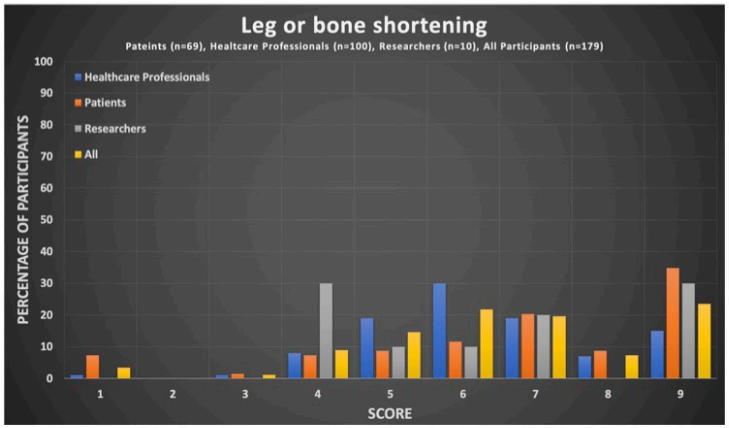

Amputation
Pateints (n=63), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=173)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

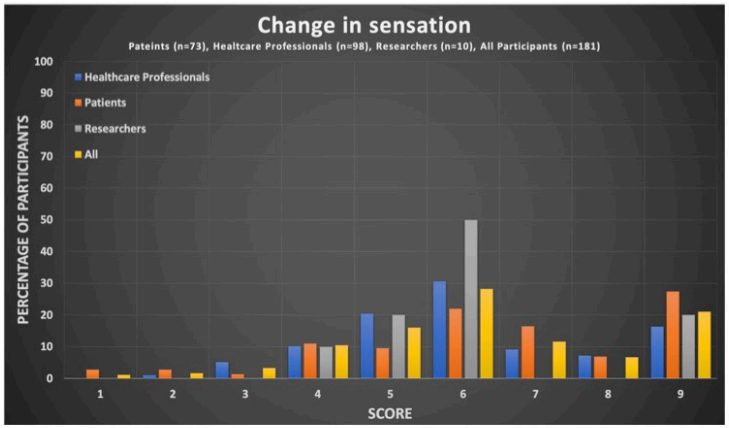

Bone healing
Pateints (n=72), Healtcare Professionals (n=100), Researchers (n=9), All Participants (n=181)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

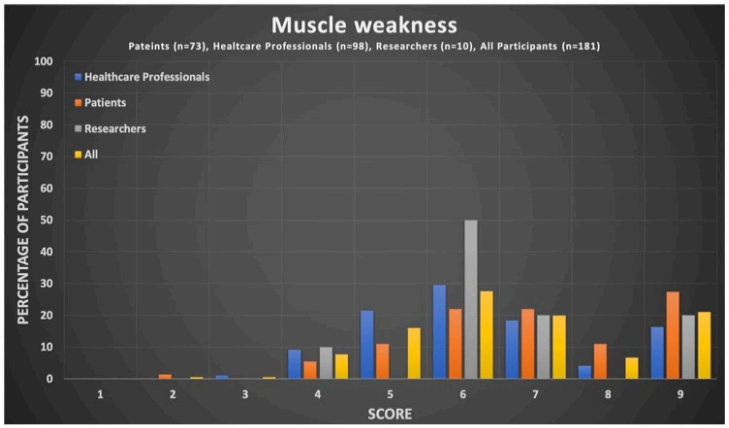

Malunion; alignment and rotational deformity
Pateints (n=71), Healtcare Professionals (n=100), Researchers (n=9), All Participants (n=180)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

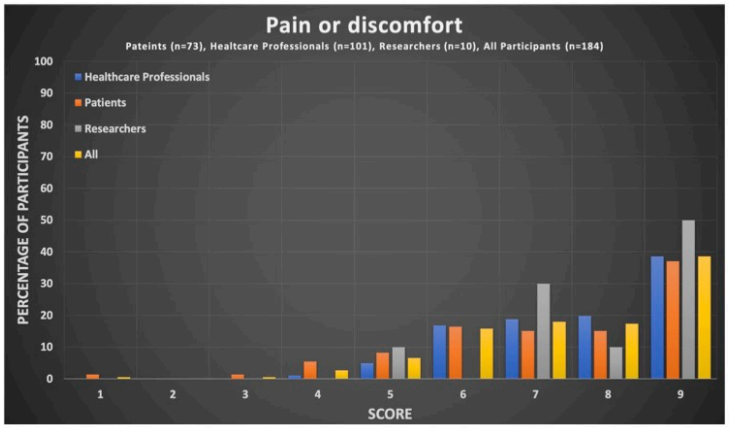

Deep infection
Pateints (n=67), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=177)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

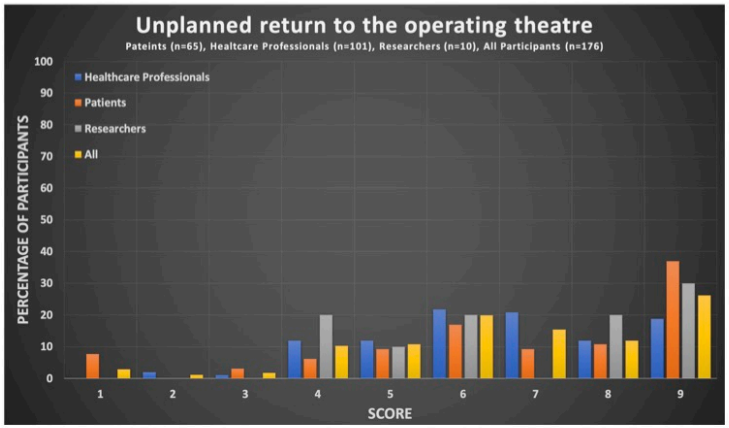

Surface infection
Pateints (n=69), Healtcare Professionals (n=99), Researchers (n=10), All Participants (n=178)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE


Leg or bone shortening
Pateints (n=69), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=179)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

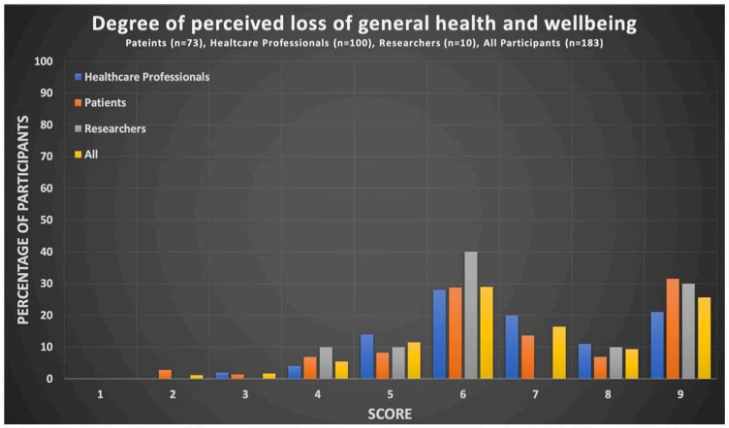

Change in sensation
Pateints (n=73), Healtcare Professionals (n=98), Researchers (n=10), All Participants (n=181)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

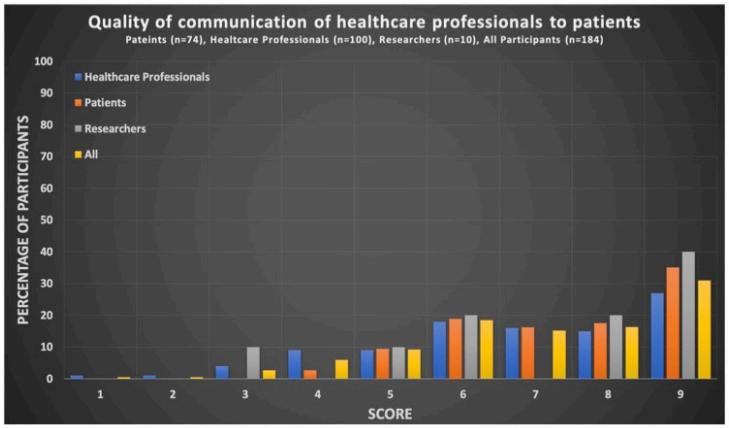

Muscle weakness
Pateints (n=73), Healtcare Professionals (n=98), Researchers (n=10), All Participants (n=181)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

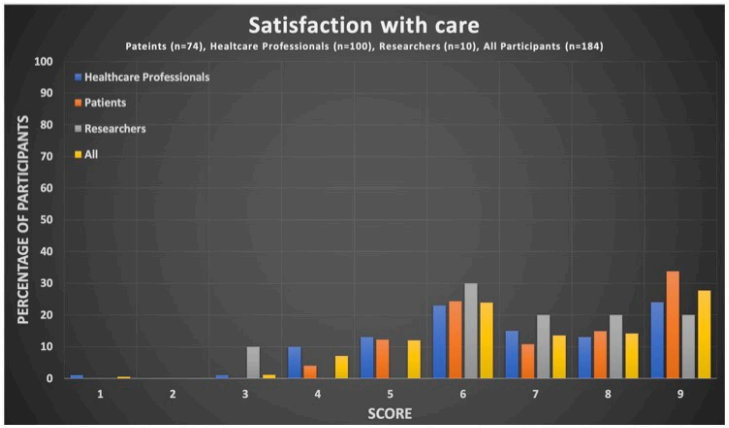

Pain or discomfort
Pateints (n=73), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=184)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

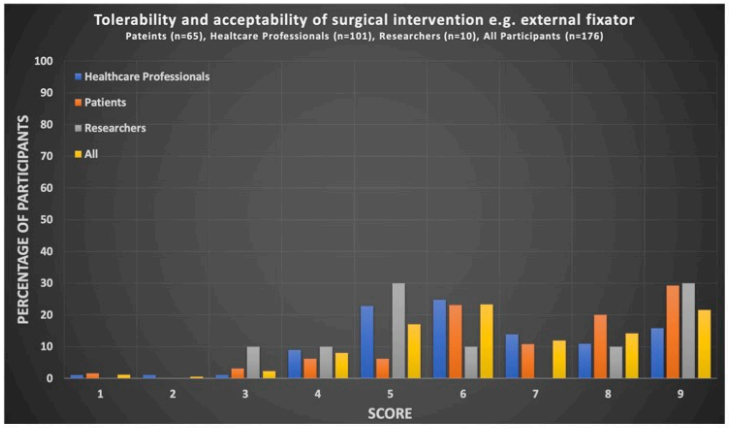

Unplanned return to the operating theatre
Pateints (n=65), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=176)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

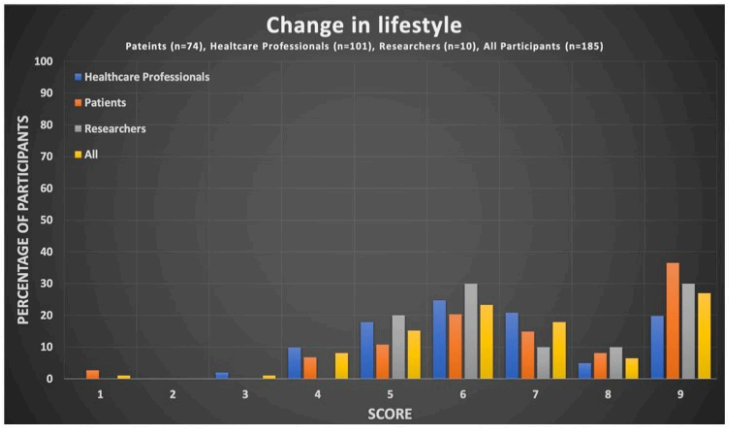
Quality of life
Pateints (n=74), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=184)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

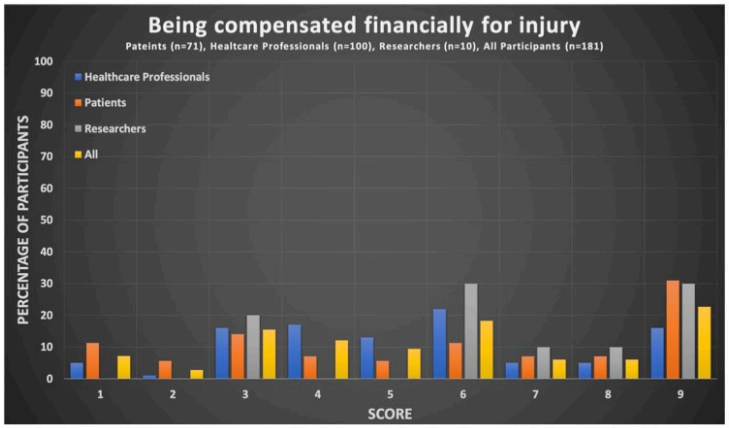

Degree of perceived loss of general health and wellbeing
Pateints (n=73), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=183)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

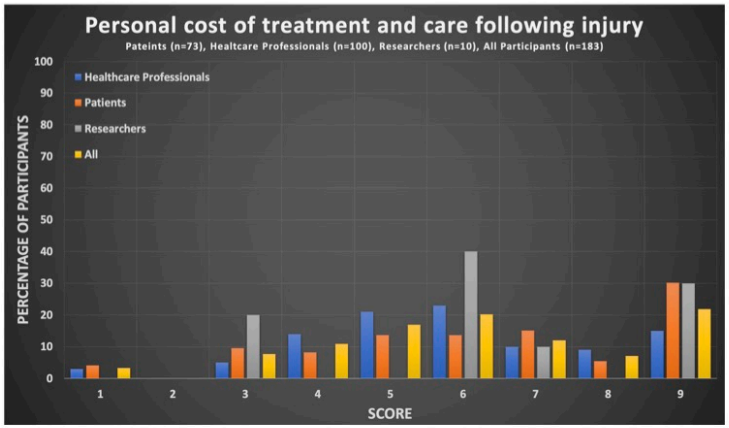

Quality of communication of healthcare professionals to patients
Pateints (n=74), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=184)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

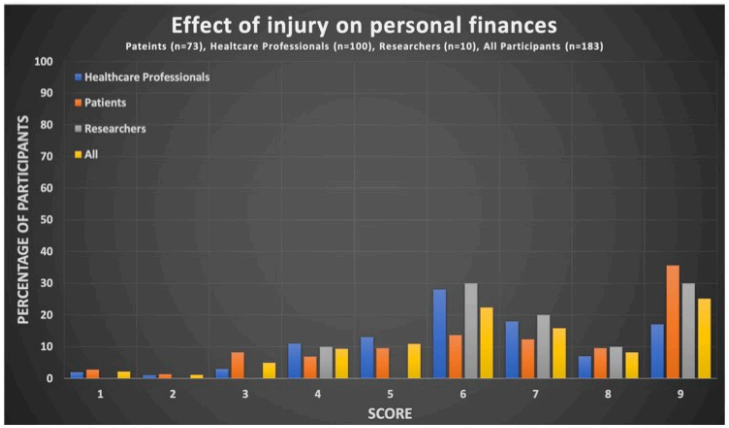

Satisfaction with care
Pateints (n=74), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=184)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

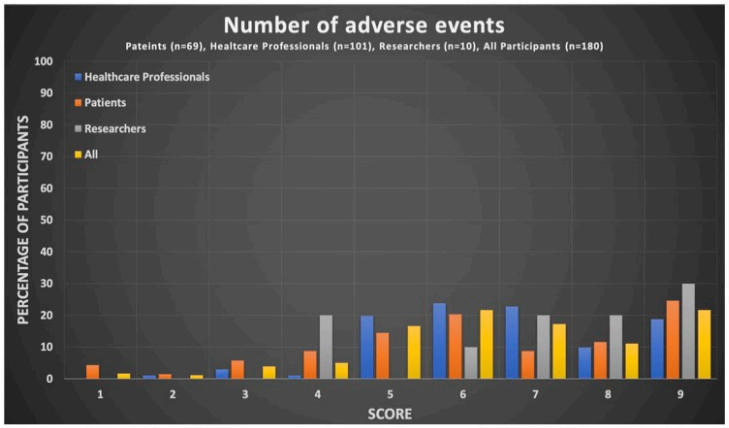

Tolerability and acceptability of surgical intervention e.g. external fixator
Pateints (n=65), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=176)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

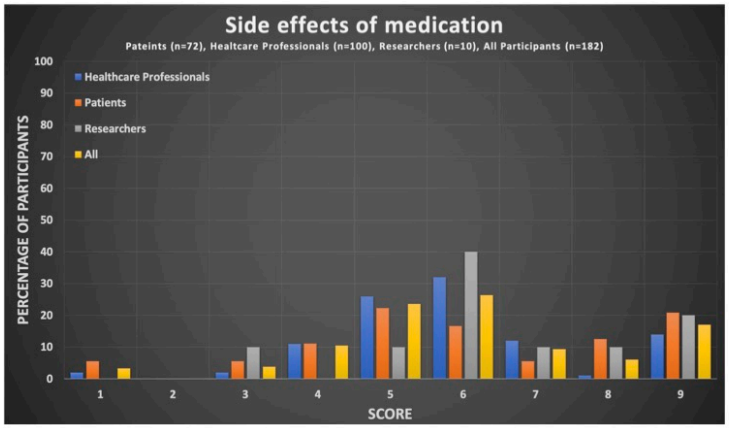

Change in lifestyle
Pateints (n=74), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=185)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

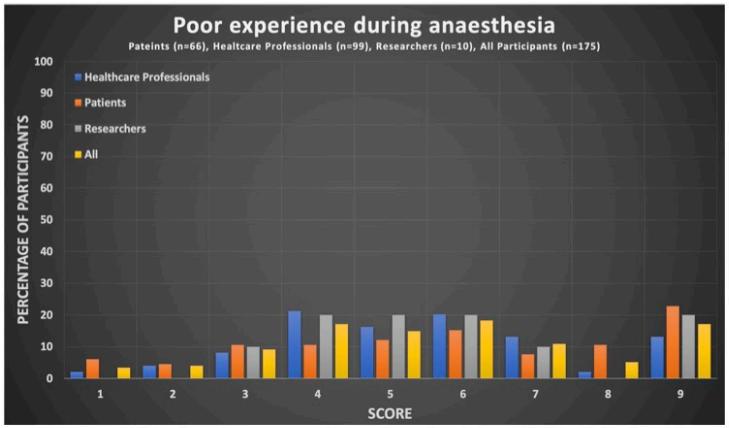

Being compensated financially for injury
Pateints (n=71), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=181)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

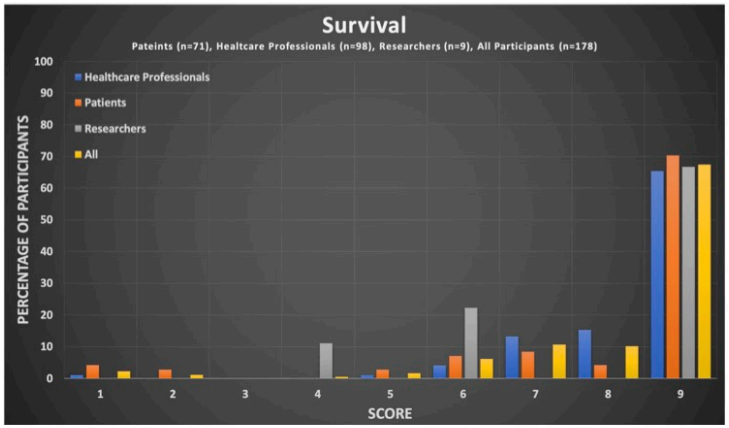

Personal cost of treatment and care following injury
Pateints (n=73), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=183)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE


Effect of injury on personal finances
Pateints (n=73), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=183)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

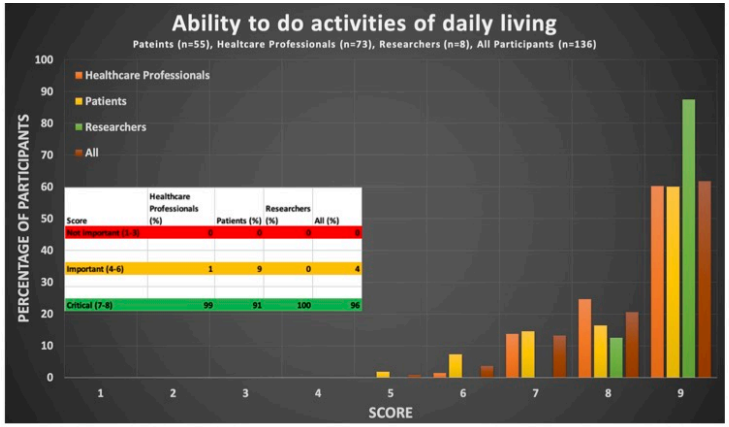

Number of adverse events
Pateints (n=69), Healtcare Professionals (n=101), Researchers (n=10), All Participants (n=180)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

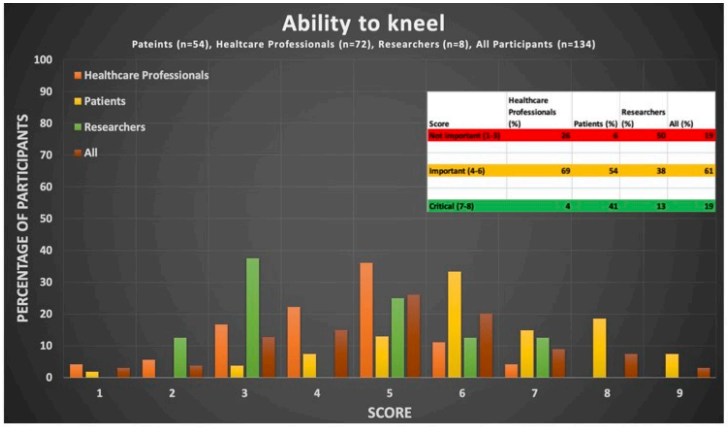

Side effects of medication
Pateints (n=72), Healtcare Professionals (n=100), Researchers (n=10), All Participants (n=182)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

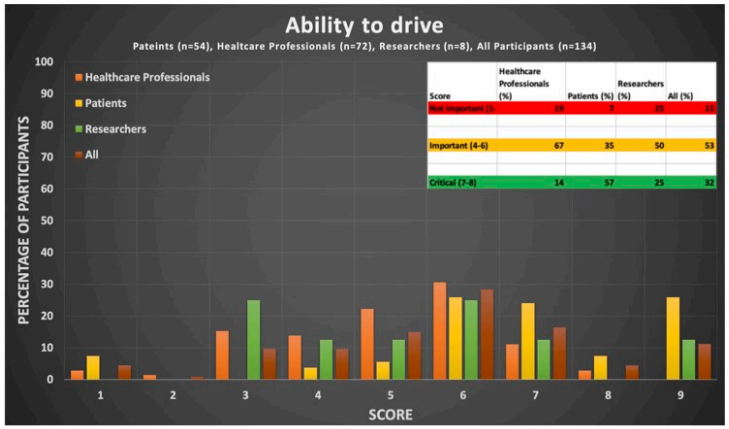

Poor experience during anaesthesia
Pateints (n=66), Healtcare Professionals (n=99), Researchers (n=10), All Participants (n=175)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

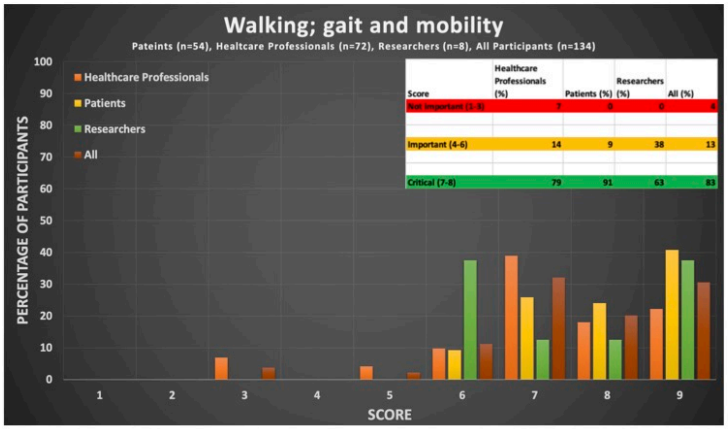

Survival
Pateints (n=71), Healtcare Professionals (n=98), Researchers (n=9), All Participants (n=178)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE

8.29 Appendix 29. Bar charts and tables of Delphi survey round 2 results, which were printed on A4 sized cards for the COS consensus meeting.



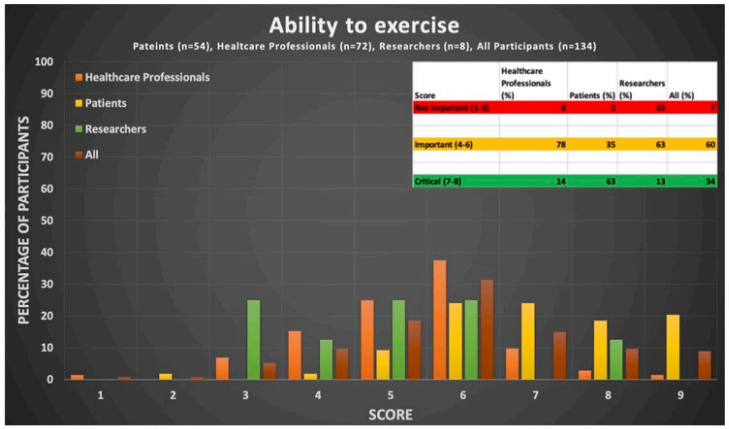



Ability to drive
Pateints (n=54), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=134)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 19 | 3 | 25 | 14
Important (4-6) | 67 | 35 | 50 | 53
Critical (7-8) | 14 | 57 | 25 | 32

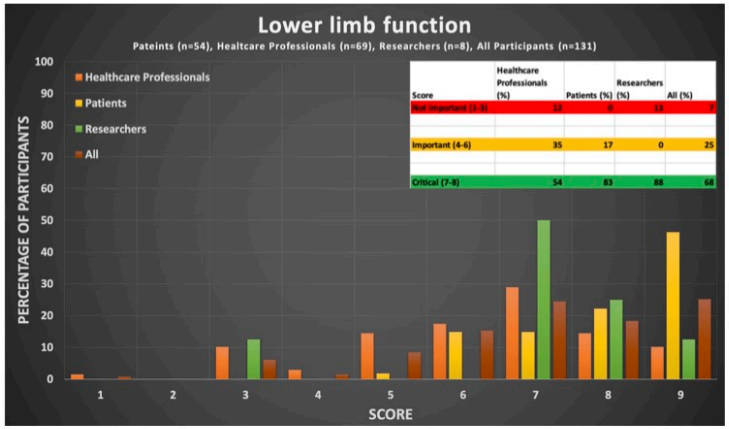

Walking; gait and mobility
Pateints (n=54), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=134)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Important (4-6) | 14 | 9 | 38 | 13
Critical (7-8) | 79 | 91 | 63 | 83

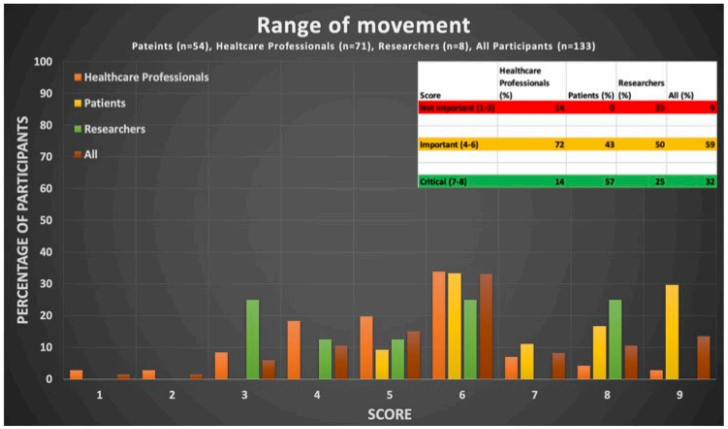
Ability to be able to dress and do self and personal care
Pateints (n=54), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=134)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Important (4-6) | 15 | 7 | 0 | 11
Critical (7-8) | 83 | 91 | 88 | 87

Ability to have intimate relationships
Pateints (n=54), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=134)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Important (4-6) | 68 | 44 | 63 | 58
Critical (7-8) | 18 | 37 | 0 | 25


Ability to exercise
Pateints (n=54), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=134)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 8 | 2 | 25 | 7
Important (4-6) | 78 | 35 | 63 | 60
Critical (7-8) | 14 | 63 | 13 | 34

Ability to comfortably wear shoes and clothes of your choice
Pateints (n=54), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=134)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 32 | 6 | 38 | 22
Important (4-6) | 60 | 50 | 38 | 54
Critical (7-8) | 8 | 44 | 25 | 24

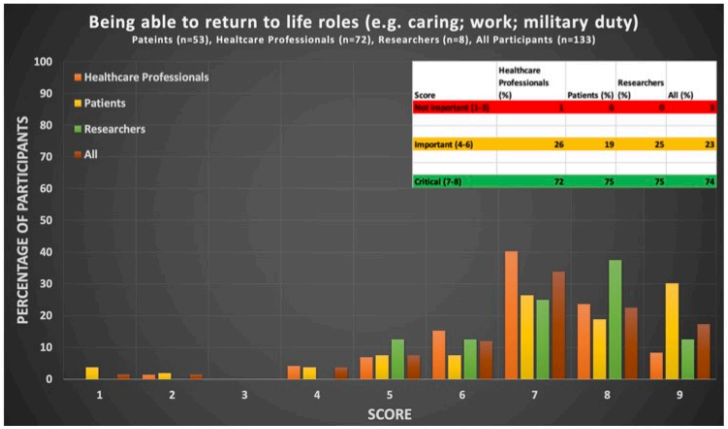

Lower limb function
Pateints (n=54), Healtcare Professionals (n=69), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 12 | 0 | 13 | 7
Important (4-6) | 35 | 17 | 0 | 25
Critical (7-8) | 54 | 83 | 88 | 68

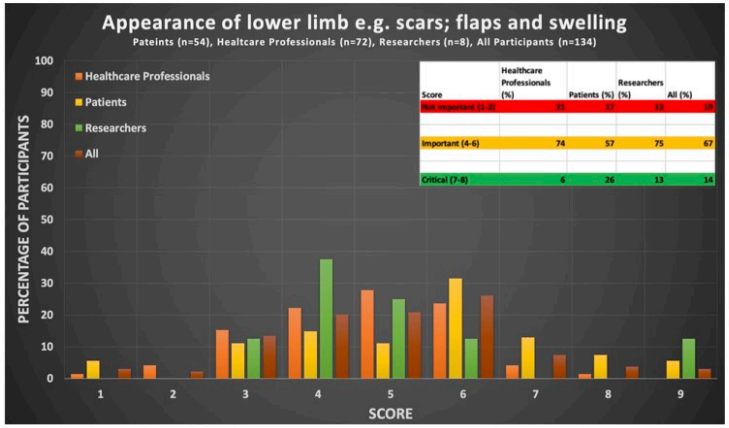

Range of movement
Pateints (n=54), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=133)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 14 | 0 | 25 | 8
Important (4-6) | 72 | 43 | 50 | 59
Critical (7-8) | 14 | 57 | 25 | 32

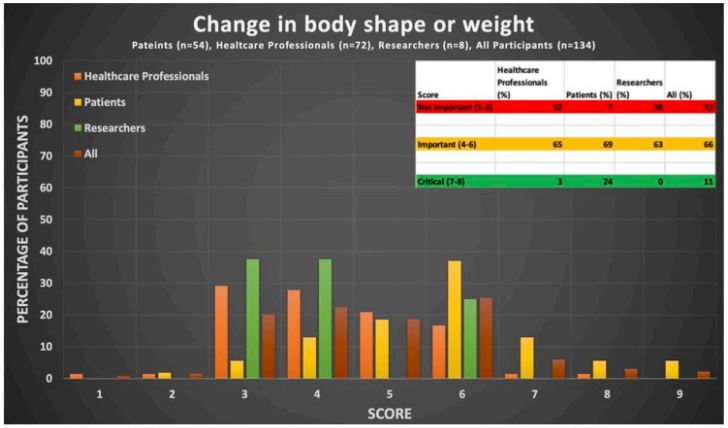
Ability to participate in social events
Pateints (n=54), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=134)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 8 | 2 | 38 | 7
Important (4-6) | 63 | 50 | 25 | 55
Critical (7-8) | 29 | 48 | 38 | 37

Ability to start; maintain and develop relationships
Pateints (n=54), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=134)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 8 | 2 | 13 | 8
Important (4-6) | 58 | 46 | 38 | 52
Critical (7-8) | 33 | 46 | 50 | 40

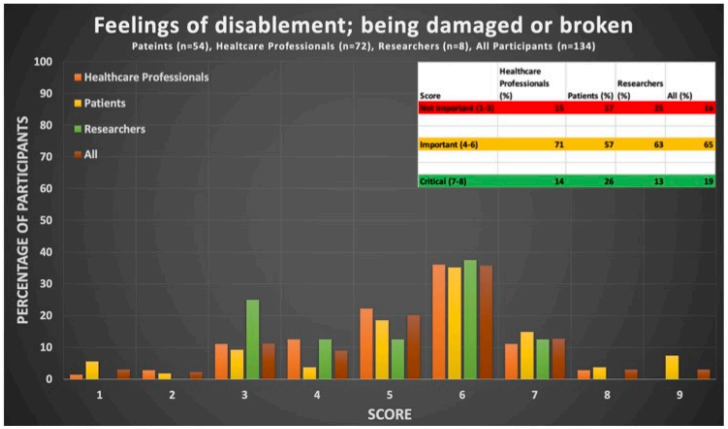
Being able to care for other people and/or animals
Pateints (n=53), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=133)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 29 | 9 | 25 | 21
Important (4-6) | 64 | 42 | 63 | 55
Critical (7-8) | 7 | 49 | 13 | 24

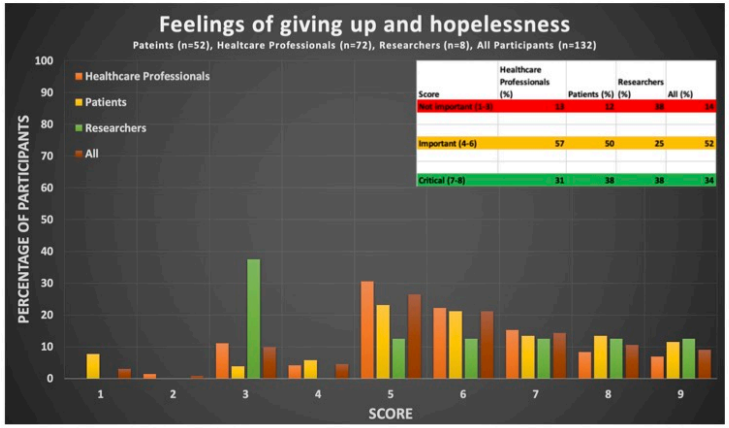

Being able to return to life roles (e.g. caring; work; military duty)
Pateints (n=53), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=133)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 1 | 6 | 0 | 3
Important (4-6) | 26 | 19 | 25 | 23
Critical (7-8) | 72 | 75 | 75 | 74


Appearance of lower limb e.g. scars; flaps and swelling
Pateints (n=54), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=134)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 21 | 17 | 13 | 18
Important (4-6) | 74 | 57 | 75 | 67
Critical (7-8) | 6 | 26 | 13 | 14

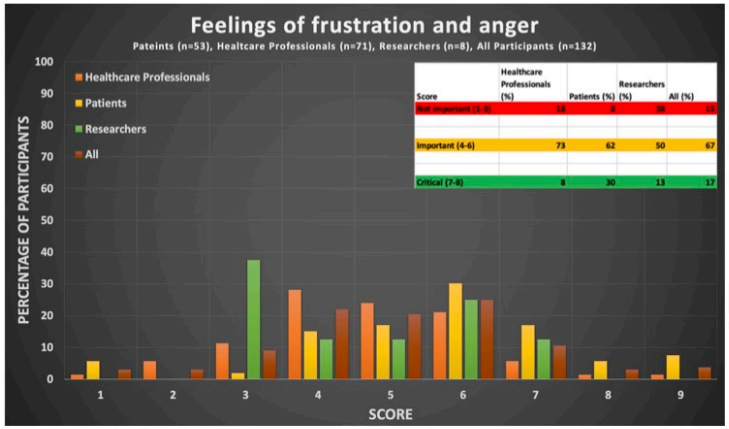

Change in body shape or weight
Pateints (n=54), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=134)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 32 | 7 | 38 | 22
Important (4-6) | 65 | 69 | 63 | 66
Critical (7-8) | 3 | 24 | 0 | 11

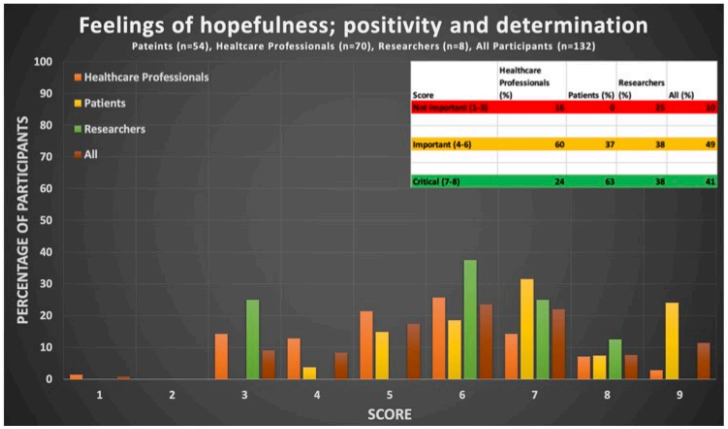
Feelings of self-identity and body wholeness
Pateints (n=54), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=134)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 21 | 19 | 25 | 20
Important (4-6) | 65 | 52 | 63 | 60
Critical (7-8) | 14 | 30 | 13 | 20

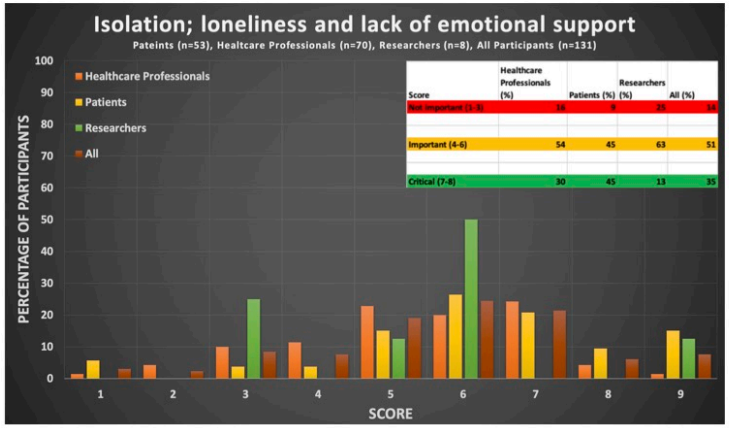

Feelings of disablement; being damaged or broken
Pateints (n=54), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=134)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 15 | 17 | 25 | 16
Important (4-6) | 71 | 57 | 63 | 65
Critical (7-8) | 14 | 26 | 13 | 19


Feelings of giving up and hopelessness
Pateints (n=52), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 13 | 22 | 88 | 34
Important (4-6) | 57 | 50 | 25 | 52
Critical (7-8) | 31 | 38 | 38 | 34

Feeling of loss
Pateints (n=53), Healtcare Professionals (n=72), Researchers (n=8), All Participants (n=133)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 22 | 15 | 25 | 20
Important (4-6) | 67 | 57 | 63 | 62
Critical (7-8) | 11 | 28 | 13 | 18

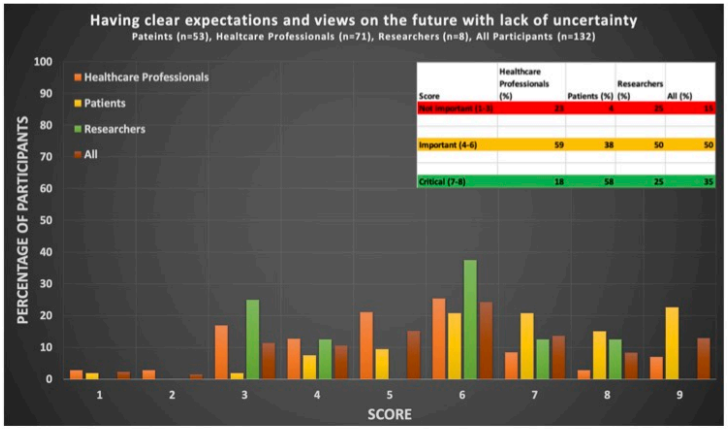

Feelings of frustration and anger
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 18 | 8 | 38 | 15
Important (4-6) | 73 | 62 | 50 | 67
Critical (7-8) | 8 | 30 | 13 | 17


Feelings of hopefulness; positivity and determination
Pateints (n=54), Healtcare Professionals (n=70), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 16 | 3 | 25 | 10
Important (4-6) | 60 | 37 | 38 | 49
Critical (7-8) | 24 | 63 | 38 | 41

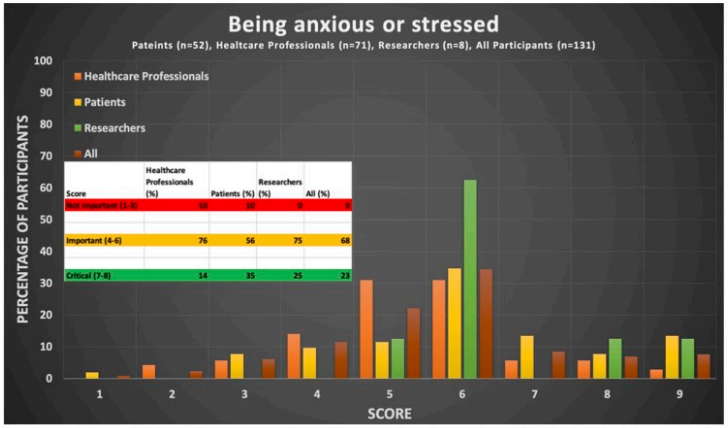

Isolation; loneliness and lack of emotional support
Pateints (n=53), Healtcare Professionals (n=70), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 16 | 9 | 25 | 14
Important (4-6) | 54 | 45 | 63 | 51
Critical (7-8) | 30 | 45 | 13 | 35

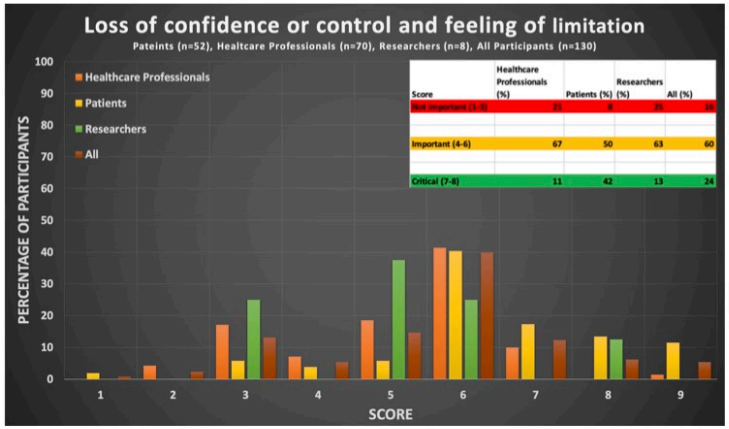
Low mood
Pateints (n=52), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 13 | 2 | 0 | 8
Important (4-6) | 68 | 62 | 63 | 65
Critical (7-8) | 21 | 35 | 38 | 27

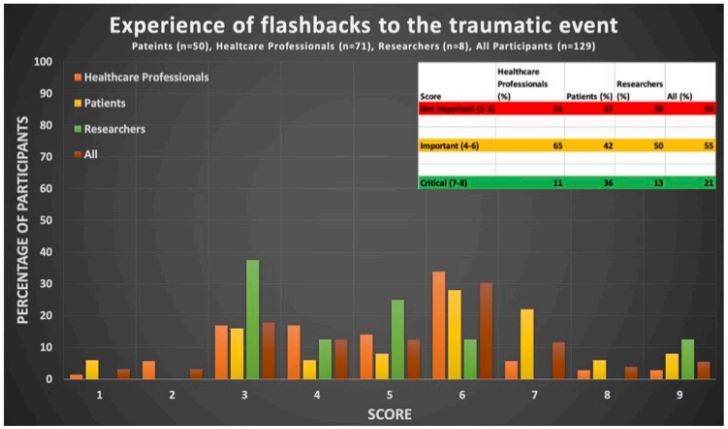
Ability to move on and feeling of getting life back
Pateints (n=42), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=133)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 10 | 6 | 25 | 7
Important (4-6) | 46 | 19 | 13 | 33
Critical (7-8) | 44 | 81 | 63 | 60

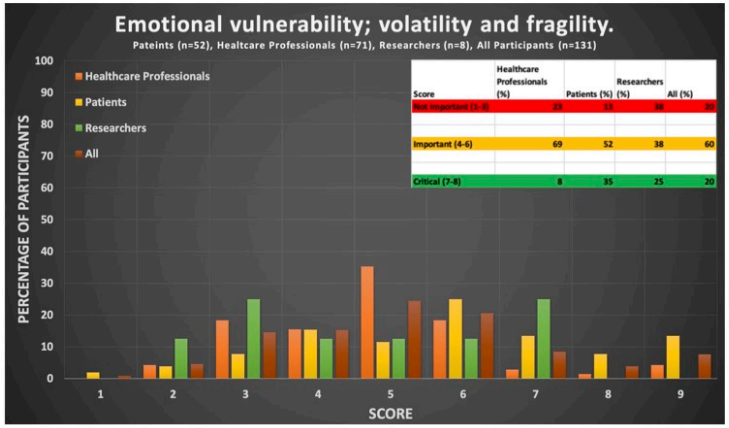

Having clear expectations and views on the future with lack of uncertainty
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 23 | 6 | 25 | 15
Important (4-6) | 59 | 38 | 50 | 50
Critical (7-8) | 18 | 58 | 25 | 35

Tolerance of uncertainty and living in fear e.g. fear of falling or going outside and fear for the future
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 21 | 9 | 25 | 16
Important (4-6) | 68 | 60 | 63 | 64
Critical (7-8) | 11 | 32 | 13 | 20

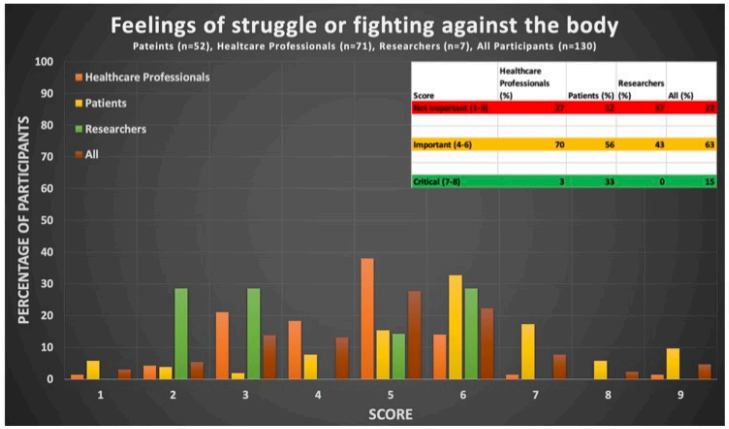

Being anxious or stressed
Pateints (n=52), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 10 | 10 | 0 | 9
Important (4-6) | 76 | 56 | 75 | 68
Critical (7-8) | 14 | 35 | 25 | 23

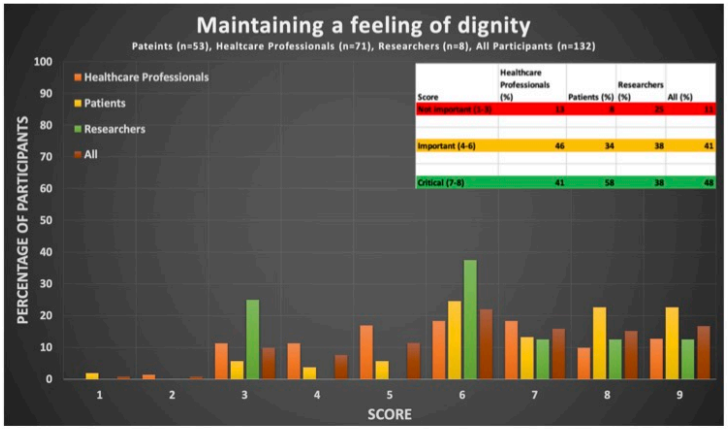

Loss of confidence or control and feeling of limitation
Pateints (n=52), Healtcare Professionals (n=70), Researchers (n=8), All Participants (n=130)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 23 | 8 | 25 | 16
Important (4-6) | 67 | 50 | 63 | 60
Critical (7-8) | 11 | 42 | 13 | 24

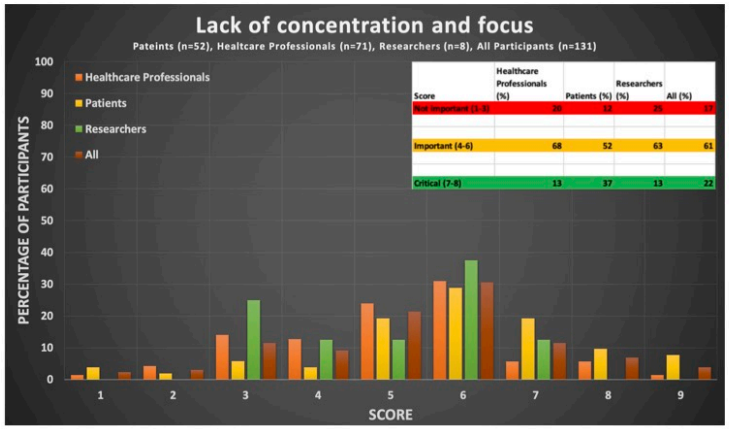

Experience of flashbacks to the traumatic event
Pateints (n=50), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=129)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 24 | 22 | 38 | 26
Important (4-6) | 65 | 42 | 50 | 55
Critical (7-8) | 11 | 36 | 13 | 21

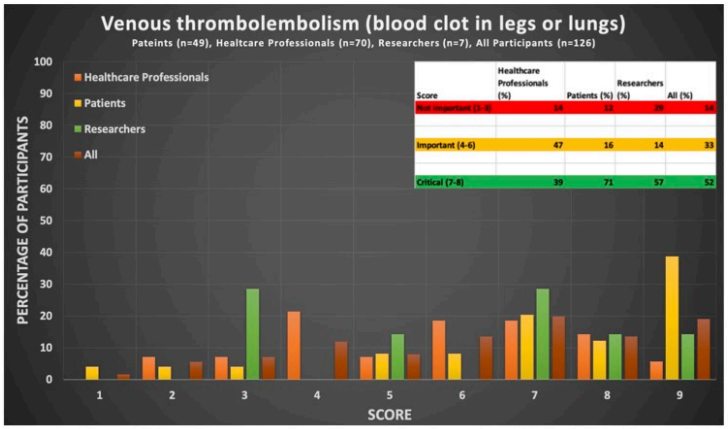

Emotional vulnerability; volatility and fragility.
Pateints (n=52), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 23 | 13 | 38 | 24
Important (4-6) | 69 | 52 | 38 | 60
Critical (7-8) | 8 | 35 | 25 | 20

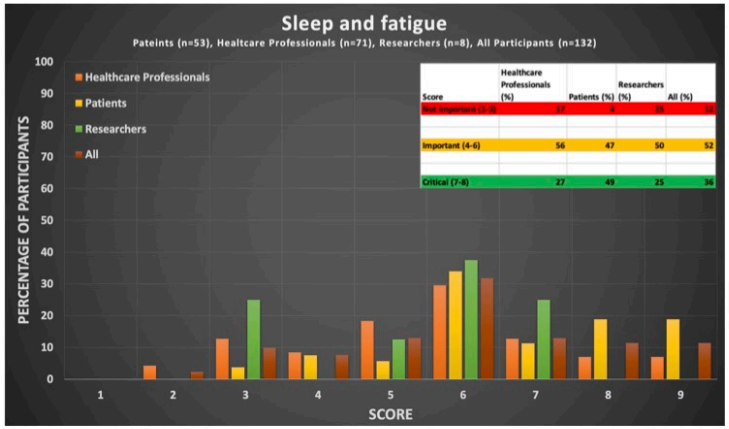
Ability to accept the event and life change
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 20 | 4 | 25 | 14
Important (4-6) | 59 | 49 | 50 | 55
Critical (7-8) | 21 | 47 | 25 | 32

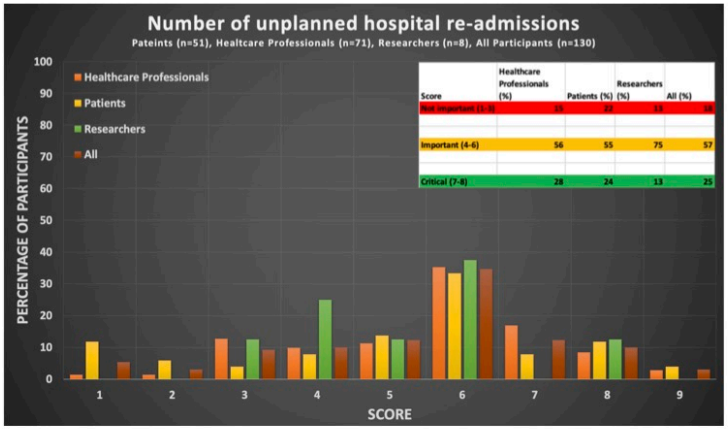

Feelings of struggle or fighting against the body
Pateints (n=52), Healtcare Professionals (n=71), Researchers (n=7), All Participants (n=130)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 27 | 12 | 57 | 22
Important (4-6) | 70 | 56 | 43 | 63
Critical (7-8) | 3 | 33 | 0 | 15

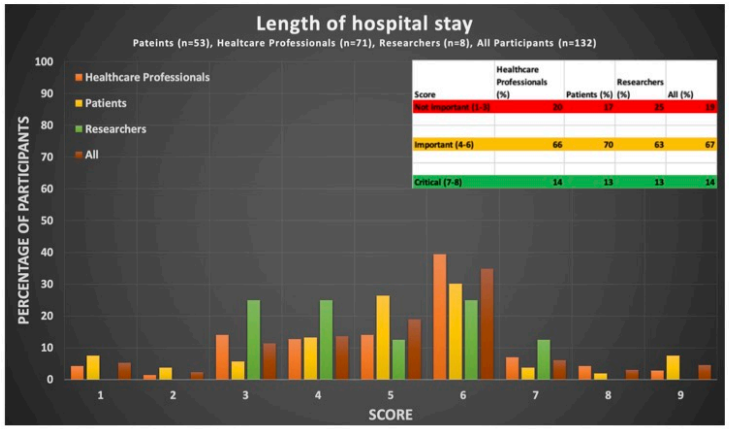

Maintaining a feeling of dignity
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 13 | 3 | 25 | 13
Important (4-6) | 46 | 34 | 38 | 41
Critical (7-8) | 41 | 58 | 38 | 46

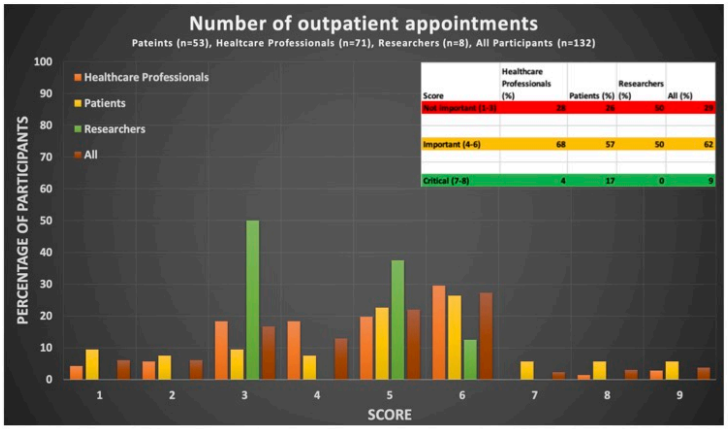

Lack of concentration and focus
Pateints (n=52), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 20 | 12 | 25 | 17
Important (4-6) | 68 | 52 | 63 | 61
Critical (7-8) | 13 | 37 | 13 | 22

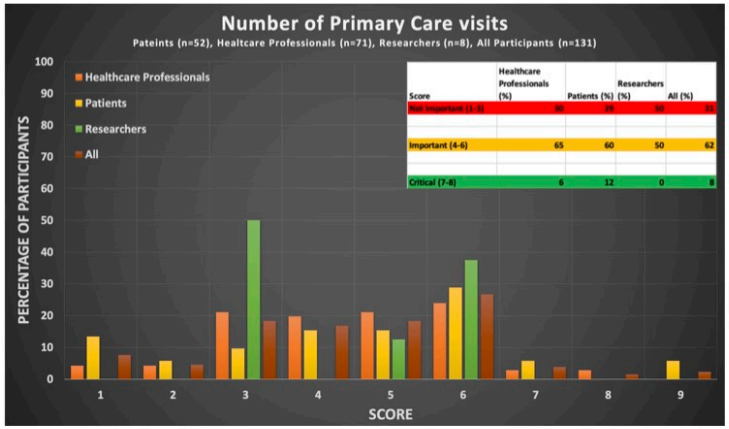

Venous thrombolembolism (blood clot in legs or lungs)
Pateints (n=49), Healtcare Professionals (n=70), Researchers (n=7), All Participants (n=126)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 14 | 12 | 29 | 18
Important (4-6) | 47 | 16 | 14 | 33
Critical (7-8) | 39 | 71 | 57 | 52

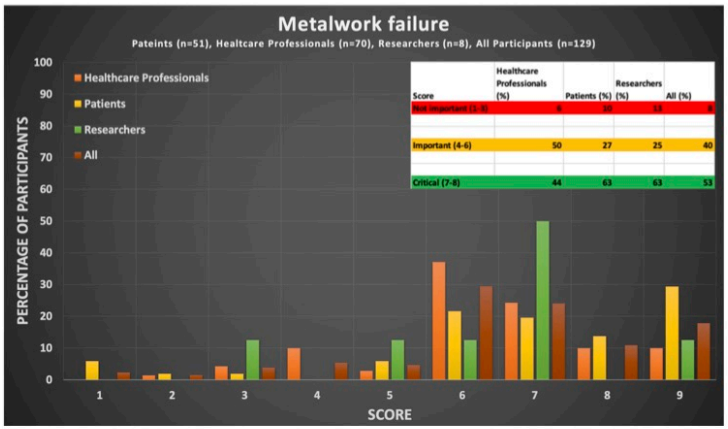

Sleep and fatigue
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 17 | 4 | 25 | 12
Important (4-6) | 56 | 47 | 50 | 52
Critical (7-8) | 27 | 49 | 25 | 36

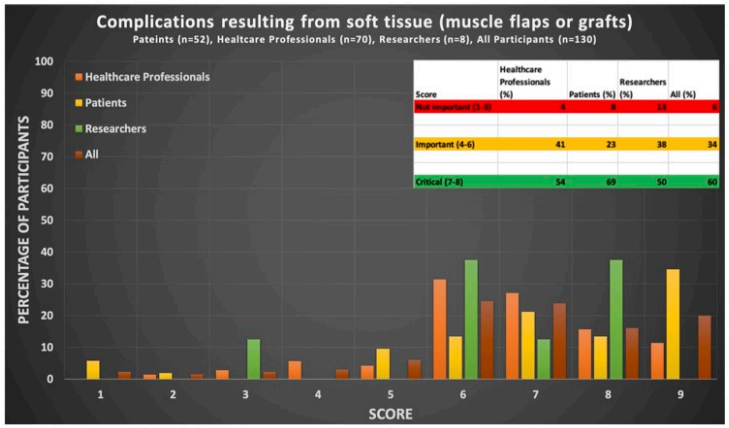

Number of unplanned hospital re-admissions
Pateints (n=51), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=130)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 16 | 21 | 13 | 18
Important (4-6) | 56 | 55 | 75 | 57
Critical (7-8) | 28 | 24 | 13 | 25

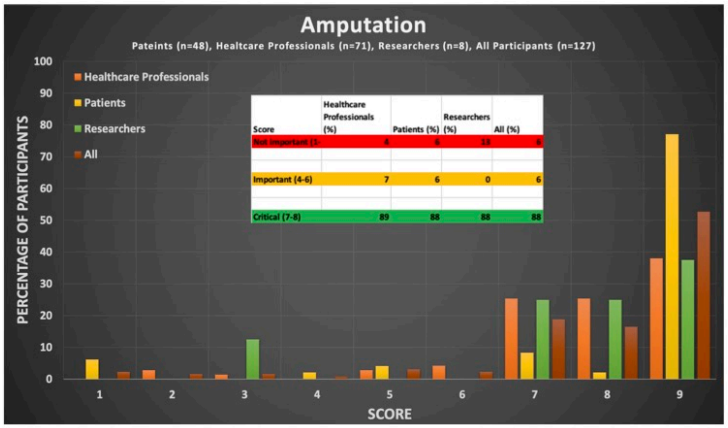

Length of hospital stay
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 20 | 17 | 25 | 18
Important (4-6) | 66 | 70 | 63 | 67
Critical (7-8) | 14 | 13 | 13 | 14

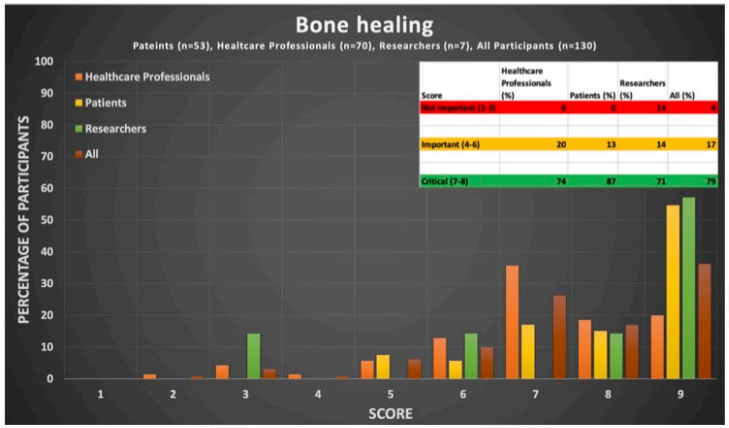

Number of outpatient appointments
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 28 | 26 | 50 | 29
Important (4-6) | 68 | 57 | 50 | 62
Critical (7-8) | 4 | 17 | 0 | 9

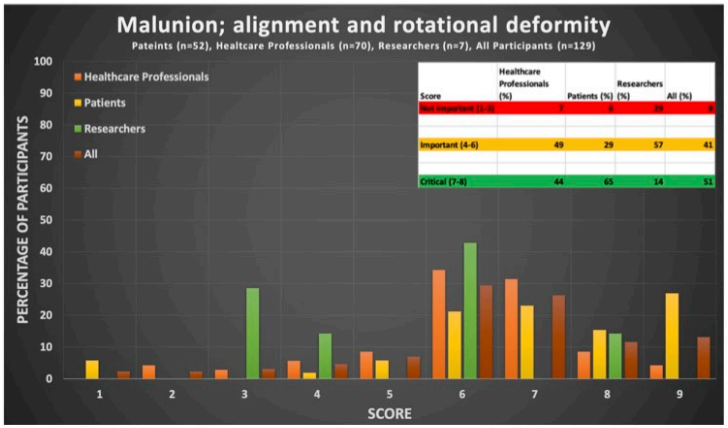

Number of Primary Care visits
Pateints (n=52), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 30 | 29 | 50 | 31
Important (4-6) | 65 | 60 | 50 | 62
Critical (7-8) | 6 | 12 | 0 | 8

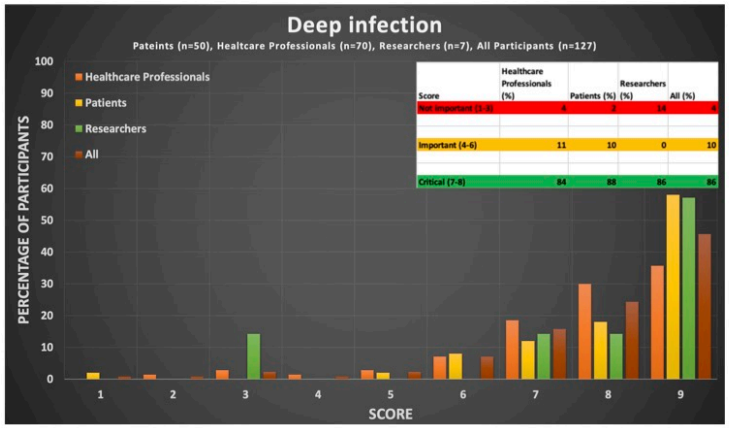

Metalwork failure
Pateints (n=51), Healtcare Professionals (n=70), Researchers (n=8), All Participants (n=129)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 6 | 10 | 13 | 8
Important (4-6) | 50 | 27 | 25 | 40
Critical (7-8) | 44 | 63 | 63 | 53

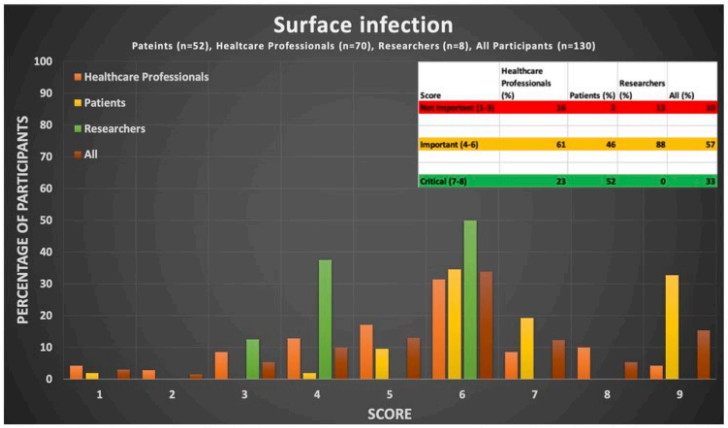

Complications resulting from soft tissue (muscle flaps or grafts)
Pateints (n=52), Healtcare Professionals (n=70), Researchers (n=8), All Participants (n=130)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 4 | 8 | 13 | 6
Important (4-6) | 41 | 23 | 38 | 34
Critical (7-8) | 54 | 69 | 50 | 60

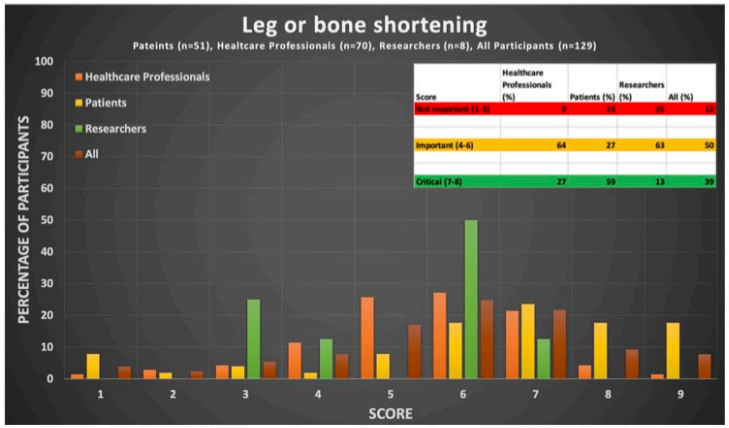

Amputation
Pateints (n=48), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=127)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-
Important (4-6) | 7 | 6 | 0 | 6
Critical (7-8) | 89 | 88 | 88 | 88

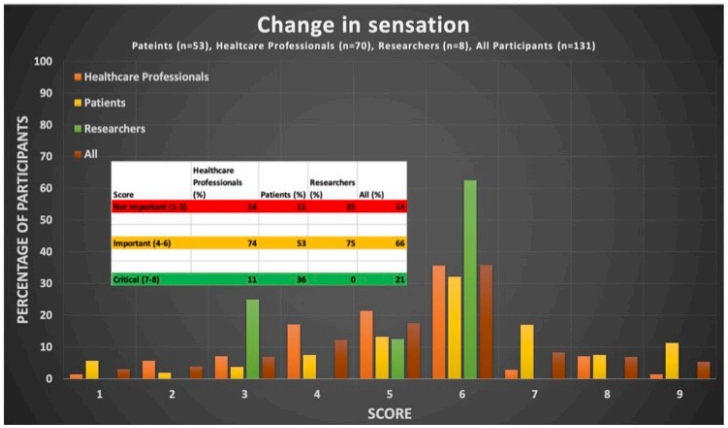

Bone healing
Pateints (n=53), Healtcare Professionals (n=70), Researchers (n=7), All Participants (n=130)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Important (4-6) | 20 | 13 | 14 | 17
Critical (7-8) | 74 | 87 | 71 | 79


Malunion; alignment and rotational deformity
Pateints (n=52), Healtcare Professionals (n=70), Researchers (n=7), All Participants (n=129)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Important (4-6) | 49 | 29 | 57 | 41
Critical (7-8) | 44 | 65 | 14 | 51

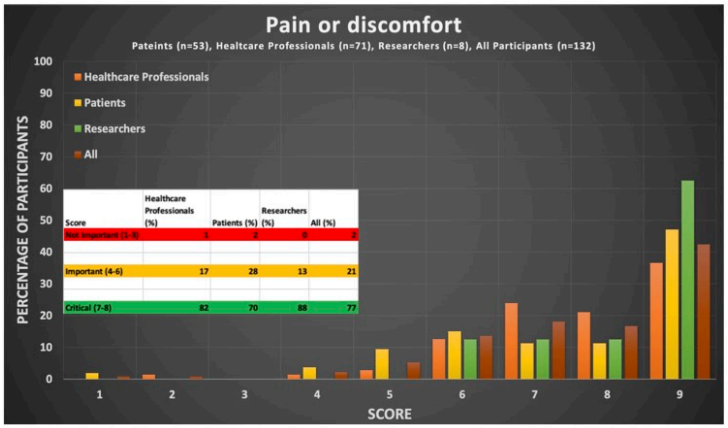

Deep infection
Pateints (n=50), Healtcare Professionals (n=70), Researchers (n=7), All Participants (n=127)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 4 | 2 | 14 | 4
Important (4-6) | 11 | 10 | 0 | 10
Critical (7-8) | 84 | 88 | 86 | 86

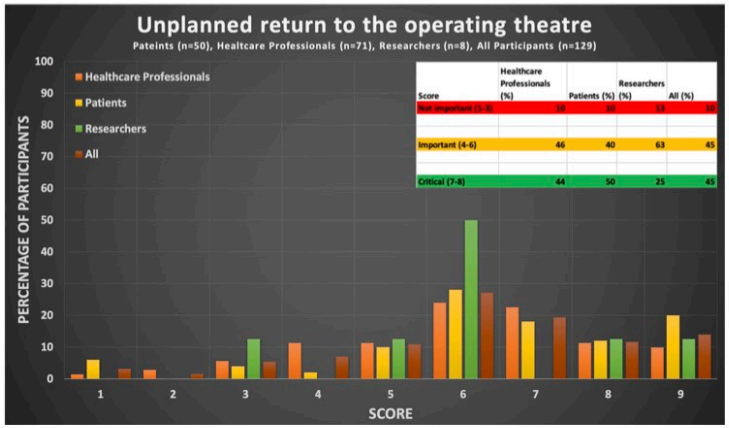

Surface infection
Pateints (n=52), Healtcare Professionals (n=70), Researchers (n=8), All Participants (n=130)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 16 | 2 | 13 | 10
Important (4-6) | 61 | 46 | 88 | 57
Critical (7-8) | 23 | 52 | 0 | 33


Leg or bone shortening
Pateints (n=51), Healtcare Professionals (n=70), Researchers (n=8), All Participants (n=129)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 9 | 14 | 25 | 12
Important (4-6) | 64 | 27 | 63 | 50
Critical (7-8) | 27 | 59 | 13 | 39

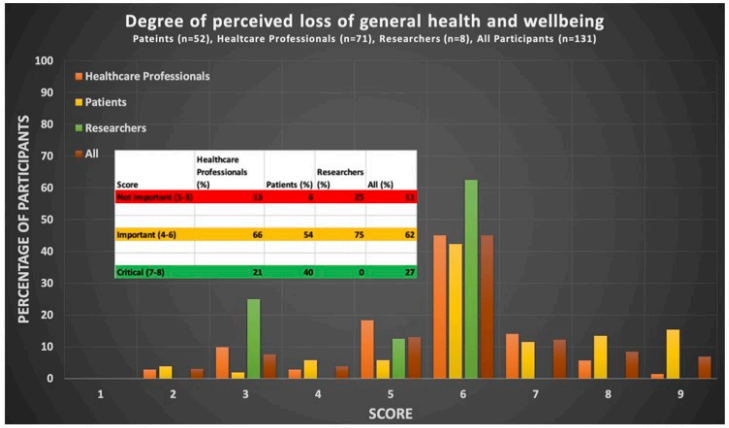

Change in sensation
Pateints (n=53), Healtcare Professionals (n=70), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 14 | 11 | 25 | 16
Important (4-6) | 74 | 53 | 75 | 66
Critical (7-8) | 11 | 36 | 0 | 21

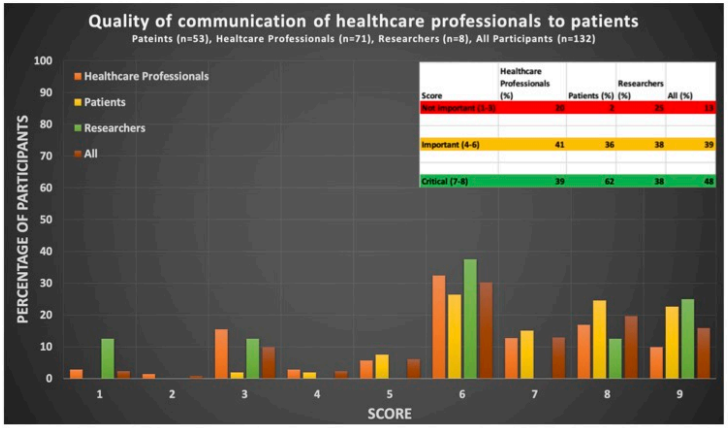
Muscle weakness
Pateints (n=53), Healtcare Professionals (n=70), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 11 | 2 | 25 | 8
Important (4-6) | 76 | 53 | 63 | 66
Critical (7-8) | 13 | 45 | 13 | 26


Pain or discomfort
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 1 | 2 | 0 | 2
Important (4-6) | 17 | 28 | 13 | 21
Critical (7-8) | 82 | 70 | 88 | 77

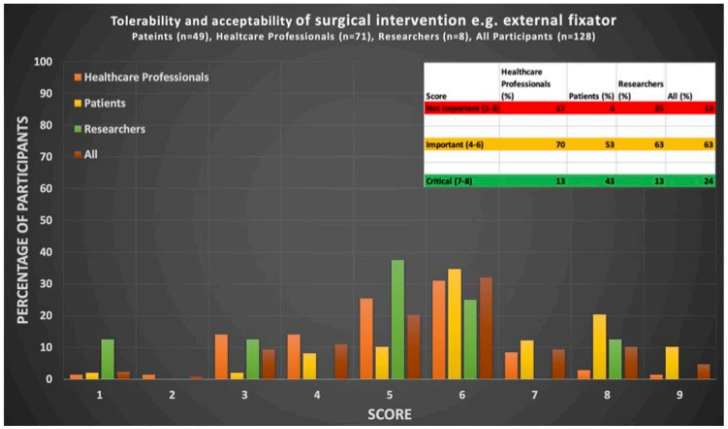

Unplanned return to the operating theatre
Pateints (n=50), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=129)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 10 | 10 | 13 | 10
Important (4-6) | 46 | 40 | 63 | 45
Critical (7-8) | 44 | 50 | 25 | 45

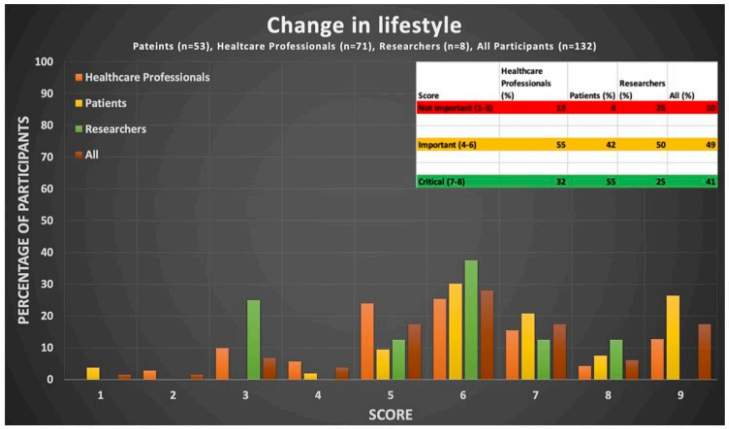
Quality of life
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 1 | 0 | 0 | 1
Important (4-6) | 0 | 9 | 0 | 4
Critical (7-8) | 99 | 91 | 100 | 95

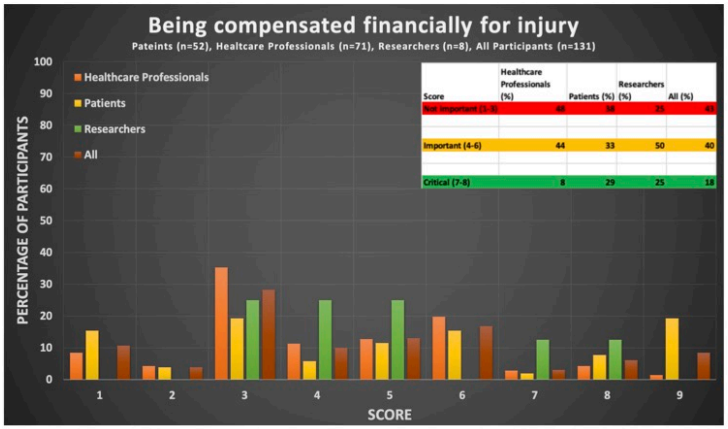

Degree of perceived loss of general health and wellbeing
Pateints (n=52), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 13 | 6 | 25 | 11
Important (4-6) | 66 | 54 | 75 | 62
Critical (7-8) | 21 | 40 | 0 | 27

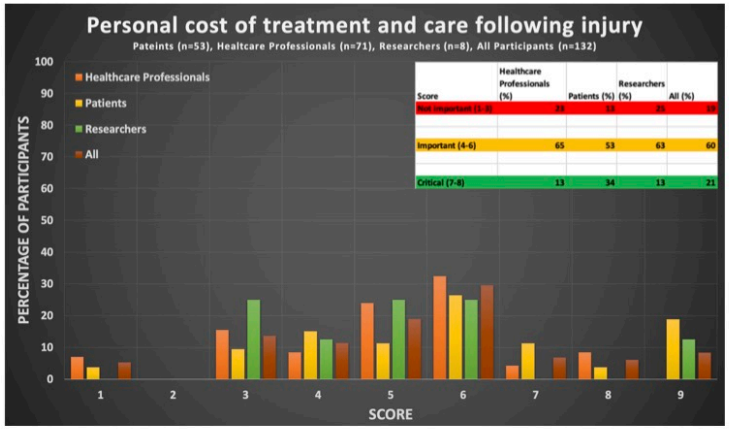

Quality of communication of healthcare professionals to patients
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Important (4-6) | 41 | 36 | 38 | 39
Critical (7-8) | 39 | 62 | 38 | 48

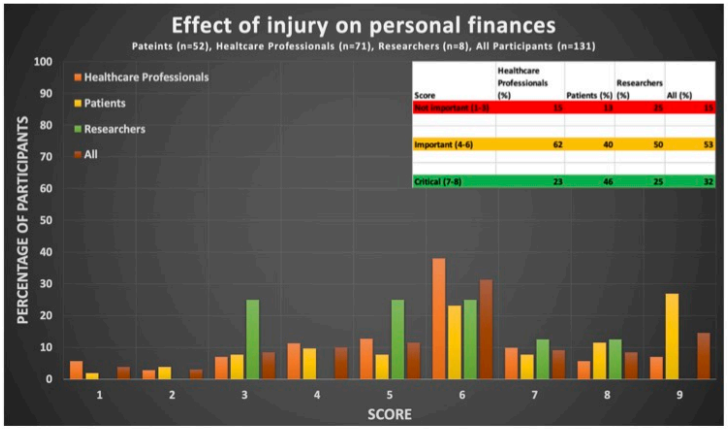
Satisfaction with care
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Important (4-6) | 59 | 51 | 25 | 54
Critical (7-8) | 25 | 49 | 50 | 36

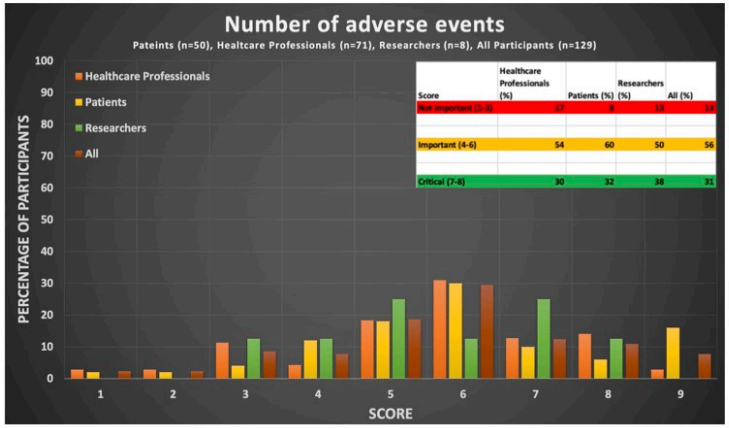

Tolerability and acceptability of surgical intervention e.g. external fixator
Pateints (n=49), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=128)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Important (4-6) | 70 | 53 | 63 | 63
Critical (7-8) | 13 | 43 | 13 | 24

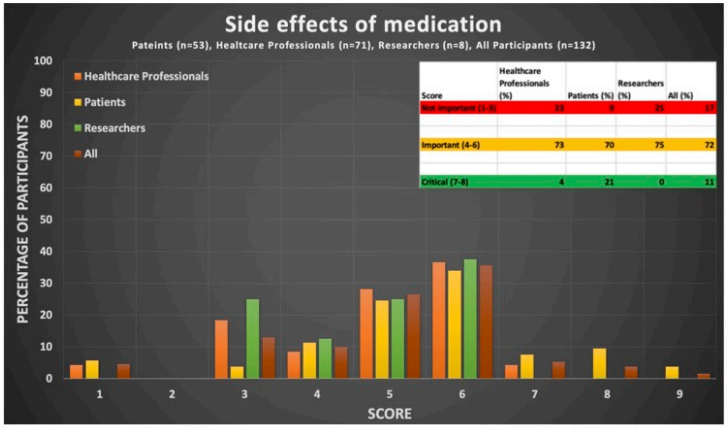

Change in lifestyle
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 13 | 4 | 25 | 10
Important (4-6) | 55 | 42 | 50 | 49
Critical (7-8) | 32 | 55 | 25 | 41

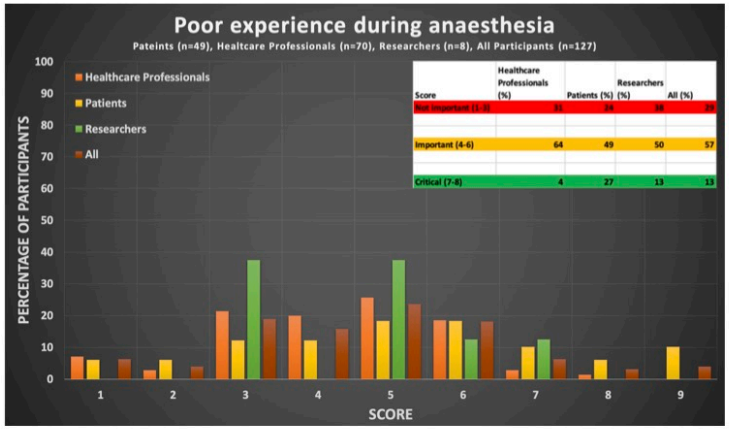

Being compensated financially for injury
Pateints (n=52), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 48 | 58 | 25 | 45
Important (4-6) | 44 | 33 | 50 | 40
Critical (7-8) | 8 | 29 | 25 | 15

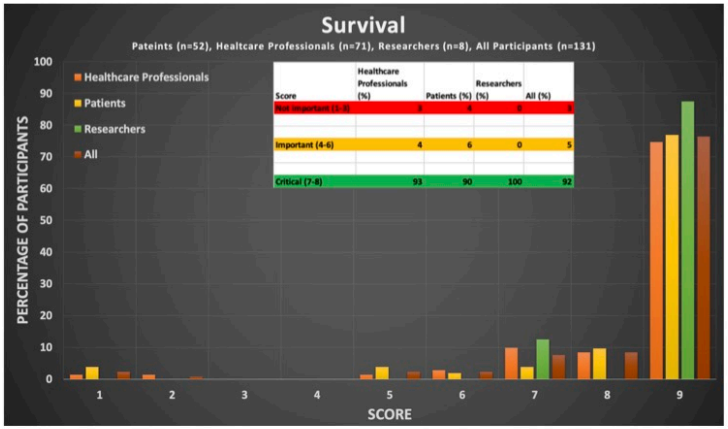

Personal cost of treatment and care following injury
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 23 | 13 | 25 | 16
Important (4-6) | 65 | 53 | 63 | 60
Critical (7-8) | 13 | 34 | 13 | 21

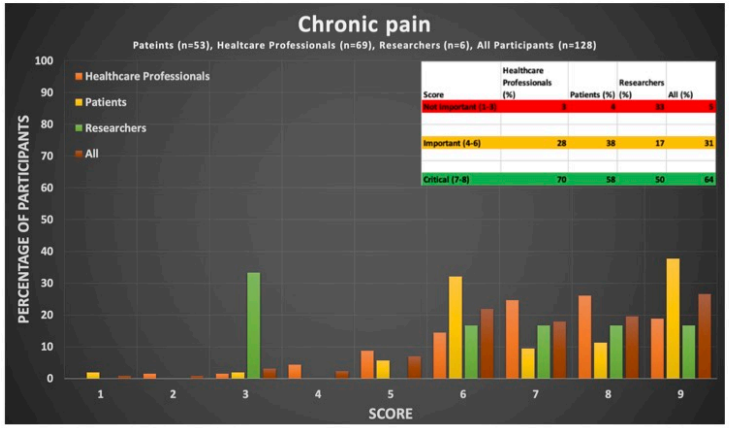

Effect of injury on personal finances
Pateints (n=52), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 15 | 13 | 25 | 15
Important (4-6) | 62 | 40 | 50 | 53
Critical (7-8) | 23 | 46 | 25 | 32

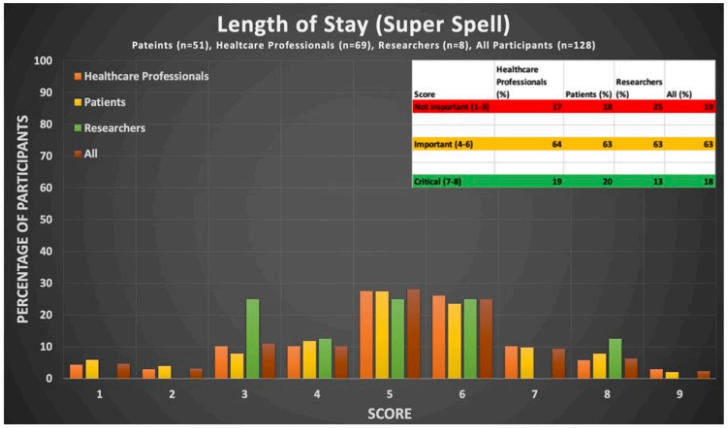

Number of adverse events
Pateints (n=50), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=129)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 17 | 8 | 13 | 13
Important (4-6) | 54 | 60 | 50 | 56
Critical (7-8) | 30 | 32 | 38 | 31


Side effects of medication
Pateints (n=53), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=132)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 23 | 9 | 25 | 17
Important (4-6) | 73 | 70 | 75 | 72
Critical (7-8) | 4 | 21 | 0 | 11


Poor experience during anaesthesia
Pateints (n=49), Healtcare Professionals (n=70), Researchers (n=8), All Participants (n=127)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 31 | 24 | 38 | 29
Important (4-6) | 64 | 49 | 50 | 57
Critical (7-8) | 4 | 27 | 13 | 13


Survival
Pateints (n=52), Healtcare Professionals (n=71), Researchers (n=8), All Participants (n=131)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 3 | 4 | 0 | 3
Important (4-6) | 4 | 6 | 0 | 5
Critical (7-8) | 93 | 90 | 100 | 92


Chronic pain
Pateints (n=53), Healtcare Professionals (n=69), Researchers (n=6), All Participants (n=128)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 3 | 4 | 33 | 4
Important (4-6) | 28 | 38 | 17 | 31
Critical (7-8) | 70 | 58 | 50 | 64


Length of Stay (Super Spell)
Pateints (n=51), Healtcare Professionals (n=69), Researchers (n=8), All Participants (n=128)
Healthcare Professionals
Patients
Researchers
All
PERCENTAGE OF PARTICIPANTS
SCORE
Score | Healthcare Professionals (%) | Patients (%) | Researchers (%) | All (%)
Not important (1-3) | 17 | 18 | 25 | 19
Important (4-6) | 64 | 63 | 63 | 63
Critical (7-8) | 19 | 20 | 13 | 18

8.30 Appendix 30. Adapted search blocks and filters used in Chapter 6

8.30.1 Walking, gait and mobility

	Searches
1	Gait Analysis/ or Gait Ataxia/ or Gait/ or Gait Apraxia/ or Gait Disorders, Neurologic/ or Gait.mp.
2	gait.ti,ab.
3	gaits.ti,ab.
4	Walking Speed/ or walking.mp. or Walking/
5	walk*.ti,ab.
6	ambulation.mp.
7	ambulat*.ti,ab.
8	mobility.ti,ab.
9	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8

Adapted from the Biomedische Informatie (BMI Group), (available form https://www.bmi-online.nl/searchblocks/search-blocks-bmi/) (270).

8.30.2 Return to life roles

	Searches
1	Absenteeism.mp. or Absenteeism/
2	Convalescence.mp. or Convalescence/
3	Recovery of Function.mp. or "Recovery of Function"/
4	Sick Leave.mp. or Sick Leave/
5	Disability Evaluation.mp. or Disability Evaluation/
6	Work Capacity Evaluation.mp. or Work Capacity Evaluation/
7	Rehabilitation, Vocational.mp. or Rehabilitation, Vocational/
8	Return to Work.mp. or Return to Work/
9	Sickness Impact Profile.mp. or Sickness Impact Profile/
10	Occupational Health.mp. or Occupational Health/
11	return to work.ti,ab.
12	(evaluation* and (disability or work capacity)).ti,ab.
13	work disability.ti,ab.
14	work incapacity.ti,ab.
15	work incapability.ti,ab.
16	work inhibition.ti,ab.
17	working incapacity.ti,ab.
18	medical leave.ti,ab.
19	sick leave.ti,ab.
20	disability leave.ti,ab.

21	absente*.ti,ab.
22	work absence.ti,ab.
23	disability absence.ti,ab.
24	convalescen*.ti,ab.
25	sick day*.ti,ab.
26	illness day*.ti,ab.
27	recovery of function.ti,ab.
28	functional recovery.ti,ab.
29	(recovery and function*).ti.
30	reintegration.ti,ab.
31	reemployment.ti,ab.
32	reemployment.ti,ab.
33	presenteeism.ti,ab.
34	reemployment.ti,ab.
35	presenteeism.ti,ab.
36	sickness absence.ti,ab.
37	work absenteeism.ti,ab.
38	work day loss.ti,ab.
39	work time loss.ti,ab.
40	work productivity.ti,ab.
41	work function*.ti,ab.
42	work participation.ti,ab.
43	work performance.ti,ab.
44	performance at work.ti,ab.
45	employment status.ti,ab.
46	work status.ti,ab.
47	occupational health.ti,ab.
48	military.mp. or Military Personnel/
49	military duty.ti,ab.
50	front line.ti,ab.
51	combat role.ti,ab.
52	"United States Department of Veterans Affairs"/ or Veterans Disability Claims/ or Hospitals, Veterans/ or Veterans Health/ or Veterans/ or veterans.mp.
53	care giver.mp. or Caregivers/
54	carer.ti,ab.
55	care giver.ti,ab.
56	normal activities.ti,ab.
57	normal life.ti,ab.
58	return to life roles.ti,ab.
59	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or

	42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58

Adapted from the Biomedische Informatie (BMI Group), (available form https://www.bmi-online.nl/searchblocks/search-blocks-bmi/) (270).

8.30.3 Pain or discomfort

	Searches
1	Musculoskeletal Pain/ or Pain Perception/ or Complex Regional Pain Syndromes/ or Pelvic Pain/ or Back Pain/ or Pain Insensitivity, Congenital/ or Pain, Postoperative/ or Acute Pain/ or Pain, Intractable/ or Abdominal Pain/ or Neck Pain/ or Pain Clinics/ or Pain, Procedural/ or pain*.mp. or Shoulder Pain/ or Patellofemoral Pain Syndrome/ or Chronic Pain/ or Visceral Pain/ or Breakthrough Pain/ or Labor Pain/ or Myofascial Pain Syndromes/ or Pain/ or Nociceptive Pain/ or Pain Measurement/ or Facial Pain/ or Cancer Pain/ or Pain Threshold/ or Low Back Pain/ or Pain Management/ or Chest Pain/
2	pain*.ti,ab.
3	ache*.ti,ab.
4	pain measurement.mp. or Pain Measurement/
5	Hyperalgesia.mp. or Hyperalgesia/
6	Hyperalges*.ti,ab.
7	allodyni*.ti,ab.
8	pain perception.mp. or Pain Perception/
9	nocicepti*.ti,ab.
10	vas.ti,ab.
11	visual analog scale*.ti,ab.
12	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11

Adapted from the Biomedische Informatie (BMI Group), (available form https://www.bmi-online.nl/searchblocks/search-blocks-bmi/) (270).

8.30.4 Quality of Life

	Searches
1	Quality of Life.mp. or "Quality of Life"/
2	quality of life.ti,ab.
3	life qualit*.ti,ab.
4	living qualit*.ti,ab.
5	quality of living.ti,ab.
6	Activities of Daily Living.mp. or "Activities of Daily Living"/
7	activities of daily living.ti,ab.

8	activity of daily living.ti,ab.
9	activities of daily life.ti,ab.
10	activity of daily life.ti,ab.
11	daily living activit*.ti,ab.
12	daily life activit*.ti,ab.
13	adl.ti,ab.
14	chronic limitation of activity.ti,ab.
15	self care*.ti,ab.
16	Health Status.mp. or Health Status/
17	Health Status.ti,ab.
18	level of health.ti,ab.
19	health level*.ti,ab.
20	qol.ti,ab.
21	hrql.ti,ab.
22	hrqol.ti,ab.
23	activity of daily living.ti,ab.
24	activities of daily life.ti,ab.
25	activity of daily life.ti,ab.
26	daily life activit*.ti,ab.
27	iadl.ti,ab.
28	living qualit*.ti,ab.
29	quality of living.ti,ab.
30	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29

Adapted from the Biomedische Informatie (BMI Group), (available form https://www.bmi-online.nl/searchblocks/search-blocks-bmi/) (270).

8.30.5 Open Lower Limb fracture population

	Searches
1	Fractures, Open/
2	((open or compound or severe* or mangle*) adj3 (fracture* or break*)).ti,ab.
3	1 or 2
4	exp lower extremity/ or exp buttocks/ or exp foot/ or exp hip/ or exp knee/ or exp leg/ or exp thigh/
5	"lower extremit*".ti,ab.
6	"lower limb*".ti,ab.
7	(leg or legs).ti,ab.
8	(foot or feet).ti,ab.
9	thigh*.ti,ab.
10	ankle*.ti,ab.

11	(hip or hips).ti,ab.
12	exp Leg Bones/
13	knee*.ti,ab.
14	femur*.ti,ab.
15	tibia*.ti,ab.
16	patella*.ti,ab.
17	talus*.ti,ab.
18	fibula*.ti,ab.
19	calcaneus*.ti,ab.
20	navicular*.ti,ab.
21	cuneiform*.ti,ab.
22	cuboid*.ti,ab.
23	metatarsal*.ti,ab.
24	exp Foot Bones/
25	phalan*.ti,ab.
26	Leg/
27	(toe or toes).ti,ab.
28	exp Toes/
29	pilon*.ti,ab.
30	4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29
31	3 and 30

Search strategy designed in collaboration with Mr Neal Thurley, Information specialist at the Cairns library, University of Oxford.

8.30.6 PROMs search filter

Search
(HR-PRO or HRPRO or HRQL or HRQoL or QL or QoL).ti,ab. or quality of life.mp. or (health index* or health indices or health profile*).ti,ab. or health status.mp. or ((patient or self or child or parent or carer or proxy) adj (appraisal* or appraised or report or reported or reporting or rated or rating* or based or assessed or assessment*)).ti,ab. or ((disability or function or functional or functions or subjective or utility or utilities or wellbeing or well being) adj2 (index or indices or instrument or instruments or measure or measures or questionnaire* or profile or profiles or scale or scales or score or scores or status or survey or surveys)).ti,ab.

Search filter recommended by COSMIN and adapted from the University of Oxford PROM group (available from https://cosmin.nl/wp-content/uploads/prom-search-filter-oxford-2010.pdf) (270).

8.30.7 COSMIN search filter for identifying studies on measurement properties

	Searches
1	(instrumentation or methods).fs.
2	(Validation Studies or Comparative Study).pt.
3	exp Psychometrics/
4	psychometr*.ti,ab.
5	(clinimetr* or clinometr*).tw.
6	outcome assessment.ti,ab.
7	outcome measure*.tw.
8	exp Observer Variation/
9	observer variation.ti,ab.
10	exp Health Status Indicators/
11	exp Reproducibility of Results/
12	reproducib*.ti,ab.
13	exp Discriminant Analysis/
14	(reliab* or unreliab* or valid* or coefficient or homogeneity or homogeneous or internal consistency).ti,ab.
15	(cronbach* and (alpha or alphas)).ti,ab.
16	(item and (correlation* or selection* or reduction*)).ti,ab.
17	(agreement or precision or imprecision or precise values or test-retest).ti,ab.
18	(test and retest).ti,ab.
19	(reliab* and (test or retest)).ti,ab.
20	(stability or interrater or inter-rater or intrarater or intra-rater or intertester or inter-tester or intratester or intra-tester or interobserver or inter-observer or intraobserver or intraobserver or intertechnician or inter-technician or intratechnician or intra-technician or interexaminer or inter-examiner or intraexaminer or intra-examiner or interassay or interassay or intraassay or intra-assay or interindividual or inter-individual or intraindividual or intra-individual or interparticipant or inter-participant or intraparticipant or intra-participant or kappa or kappas or repeatab*).ti,ab.
21	((replicab* or repeated) and (measure or measures or findings or result or results or test or tests)).ti,ab.
22	(generaliza* or generalisa* or concordance).ti,ab.
23	(intraclass and correlation*).ti,ab.
24	(discriminative or known group or factor analysis or factor analyses or dimension* or subscale*).ti,ab.

25	(multitrait and scaling and (analysis or analyses)).ti,ab.
26	(item discriminant or interscale correlation* or error or errors or individual variability).ti,ab.
27	(variability and (analysis or values)).ti,ab.
28	(uncertainty and (measurement or measuring)).ti,ab.
29	(standard error of measurement or sensitiv* or responsive*).ti,ab.
30	((minimal or minimally or clinical or clinically) and (important or significant or detectable) and (change or difference)).ti,ab.
31	(small* and (real or detectable) and (change or difference)).ti,ab.
32	(meaningful change or ceiling effect or floor effect or Item response model or IRT or Rasch or Differential item functioning or DIF or computer adaptive testing or item bank or cross-cultural equivalence).ti,ab.
33	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32

The COMSIN highly sensitive and validated search filter for identifying studies on measurement properties (available from https://www.cosmin.nl/tools/pubmed-search-filters/) (271).

Key for abbreviations used in Ovid
MeSH- Medical Subject Heading (MeSH)
exp – exploded MeSH heading
* – Truncation/wildcard symbol
ti – Title search (search for key word in article titles)
ab – Abstract search (search for keywork in article abstracts)
adj3 – Proximity search term (two words next to each other, in any order, up to 2 words in between

8.31 Appendix 31. Example data extraction tables adapted from COSMIN

Example tables available from: https://www.cosmin.nl/tools/guideline-conducting-systematic-review-outcome-measures/

A. Example table on characteristics of the included PROMs.

PROM* (reference to first article)	**Construct(s)**	**Target population**	**Mode of administration** (e.g. self-report, interview-based, parent/proxy report etc)	**Recall period**	**(Sub)scale (s) (number of items)**	**Response options**	**Range of scores/scoring**	**Original language**	**Available translations**

* Each version of a PROM is considered a separate PROM.

Other characteristics extracted: 'administration time'; 'year of development'; 'conceptual model used'; 'number of studies evaluating the instrument'; 'completion time (minutes)'; 'full copy available'; 'licensing information and costs'

B. Example table on characteristics of the included study populations.

		Population			**Disease characteristics**			**Instrument administration**			
PROM	**Ref**	**N**	**Age Mean (SD, range) yr**	**Gender % female**	**Disease**	**Disease duration mean (SD) yr**	**Disease severity**	**Setting**	**Country**	**Language**	**Response rate**
A	1										
	2										
	3										
B	1										

8.32 Appendix 32. Search results identifying validated OMIs for each core outcome construct in the OLLF population

8.32.1 Search 1. Walking, gait and mobility

Database(s): Embase 1974 to present, Medline (Ovid MEDLINE® Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®) 1946 to present.

Date searched: 17th of July 2019

#	Searches	Results
1	(instrumentation or methods).fs.	3915143
2	(Validation Studies or Comparative Study).pt.	1911035
3	exp Psychometrics/	157647
4	psychometr*.ti,ab.	94968
5	(clinimetr* or clinometr*).tw.	2429
6	outcome assessment.ti,ab.	8425
7	outcome measure*.tw.	480235
8	exp Observer Variation/	60439
9	observer variation.ti,ab.	2503
10	exp Health Status Indicators/	313168
11	exp Reproducibility of Results/	585617
12	reproducib*.ti,ab.	344581
13	exp Discriminant Analysis/	27755
14	(reliab* or unreliab* or valid* or coefficient or homogeneity or homogeneous or internal consistency).ti,ab.	3001053
15	(cronbach* and (alpha or alphas)).ti,ab.	45698
16	(item and (correlation* or selection* or reduction*)).ti,ab.	48619
17	(agreement or precision or imprecision or precise values or test-retest).ti,ab.	857841
18	(test and retest).ti,ab.	55926
19	(reliab* and (test or retest)).ti,ab.	195247
20	(stability or interrater or inter-rater or intrarater or intra-rater or intertester or inter-tester or intratester or intra-tester or interobserver or inter-observer or intraobserver or intraobserver or intertechnician or inter-technician or intratechnician or intra-technician or interexaminer or inter-examiner or intraexaminer or intra-examiner or interassay or interassay or intraassay or intra-assay or interindividual or inter-individual or intraindividual or	1226959

	intra-individual or interparticipant or inter-participant or intraparticipant or intra-participant or kappa or kappas or repeatab*).ti,ab.	
21	((replicab* or repeated) and (measure or measures or findings or result or results or test or tests)).ti,ab.	455125
22	(generaliza* or generalisa* or concordance).ti,ab.	192092
23	(intraclass and correlation*).ti,ab.	50165
24	(discriminative or known group or factor analysis or factor analyses or dimension* or subscale*).ti,ab.	1280941
25	(multitrait and scaling and (analysis or analyses)).ti,ab.	288
26	(item discriminant or interscale correlation* or error or errors or individual variability).ti,ab.	647123
27	(variability and (analysis or values)).ti,ab.	221225
28	(uncertainty and (measurement or measuring)).ti,ab.	15307
29	(standard error of measurement or sensitiv* or responsive*).ti,ab.	3350311
30	((minimal or minimally or clinical or clinically) and (important or significant or detectable) and (change or difference)).ti,ab.	588727
31	(small* and (real or detectable) and (change or difference)).ti,ab.	17827
32	(meaningful change or ceiling effect or floor effect or Item response model or IRT or Rasch or Differential item functioning or DIF or computer adaptive testing or item bank or cross-cultural equivalence).ti,ab.	29251
33	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32	14426731
34	Gait Analysis/ or Gait Ataxia/ or Gait/ or Gait Apraxia/ or Gait Disorders, Neurologic/ or Gait.mp.	142866
35	gait.ti,ab.	110728
36	gaits.ti,ab.	2365
37	Walking Speed/ or walking.mp. or Walking/	199552
38	walk*.ti,ab.	259251
39	ambulation.mp.	28031
40	ambulat*.ti,ab.	207958
41	mobility.ti,ab.	284115
42	34 or 35 or 36 or 37 or 38 or 39 or 40 or 41	833530
43	Fractures, Open/	9000
44	((open or compound or severe* or mangle*) adj3 (fracture* or break*)).ti,ab.	24351
45	43 or 44	27949
46	exp lower extremity/ or exp buttocks/ or exp foot/ or exp hip/ or exp knee/ or exp leg/ or exp thigh/	525089
47	"lower extremit*".ti,ab.	120015
48	"lower limb*".ti,ab.	113174
49	(leg or legs).ti,ab.	253419
50	(foot or feet).ti,ab.	247754

51	thigh*.ti,ab.	66553
52	ankle*.ti,ab.	130977
53	(hip or hips).ti,ab.	308054
54	exp Leg Bones/	192599
55	knee*.ti,ab.	317204
56	femur*.ti,ab.	113358
57	tibia*.ti,ab.	181496
58	patella*.ti,ab.	42515
59	talus*.ti,ab.	9624
60	fibula*.ti,ab.	25859
61	calcaneus*.ti,ab.	11331
62	navicular*.ti,ab.	4913
63	cuneiform*.ti,ab.	2978
64	cuboid*.ti,ab.	11134
65	metatarsal*.ti,ab.	18968
66	exp Foot Bones/	36188
67	phalan*.ti,ab.	23223
68	Leg/	133994
69	(toe or toes).ti,ab.	44759
70	exp Toes/	25107
71	pilon*.ti,ab.	5342
72	46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 60 or 59 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71	1698001
73	45 and 72	13030
74	33 and 42 and 73	372

8.32.2 Search 2: Return to life roles

Database(s): Embase 1974 to present, Medline (Ovid MEDLINE® Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®) 1946 to present.

Date searched: 17th of July 2019

#	Searches	Results
1	(instrumentation or methods).fs.	3917553
2	(Validation Studies or Comparative Study).pt.	1911383
3	exp Psychometrics/	157717
4	psychometr*.ti,ab.	95052
5	(clinimetr* or clinometr*).tw.	2434

6	outcome assessment.ti,ab.	8439
7	outcome measure*.tw.	480713
8	exp Observer Variation/	60465
9	observer variation.ti,ab.	2505
10	exp Health Status Indicators/	313309
11	exp Reproducibility of Results/	585822
12	reproducib*.ti,ab.	344805
13	exp Discriminant Analysis/	27787
14	(reliab* or unreliab* or valid* or coefficient or homogeneity or homogeneous or internal consistency).ti,ab.	3004087
15	(cronbach* and (alpha or alphas)).ti,ab.	45760
16	(item and (correlation* or selection* or reduction*)).ti,ab.	48665
17	(agreement or precision or imprecision or precise values or test-retest).ti,ab.	858613
18	(test and retest).ti,ab.	55988
19	(reliab* and (test or retest)).ti,ab.	195420
20	(stability or interrater or inter-rater or intrarater or intra-rater or intertester or inter-tester or intratester or intra-tester or interobserver or inter-observer or intraobserver or intraobserver or intertechnician or inter-technician or intratechnician or intra-technician or interexaminer or inter-examiner or intraexaminer or intra-examiner or interassay or interassay or intraassay or intra-assay or interindividual or inter-individual or intraindividual or intra-individual or interparticipant or inter-participant or intraparticipant or intra-participant or kappa or kappas or repeatab*).ti,ab.	1228152
21	((replicab* or repeated) and (measure or measures or findings or result or results or test or tests)).ti,ab.	455544
22	(generaliza* or generalisa* or concordance).ti,ab.	192314
23	(intraclass and correlation*).ti,ab.	50237
24	(discriminative or known group or factor analysis or factor analyses or dimension* or subscale*).ti,ab.	1282060
25	(multitrait and scaling and (analysis or analyses)).ti,ab.	288
26	(item discriminant or interscale correlation* or error or errors or individual variability).ti,ab.	647775
27	(variability and (analysis or values)).ti,ab.	221443
28	(uncertainty and (measurement or measuring)).ti,ab.	15317
29	(standard error of measurement or sensitiv* or responsive*).ti,ab.	3352813
30	((minimal or minimally or clinical or clinically) and (important or significant or detectable) and (change or difference)).ti,ab.	589426
31	(small* and (real or detectable) and (change or difference)).ti,ab.	17845
32	(meaningful change or ceiling effect or floor effect or Item response model or IRT or Rasch or Differential item functioning or DIF or computer adaptive testing or item bank or cross-cultural equivalence).ti,ab.	29320

33	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32	14437782
34	Musculoskeletal Pain/ or Pain Perception/ or Complex Regional Pain Syndromes/ or Pelvic Pain/ or Back Pain/ or Pain Insensitivity, Congenital/ or Pain, Postoperative/ or Acute Pain/ or Pain, Intractable/ or Abdominal Pain/ or Neck Pain/ or Pain Clinics/ or Pain, Procedural/ or pain*.mp. or Shoulder Pain/ or Patellofemoral Pain Syndrome/ or Chronic Pain/ or Visceral Pain/ or Breakthrough Pain/ or Labor Pain/ or Myofascial Pain Syndromes/ or Pain/ or Nociceptive Pain/ or Pain Measurement/ or Facial Pain/ or Cancer Pain/ or Pain Threshold/ or Low Back Pain/ or Pain Management/ or Chest Pain/	2034319
35	pain*.ti,ab.	1588108
36	ache*.ti,ab.	44628
37	pain measurement.mp. or Pain Measurement/	90470
38	Hyperalgesia.mp. or Hyperalgesia/	40478
39	Hyperalges*.ti,ab.	30912
40	allodyni*.ti,ab.	19866
41	pain perception.mp. or Pain Perception/	45455
42	nocicepti*.ti,ab.	67398
43	vas.ti,ab.	113899
44	visual analog scale*.ti,ab.	57639
45	34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44	2152107
46	(HR-PRO or HRPRO or HRQL or HRQoL or QL or QoL).ti,ab. or quality of life.mp. or (health index* or health indices or health profile*).ti,ab. or health status.mp. or ((patient or self or child or parent or carer or proxy) adj (appraisal* or appraised or report or reported or reporting or rated or rating* or based or assessed or assessment*)).ti,ab. or ((disability or function or functional or functions or subjective or utility or utilities or wellbeing or well being) adj2 (index or indices or instrument or instruments or measure or measures or questionnaire* or profile or profiles or scale or scales or score or scores or status or survey or surveys)).ti,ab.	1716830
47	Fractures, Open/	9003
48	((open or compound or severe* or mangle*) adj3 (fracture* or break*)).ti,ab.	24372
49	47 or 48	27970
50	exp lower extremity/ or exp buttocks/ or exp foot/ or exp hip/ or exp knee/ or exp leg/ or exp thigh/	525454
51	"lower extremit*".ti,ab.	120121
52	"lower limb*".ti,ab.	113286
53	(leg or legs).ti,ab.	253578
54	(foot or feet).ti,ab.	247927
55	thigh*.ti,ab.	66607

56	ankle*.ti,ab.	131066
57	(hip or hips).ti,ab.	308309
58	exp Leg Bones/	192712
59	knee*.ti,ab.	317512
60	femur*.ti,ab.	113436
61	tibia*.ti,ab.	181615
62	patella*.ti,ab.	42544
63	talus*.ti,ab.	9625
64	fibula*.ti,ab.	25875
65	calcaneus*.ti,ab.	11336
66	navicular*.ti,ab.	4914
67	cuneiform*.ti,ab.	2979
68	cuboid*.ti,ab.	11139
69	metatarsal*.ti,ab.	18973
70	exp Foot Bones/	36198
71	phalan*.ti,ab.	23235
72	Leg/	134032
73	(toe or toes).ti,ab.	44792
74	exp Toes/	25123
75	pilon*.ti,ab.	5346
76	50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 64 or 63 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75	1699234
77	49 and 76	13043
78	33 and 45 and 46 and 77	111

8.32.3 Search 3. Pain of discomfort

Database(s): Embase 1974 to present, Medline (Ovid MEDLINE® Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®) 1946 to present.

Date searched: 17th of July 2019

#	Searches	Results
1	(instrumentation or methods).fs.	3917553
2	(Validation Studies or Comparative Study).pt.	1911383
3	exp Psychometrics/	157717
4	psychometr*.ti,ab.	95052
5	(clinimetr* or clinometr*).tw.	2434
6	outcome assessment.ti,ab.	8439

7	outcome measure*.tw.	480713
8	exp Observer Variation/	60465
9	observer variation.ti,ab.	2505
10	exp Health Status Indicators/	313309
11	exp Reproducibility of Results/	585822
12	reproducib*.ti,ab.	344805
13	exp Discriminant Analysis/	27787
14	(reliab* or unreliab* or valid* or coefficient or homogeneity or homogeneous or internal consistency).ti,ab.	3004087
15	(cronbach* and (alpha or alphas)).ti,ab.	45760
16	(item and (correlation* or selection* or reduction*)).ti,ab.	48665
17	(agreement or precision or imprecision or precise values or test-retest).ti,ab.	858613
18	(test and retest).ti,ab.	55988
19	(reliab* and (test or retest)).ti,ab.	195420
20	(stability or interrater or inter-rater or intrarater or intra-rater or intertester or inter-tester or intratester or intra-tester or interobserver or inter-observer or intraobserver or intraobserver or intertechnician or inter-technician or intratechnician or intra-technician or interexaminer or inter-examiner or intraexaminer or intra-examiner or interassay or interassay or intraassay or intra-assay or interindividual or inter-individual or intraindividual or intra-individual or interparticipant or inter-participant or intraparticipant or intra-participant or kappa or kappas or repeatab*).ti,ab.	1228152
21	((replicab* or repeated) and (measure or measures or findings or result or results or test or tests)).ti,ab.	455544
22	(generaliza* or generalisa* or concordance).ti,ab.	192314
23	(intraclass and correlation*).ti,ab.	50237
24	(discriminative or known group or factor analysis or factor analyses or dimension* or subscale*).ti,ab.	1282060
25	(multitrait and scaling and (analysis or analyses)).ti,ab.	288
26	(item discriminant or interscale correlation* or error or errors or individual variability).ti,ab.	647775
27	(variability and (analysis or values)).ti,ab.	221443
28	(uncertainty and (measurement or measuring)).ti,ab.	15317
29	(standard error of measurement or sensitiv* or responsive*).ti,ab.	3352813
30	((minimal or minimally or clinical or clinically) and (important or significant or detectable) and (change or difference)).ti,ab.	589426
31	(small* and (real or detectable) and (change or difference)).ti,ab.	17845
32	(meaningful change or ceiling effect or floor effect or Item response model or IRT or Rasch or Differential item functioning or DIF or computer adaptive testing or item bank or cross-cultural equivalence).ti,ab.	29320

33	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32	14437782
34	Musculoskeletal Pain/ or Pain Perception/ or Complex Regional Pain Syndromes/ or Pelvic Pain/ or Back Pain/ or Pain Insensitivity, Congenital/ or Pain, Postoperative/ or Acute Pain/ or Pain, Intractable/ or Abdominal Pain/ or Neck Pain/ or Pain Clinics/ or Pain, Procedural/ or pain*.mp. or Shoulder Pain/ or Patellofemoral Pain Syndrome/ or Chronic Pain/ or Visceral Pain/ or Breakthrough Pain/ or Labor Pain/ or Myofascial Pain Syndromes/ or Pain/ or Nociceptive Pain/ or Pain Measurement/ or Facial Pain/ or Cancer Pain/ or Pain Threshold/ or Low Back Pain/ or Pain Management/ or Chest Pain/	2034319
35	pain*.ti,ab.	1588108
36	ache*.ti,ab.	44628
37	pain measurement.mp. or Pain Measurement/	90470
38	Hyperalgesia.mp. or Hyperalgesia/	40478
39	Hyperalges*.ti,ab.	30912
40	allodyni*.ti,ab.	19866
41	pain perception.mp. or Pain Perception/	45455
42	nocicepti*.ti,ab.	67398
43	vas.ti,ab.	113899
44	visual analog scale*.ti,ab.	57639
45	34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44	2152107
46	(HR-PRO or HRPRO or HRQL or HRQoL or QL or QoL).ti,ab. or quality of life.mp. or (health index* or health indices or health profile*).ti,ab. or health status.mp. or ((patient or self or child or parent or carer or proxy) adj (appraisal* or appraised or report or reported or reporting or rated or rating* or based or assessed or assessment*)).ti,ab. or ((disability or function or functional or functions or subjective or utility or utilities or wellbeing or well being) adj2 (index or indices or instrument or instruments or measure or measures or questionnaire* or profile or profiles or scale or scales or score or scores or status or survey or surveys)).ti,ab.	1716830
47	Fractures, Open/	9003
48	((open or compound or severe* or mangle*) adj3 (fracture* or break*)).ti,ab.	24372
49	47 or 48	27970
50	exp lower extremity/ or exp buttocks/ or exp foot/ or exp hip/ or exp knee/ or exp leg/ or exp thigh/	525454
51	"lower extremit*".ti,ab.	120121
52	"lower limb*".ti,ab.	113286
53	(leg or legs).ti,ab.	253578
54	(foot or feet).ti,ab.	247927
55	thigh*.ti,ab.	66607

56	ankle*.ti,ab.	131066
57	(hip or hips).ti,ab.	308309
58	exp Leg Bones/	192712
59	knee*.ti,ab.	317512
60	femur*.ti,ab.	113436
61	tibia*.ti,ab.	181615
62	patella*.ti,ab.	42544
63	talus*.ti,ab.	9625
64	fibula*.ti,ab.	25875
65	calcaneus*.ti,ab.	11336
66	navicular*.ti,ab.	4914
67	cuneiform*.ti,ab.	2979
68	cuboid*.ti,ab.	11139
69	metatarsal*.ti,ab.	18973
70	exp Foot Bones/	36198
71	phalan*.ti,ab.	23235
72	Leg/	134032
73	(toe or toes).ti,ab.	44792
74	exp Toes/	25123
75	pilon*.ti,ab.	5346
76	50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 64 or 63 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75	1699234
77	49 and 76	13043
78	33 and 45 and 46 and 77	111

8.32.4 Search 4. Quality of life

Database(s): Embase 1974 to present, Medline (Ovid MEDLINE® Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily and Ovid MEDLINE®) 1946 to present.

Date searched: 17th of July 2019

#	Searches	Results
1	(instrumentation or methods).fs.	3917553
2	(Validation Studies or Comparative Study).pt.	1911383
3	exp Psychometrics/	157717
4	psychometr*.ti,ab.	95052
5	(clinimetr* or clinometr*).tw.	2434
6	outcome assessment.ti,ab.	8439

7	outcome measure*.tw.	480713
8	exp Observer Variation/	60465
9	observer variation.ti,ab.	2505
10	exp Health Status Indicators/	313309
11	exp Reproducibility of Results/	585822
12	reproducib*.ti,ab.	344805
13	exp Discriminant Analysis/	27787
14	(reliab* or unreliab* or valid* or coefficient or homogeneity or homogeneous or internal consistency).ti,ab.	3004087
15	(cronbach* and (alpha or alphas)).ti,ab.	45760
16	(item and (correlation* or selection* or reduction*)).ti,ab.	48665
17	(agreement or precision or imprecision or precise values or test-retest).ti,ab.	858613
18	(test and retest).ti,ab.	55988
19	(reliab* and (test or retest)).ti,ab.	195420
20	(stability or interrater or inter-rater or intrarater or intra-rater or intertester or inter-tester or intratester or intra-tester or interobserver or inter-observer or intraobserver or intraobserver or intertechnician or inter-technician or intratechnician or intra-technician or interexaminer or inter-examiner or intraexaminer or intra-examiner or interassay or interassay or intraassay or intra-assay or interindividual or inter-individual or intraindividual or intra-individual or interparticipant or inter-participant or intraparticipant or intra-participant or kappa or kappas or repeatab*).ti,ab.	1228152
21	((replicab* or repeated) and (measure or measures or findings or result or results or test or tests)).ti,ab.	455544
22	(generaliza* or generalisa* or concordance).ti,ab.	192314
23	(intraclass and correlation*).ti,ab.	50237
24	(discriminative or known group or factor analysis or factor analyses or dimension* or subscale*).ti,ab.	1282060
25	(multitrait and scaling and (analysis or analyses)).ti,ab.	288
26	(item discriminant or interscale correlation* or error or errors or individual variability).ti,ab.	647775
27	(variability and (analysis or values)).ti,ab.	221443
28	(uncertainty and (measurement or measuring)).ti,ab.	15317
29	(standard error of measurement or sensitiv* or responsive*).ti,ab.	3352813
30	((minimal or minimally or clinical or clinically) and (important or significant or detectable) and (change or difference)).ti,ab.	589426
31	(small* and (real or detectable) and (change or difference)).ti,ab.	17845
32	(meaningful change or ceiling effect or floor effect or Item response model or IRT or Rasch or Differential item functioning or DIF or computer adaptive testing or item bank or cross-cultural equivalence).ti,ab.	29320

33	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32	14437782
34	(HR-PRO or HRPRO or HRQL or HRQoL or QL or QoL).ti,ab. or quality of life.mp. or (health index* or health indices or health profile*).ti,ab. or health status.mp. or ((patient or self or child or parent or carer or proxy) adj (appraisal* or appraised or report or reported or reporting or rated or rating* or based or assessed or assessment*)).ti,ab. or ((disability or function or functional or functions or subjective or utility or utilities or wellbeing or well being) adj2 (index or indices or instrument or instruments or measure or measures or questionnaire* or profile or profiles or scale or scales or score or scores or status or survey or surveys)).ti,ab.	1716830
35	Fractures, Open/	9003
36	((open or compound or severe* or mangle*) adj3 (fracture* or break*)).ti,ab.	24372
37	35 or 36	27970
38	exp lower extremity/ or exp buttocks/ or exp foot/ or exp hip/ or exp knee/ or exp leg/ or exp thigh/	525454
39	"lower extremit*".ti,ab.	120121
40	"lower limb*".ti,ab.	113286
41	(leg or legs).ti,ab.	253578
42	(foot or feet).ti,ab.	247927
43	thigh*.ti,ab.	66607
44	ankle*.ti,ab.	131066
45	(hip or hips).ti,ab.	308309
46	exp Leg Bones/	192712
47	knee*.ti,ab.	317512
48	femur*.ti,ab.	113436
49	tibia*.ti,ab.	181615
50	patella*.ti,ab.	42544
51	talus*.ti,ab.	9625
52	fibula*.ti,ab.	25875
53	calcaneus*.ti,ab.	11336
54	navicular*.ti,ab.	4914
55	cuneiform*.ti,ab.	2979
56	cuboid*.ti,ab.	11139
57	metatarsal*.ti,ab.	18973
58	exp Foot Bones/	36198
59	phalan*.ti,ab.	23235
60	Leg/	134032
61	(toe or toes).ti,ab.	44792
62	exp Toes/	25123
63	pilon*.ti,ab.	5346

64	38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 52 or 51 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63	1699234
65	37 and 64	13043
66	Quality of Life.mp. or "Quality of Life"/	859704
67	quality of life.ti,ab.	650001
68	life qualit*.ti,ab.	18889
69	living qualit*.ti,ab.	749
70	quality of living.ti,ab.	493
71	Activities of Daily Living.mp. or "Activities of Daily Living"/	153637
72	activities of daily living.ti,ab.	57829
73	activity of daily living.ti,ab.	4663
74	activities of daily life.ti,ab.	2984
75	activity of daily life.ti,ab.	1082
76	daily living activit*.ti,ab.	3094
77	daily life activit*.ti,ab.	3698
78	adl.ti,ab.	24357
79	chronic limitation of activity.ti,ab.	3
80	self care*.ti,ab.	38986
81	Health Status.mp. or Health Status/	296535
82	Health Status.ti,ab.	122055
83	level of health.ti,ab.	9984
84	health level*.ti,ab.	2575
85	qol.ti,ab.	100560
86	hrql.ti,ab.	8780
87	hrqol.ti,ab.	38485
88	activity of daily living.ti,ab.	4663
89	activities of daily life.ti,ab.	2984
90	activity of daily life.ti,ab.	1082
91	daily life activit*.ti,ab.	3698
92	iadl.ti,ab.	6685
93	living qualit*.ti,ab.	749
94	quality of living.ti,ab.	493
95	66 or 67 or 68 or 69 or 70 or 71 or 72 or 73 or 74 or 75 or 76 or 77 or 78 or 79 or 80 or 81 or 82 or 83 or 84 or 85 or 86 or 87 or 88 or 89 or 90 or 91 or 92 or 93 or 94	1266060
96	33 and 34 and 65 and 95	163

8.33 Appendix 33. COSMIN quality assessment tables for the Wales Lower Limb Recovery (WaLLTR) scale.

Source articles assessed for measurement properties:

1. 1. Trickett RW, Mudge E, Price P, Pallister I. The development of a novel patient-derived recovery scale for open tibial fractures. The Bone & Joint Journal. 11 ed. 2020 Jan;102-B(1):17–25.
2. 1. Trickett RW, Mudge E, Price P, Pallister I. A qualitative approach to recovery after open tibial fracture: the road to a novel, patient-derived recovery scale. Injury. 2012 Jul;43(7):1071–8.

8.33.1 Measurement properties assessed/considered in the development of the Wales Lower Limb Recovery (WaLLTR) scale

Assessed/considered	*Content validity*
Yes	Box 1. PROM development
Yes	Box 2. Content validity
	Internal structure
NA	Box 3. Structural validity
Yes	Box 4. Internal consistency
No	Box 5. Cross-cultural validity/measurement invariance
	Remaining measurement properties
Yes	Box 6. Reliability
Yes	Box 7. Measurement error
NA	Box 8. Criterion validity
Yes	Box 9. Hypotheses testing for construct validity
Yes	Box 10. Responsiveness

8.33.2 COSMIN box 1. Standards for evaluating the quality of Wales Lower Limb Recovery (WaLLTR) scale development

Ratings: V= very good; A = adequate; D = doubtful; I = inadequate; N= not applicable	**Wales Lower Limb Recovery (WaLLTR) scale**		
1a. PROM design	References: Studies 1 and 2		
General design requirements	**Rater 1**	**Rater 2**	**Consensus**
1 Is a clear description provided of the construct to be measured?	V	V	V
2 Is the origin of the construct clear: was a theory, conceptual framework or disease model used or clear rationale provided to define the construct to be measured?	V	V	V
3 Is a clear description provided of the target population for which the PROM was developed?	V	V	V
4 Is a clear description provided of the context of use (i.e. discriminative, evaluative purpose, and/or predictive)	V	V	V
5 Was the PROM development study performed in a sample representing the target population for which the PROM was developed?	V	V	V
Concept elicitation (relevance and comprehensiveness)	**Rater 1**	**Rater 2**	**Consensus**
6 Was an appropriate qualitative data collection method used to identify relevant items for a new PROM?	V	V	V

7	Were skilled group moderators/ interviewers used?	V	V	V
8	Were the group meetings or interviews based on an appropriate topic or interview guide?	V	V	V
9	Were the group meetings or interviews recorded and transcribed verbatim?	V	V	V
10	Was an appropriate approach used to analyse the data?	V	V	V
11	Was at least part of the data coded independently?	V	V	V
12	Was data collection continued until saturation was reached?	V	V	V
13	For quantitative studies: was the sample size appropriate?	N	N	N
	SUBTOTAL QUALITY CONCEPT ELICITATION STUDY *Lowest score of items 6-13*	**V**	**V**	**V**
	TOTAL QUALITY OF THE PROM DESIGN *Lowest score of items 1-13*	**V**	**V**	**V**

1b. Cognitive interview study or other pilot test

		Rater 1	**Rater 2**	**Consensus**
14	Was a cognitive interview study or other pilot test performed? *If NO skip items 15-35*	YES	YES	YES
General design requirements		**Rater 1**	**Rater 2**	**Consensus**

15	Was the cognitive interview study or other pilot test performed in a sample representing the target population?	V	V	V
Comprehensibility		**Rater 1**	**Rater 2**	**Consensus**
16	Were patients asked about the comprehensibility of the PROM? *If NO or not clear, skip items 17-25*	D	V	V
		Rater 1	**Rater 2**	**Consensus**
17	Were all items tested in their final form?	V	D	V
18	Was an appropriate qualitative method used to assess the comprehensibility of the PROM instructions, items, response options, and recall period?	D	A	D
19	Was each item tested in an appropriate number of patients?	V	V	V
20	Were skilled interviewers used?	N	N	N
21	Were the interviews based on an appropriate interview guide?	N	N	N
22	Were the interviews recorded and transcribed verbatim?	N	N	N
23	Was an appropriate approach used to analyse the data?	A	A	A
24	Were at least two researchers involved in the analysis?	V	V	V
25	Were problems regarding the comprehensibility of the PROM instructions, items, response options, and recall period appropriately addressed by adapting the PROM?	V	V	V

	SUBTOTAL QUALITY OF COMPREHENSIBILITY STUDY *Lowest score of items 15-25*	D	D	D
Comprehensiveness		**Rater 1**	**Rater 2**	**Consensus**
26	Were patients asked about the comprehensiveness of the PROM? *If NO or not clear, skip items 27-35*	D	D	D
		Rater 1	**Rater 2**	**Consensus**
27	Was the final set of items tested?	-	-	-
28	Was an appropriate method used for assessing the comprehensiveness of the PROM?	-	-	-
29	Was each item tested in an appropriate number of patients?	-	-	-
30	Were skilled interviewers used?	-	-	-
31	Were the interviews based on an appropriate interview guide?	-	-	-
32	Were the interviews recorded and transcribed verbatim?	-	-	-
33	Was an appropriate approach used to analyse the data?	-	-	-
34	Were at least two researchers involved in the analysis?	-	-	-
35	Were problems regarding the comprehensiveness of the PROM appropriately addressed by adapting the PROM?	A	A	A

SUBTOTAL QUALITY OF COMPREHENSIVENESS STUDY *Lowest score of items 15, 26-35*	D	D	D
TOTAL QUALITY OF THE PILOT STUDY *Lowest score of items 14-35*	D	D	D
TOTAL QUALITY OF THE PROM DEVELOPMENT STUDY *Lowest score of items 1-35*	D	D	D

8.33.3 COSMIN box 2. Standards for evaluating the quality of content validity studies of the Wales Lower Limb Recovery (WaLLTR) scale

Trickett *et al.* 2020, surveyed an alpha and beta scale on 35 and 228 participants, respectively, each of which contained additional free test space after each item for participant comments (214). This method could be assumed to have been used by the authors to evaluate the content validity of questionnaire items i.e. allow patients to comment on the relevance, comprehensiveness or compressibility of the WaLLTR items. However, this intention was not directly stated.

		Wales Lower Limb Recovery (WaLLTR) scale		
Score: V= very good; A = adequate; D = doubtful; I = inadequate; N= not applicable		References: Study 1		
2a. Asking patient about relevance		**rater 1**	**rater 2**	**Consensus**
1	Was an appropriate method used to ask patients whether each item is relevant for their experience with the condition?	A	D	A
2	Was each item tested in an appropriate number of patients?	V	D	V
3	Were skilled group moderators/interviewers used?	N	N	N
4	Were the group meetings or interviews based on an appropriate topic or interview guide?	N	N	N

5	Were the group meetings or interviews recorded and transcribed verbatim?	N	N	N
6	Was an appropriate approach used to analyse the data?	A	D	A
7	Were at least two researchers involved in the analysis?	A	A	A
	SUBTOTAL QUALITY OF RELEVANCE STUDY *Lowest score of items 1-7*	**A**	**D**	**A**

2b. Asking patients about comprehensiveness		**rater 1**	**rater 2**	**Consensus**
8	Was an appropriate method used for assessing the comprehensiveness of the PROM?	A	D	A
9	Was each item tested in an appropriate number of patients?	V	D	V
10	Were skilled group moderators/interviewers used?	N	N	N
11	Were the group meetings or interviews based on an appropriate topic or interview guide?	N	N	N
12	Were the group meetings or interviews recorded and transcribed verbatim?	N	N	N
13	Was an appropriate approach used to analyse the data?	A	D	A
14	Were at least two researchers involved in the analysis?	V	D	D
	SUBTOTAL QUALITY OF COMPREHENSIVENESS STUDY *Lowest score of items 8-14*	**A**	**D**	**A**

2c. Asking patients about comprehensibility		**rater 1**	**rater 2**	**Consensus**
15	Was an appropriate qualitative method used for assessing the comprehensibility of the PROM instructions, items, response options, and recall period?	I	D	I
16	Was each item tested in an appropriate number of patients?	V	V	V
17	Were skilled group moderators/interviewers used?	N	N	N
18	Were the group meetings or interviews based on an appropriate topic or interview guide?	N	N	N
19	Were the group meetings or interviews recorded and transcribed verbatim?	N	N	N
20	Was an appropriate approach used to analyse the data?	D	D	D
21	Were at least two researchers involved in the analysis?	V	V	V
	SUBTOTAL QUALITY OF COMPREHENSIBILITY STUDY *Lowest score of items 15-21*	**I**	**D**	**I**

2d. Asking professionals about relevance		**rater 1**	**rater 2**	**Consensus**
22	Was an appropriate method used to ask professionals whether each item is relevant for the construct of interest?	I	D	I
23	Were professionals from all relevant disciplines included?	D	D	D
24	Was each item tested in an appropriate number of professionals?	D	D	D

25	Was an appropriate approach used to analyse the data?	D	D	D
26	Were at least two researchers involved in the analysis?	D	D	D
	SUBTOTAL QUALITY OF RELEVANCE STUDY *Lowest score of items 22-26*	**I**	**D**	**I**

2e. Asking professionals about comprehensiveness		**rater 1**	**rater 2**	**Consensus**
27	Was an appropriate method used for assessing the comprehensiveness of the PROM?	I	D	I
28	Were professionals from all relevant disciplines included?	D	D	D
29	Was each item tested in an appropriate number of professionals?	D	D	D
30	Was an appropriate approach used to analyse the data?	D	D	D
31	Were at least two researchers involved in the analysis?	D	D	D
	SUBTOTAL QUALITY OF COMPREHENSIVENESS STUDY *Lowest score of items 27-31*	**I**	**D**	**I**

8.33.4 Evaluation of PROM development and content validity studies on the Wales Lower Limb Recovery (WaLLTR) scale against the 10 criteria for good measurement properties for content validity and grading for the quality of evidence using the modified GRADE approach.

In the table below the content validity of WaLLTR is rated based on the summary tables above.

The results of all available studies were not quantitively summarised as only one PROM development study with an associated qualitative study has been published for the WaLLTR scale (213,214).

Wales Lower Limb Recovery (WaLLTR) scale		**PROM development study and content validity study 1**					
		RATING			**QUALITY OF EVIDENCE**		
		+ / - / ?			**High, moderate, low, very low**		
Score: + = sufficient; - = insufficient; ? = indeterminate; ± = inconsistent		**rater 1**	**rater 2**	**consensus**	**rater 1**	**rater 2**	**consensus**
Relevance							
1	Are the included items relevant for the construct of interest?	+	+	+			
2	Are the included items relevant for the target population of interest?	+	+	+			
3	Are the included items relevant for the context of use of interest?	+	+	+			
4	Are the response options appropriate?	+	+	+			
5	Is the recall period appropriate?	?	?	?			
	RELEVANCE RATING (+ / - / ± / ?)	**+**	**+**	**+**	**moderate**	**moderate**	**moderate**

Wales Lower Limb Recovery (WaLLTR) scale		**PROM development study and content validity study 1**					
		RATING			**QUALITY OF EVIDENCE**		
		+ / - / ?			**High, moderate, low, very low**		
Score: + = sufficient; - = insufficient; ? = indeterminate; ± = inconsistent		**rater 1**	**rater 2**	**consensus**	**rater 1**	**rater 2**	**consensus**
Comprehensiveness							
6	Are all key concepts included?	?	?	?			
	COMPREHENSIVENESS RATING (+ / - / ± / ?)	**?**	**?**	**?**	**Unable to rate**	**Unable to rate**	**Unable to rate**
Comprehensibility							
7	Are the PROM instructions understood by the population of interest as intended?	-	?	-			
8	Are the PROM items and response options understood by the population of interest as intended?	-	?	-			
9	Are the PROM items appropriately worded?	-	+	-			
10	Do the response options match the question?	-	+	-			
	COMPREHENSIBILITY RATING (+ / - / ± / ?)	**-**	**?**	**-**	**Unable to rate**	**Unable to rate**	**Unable to rate**
	CONTENT VALIDITY RATING (+ / - / ± / ?)	**±**	**?**	**±**	**moderate**	**moderate**	**moderate**

8.33.5 COSMIN boxes 3 to 10. Evaluation of the internal structure of the Wales Lower Limb Recovery (WaLLTR) scale

Score: V= very good; A = adequate; D = doubtful; I = inadequate; N= not applicable	**Wales Lower Limb Recovery (WaLLTR) scale**		
	References: Study 1		
3. Structural validity	**rater 1**	**rater 2**	**Consensus**
1 For CTT: Was exploratory or confirmatory factor analysis performed?	N	N	N
2 For IRT/Rasch: does the chosen model fit to the research question?	N	N	N
3 Was the sample size included in the analysis adequate?	N	N	N
4 Were there any other important flaws?	N	N	N
TOTAL *Lowest score of items 1-4*	N	N	N
The WaLLTR scale appears to be based on a formative model (items together form a construct), as such unidimensionality or structural validity is not relevant			
4. Internal consistency	**rater 1**	**rater 2**	**Consensus**
1 Was an internal consistency statistic calculated for each unidimensional (sub)scale separately?	V	V	V

2	For continuous scores: Was Cronbach's alpha or omega calculated?	V	N	V
3	For dichotomous scores: Was Cronbach's alpha or KR-20 calculated?	N	N	N
4	For IRT-based scores: Was standard error of the theta (SE (θ)) or reliability coefficient of estimated latent trait value (index of (subject or item) separation) calculated?	N	N	N
5	Were there any other important flaws?	V	V	V
	TOTAL *Lowest score of items 1-5*	V	V	V

5. Cross-cultural validity\measurement invariance		**rater 1**	**rater 2**	**Consensus**
1	Were the samples similar for relevant characteristics except for the group variable?	D	D	D
2	Was an adequate approach used to analyse the data?	D	D	D
3	D	D	D	D
4	Were there any other important flaws?	D	D	D
	TOTAL *Lowest score of items 1-4*	D	D	D

6. Reliability		**rater 1**	**rater 2**	**Consensus**
1	Were patients stable in the interim period on the construct to be measured?	A	D	A
2	Was the time interval appropriate?	V	D	V
3	Were the test conditions similar for the measurements? e.g. type of administration, environment, instructions	A	D	A
4	For continuous scores: Was an intraclass correlation coefficient (ICC) calculated?	A	A	A
5	For dichotomous/nominal/ordinal scores: Was kappa calculated?	N	N	N
6	For ordinal scores: Was a weighted kappa calculated?	N	N	N
7	For ordinal scores: Was the weighting scheme described? e.g. linear, quadratic	N	N	N
8	Were there any other important flaws?	V	V	V
	TOTAL *Lowest score of items 1-8*	A	A	A

7. Measurement error		**rater 1**	**rater 2**	**Consensus**
1	Were patients stable in the interim period on the construct to be measured?	A	A	A

2	Was the time interval appropriate?	V	D	V
3	Were the test conditions similar for the measurements? e.g. type of administration, environment, instructions	A	A	A
4	For continuous scores: Was the Standard Error of Measurement (SEM), Smallest Detectable Change (SDC) or Limits of Agreement (LoA) calculated?	I	I	I
5	For dichotomous/nominal/ordinal scores: Was the percentage (positive and negative) agreement calculated?	N	N	N
6	Were there any other important flaws?	D	D	V
	TOTAL *Lowest score of items 1-6*	I	I	I

8. Criterion validity		**rater 1**	**rater 2**	**Consensus**
1	For continuous scores: Were correlations, or the area under the receiver operating curve calculated?	N	N	N
2	For dichotomous scores: Were sensitivity and specificity determined?	N	N	N
3	Were there any other important flaws?	N	N	N
	TOTAL *Lowest score of items 1-3*	N	N	N

9. Hypotheses testing for construct validity				
9a. Comparison with other outcome measurement instruments (convergent validity)		**rater 1**	**rater 2**	**Consensus**
1	Is it clear what the comparator instrument(s) measure(s)?	N	N	N
2	Were the measurement properties of the comparator instrument(s) adequate?	N	N	N
3	Was the statistical method appropriate for the hypotheses to be tested?	N	N	N
4	Were there any other important flaws?	N	N	N
	TOTAL *Lowest score of items 1-4*	N	N	N
9b. Comparison between subgroups (discriminative or known-groups validity)		**rater 1**	**rater 2**	**Consensus**
5	Was an adequate description provided of important characteristics of the subgroups?	A	A	A
6	Was the statistical method appropriate for the hypotheses to be tested?	A	A	A
7	Were there any other important flaws?	V	V	V
	TOTAL *Lowest score of items 5-7*	A	A	A

10. Responsiveness			
10a. Criterion approach (i.e. comparison to a gold standard)	**rater 1**	**rater 2**	**Consensus**
1 For continuous scores: Were correlations between change scores, or the area under the Receiver Operator Curve (ROC) curve calculated?	N	N	N
2 For dichotomous scales: Were sensitivity and specificity (changed versus not changed) determined?	N	N	N
3 Were there any other important flaws?	N	N	N
TOTAL *Lowest score of items 1-3*	N	N	N
10b. Construct approach (i.e. hypotheses testing; comparison with other outcome measurement instruments)	**rater 1**	**rater 2**	**Consensus**
4 Is it clear what the comparator instrument(s) measure(s)?	N	N	N
5 Were the measurement properties of the comparator instrument(s) adequate?	N	N	N
6 Was the statistical method appropriate for the hypotheses to be tested?	N	N	N
7 Were there any other important flaws?	N	N	N

	TOTAL *Lowest score of items 4-7*	N	N	N
10c. Construct approach: (i.e. hypotheses testing: comparison between subgroups)		**rater 1**	**rater 2**	**Consensus**
8	Was an adequate description provided of important characteristics of the subgroups?	V	V	V
9	Was the statistical method appropriate for the hypotheses to be tested?	V	V	V
10	Were there any other important flaws?	V	V	V
	TOTAL *Lowest score of items 8-10*	V	V	V
10d. Construct approach: (i.e. hypotheses testing: before and after intervention)		**rater 1**	**rater 2**	**Consensus**
11	Was an adequate description provided of the intervention given?	N	N	N
12	Was the statistical method appropriate for the hypotheses to be tested?	N	N	N
13	Were there any other important flaws?	N	N	N
	TOTAL *Lowest score of items 11-13*	N	N	N

8.33.6 Evaluation of PROM development and content validity studies on the Wales Lower Limb Recovery (WaLLTR) scale against the updated criteria for good measurement properties

Wales Lower Limb Recovery (WaLLTR) scale	**PROM development study and content validity study 1**					
	RATING			**QUALITY OF EVIDENCE**		
Score: + = sufficient; - = insufficient; ? = indeterminate; ± = inconsistent	**+ / - / ?**			**High, moderate, low, very low**		
	rater 1	**rater 2**	**consensus**	**rater 1**	**rater 2**	**consensus**
Structural validity	Not applicable					
Internal consistency	+	+	+	High	High	High
Cross-cultural validity/measurement invariance	?	?	?	Very low	Very low	Very low
Reliability	+	+	+	Moderate	Moderate	Moderate
Measurement error	-	-	-	Very low	Very low	Very low
Criterion validity	Not undertaken					
Hypothesis testing for construct validity	+	+	+	Moderate	Moderate	Moderate
Responsiveness	+	+	+	High	High	High

8.34 Appendix 34. Outcome Measurement Instruments not validated in target population assessed for inclusion at the COMIS consensus meeting.

Key	
Included	Shaded green
Rejected	Shaded red

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
	Adverse events outcome measurement instruments	**Includes outcomes broadly labelled as some form of unintended consequence (e.g. adverse events/effects, adverse reactions, safety, harm, negative effects, toxicity, complications, sequelae). Specifically named adverse events should be classified within the appropriate taxonomy domain above with an additional level of categorisation which identifies that this outcome is being considered as an adverse event.**						
1	Definitions of complications		18					Core outcome not measured
2	Definitions of flap complications		15					Core outcome not measured

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
	Death outcome measurement instruments	**Includes overall (all-cause) survival/mortality and cause-specific survival/mortality, as well as composite survival outcomes that include death (e.g. disease-free survival, progression-free survival, amputation-free survival)**						
3	Charlson co-morbidity index (323)	Physician reported outcome measurement instrument used to predict 10-year survival in patients with multiple co-morbidities.	1					Core outcome not measured
4	Definitions of mortality		3					Core outcome not measured
	Life impact outcome measurement instruments							
	Delivery of care outcome measurement instruments	Includes outcomes relating to the delivery of care, including - adherence/compliance - patient preference - tolerability/acceptability of intervention - withdrawal from intervention (e.g. time to treatment failure, reason for stopping therapy) - appropriateness of intervention - accessibility, quality and adequacy of intervention - patient/carer satisfaction (emotional rather than financial burden) - process, implementation and service outcomes						

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
	Satisfaction outcome measurement instruments							
5	Definitions of satisfaction		1					Core outcome not measured
6	The Patient Satisfaction Questionnaire Short Form (PSQ-18) (361)	Patient-reported outcome measurement instrument assessing satisfaction in the following domains: 1. general satisfaction 2. technical quality 3. interpersonal manner 4. communication 5. financial aspects 6. time spent with doctor 7. accessibility and convenience	1					Core outcome not measured
7	Visual Analogue scale for satisfaction (362)	Patient-reported outcome measurement instruments assessing satisfaction on a	1					Core outcome not measured

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		continuous scale (0-100mm). Novel score only used in citing study.						
	Global quality of life outcome measurement instruments	Includes only implicit composite outcomes measuring global quality of life.						
8	Health related quality of life outcome measurement instruments							
9	EuroQol 5-Dimensions 3-Level (EQ-5D-3L) (277)	The EQ-5D-3L descriptive system comprises the following five dimensions: 1. mobility 2. self-care 3. usual activities 4. pain/discomfort 5. anxiety/depression Each dimension has 3 levels: no problems, some problems, and extreme problems. The patient is asked to	2	AA HC	AA HC	AA HC	AA HC	Included

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		indicate his/her health state by ticking the box next to the most appropriate statement in each of the five dimensions.						
10	EuroQol 5-Dimensions 5-Level (EQ-5D-5L) (200)	Patient-reported outcome measurement instrument. The descriptive system comprises five dimensions: 1. mobility 2. self-care 3. usual activities 4. pain/discomfort 5. anxiety/depression Each dimension has 5 levels: no problems, slight problems, moderate problems, severe problems and extreme problems. The patient is asked to indicate his/her health state by ticking the box next to the most appropriate statement in each of the five dimensions.	6	AA HC	AA HC	AA HC	AA HC	Included

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
11	Short Form-12 (SF-12) (281)	Patient-reported outcome measurement instrument. Assessing the following domains: 1. physical functioning 2. role-physical 3. bodily pain 4. general health 5. vitality 6. social functioning 7. role-emotional 8. mental Health	5	AA HC	HC	AA HC	AA HC	Included
12	Short Form-36 (SF-36) (165)	Patient-reported outcome measurement instrument. Assessing the following domains: 1. physical functioning 2. role-physical 3. bodily pain	17	AA HC	AA HC	AA HC	AA HC	Included

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		4. general health 5. vitality 6. social functioning 7. role-emotional 8. mental Health						
13	Short Form-6 Dimensions (SF-6D) (359)	Patient-reported outcome measurement instrument. Assessing the following domains: 1. physical functioning 2. role limitations 3. social functioning 4. pain 5. mental health 6. vitality	1	AA HC	HC	AA HC	AA HC	Used only once in the literature
14	Sickness Impact Profile (SIP) (202,203)	Patient-reported outcome measurement instrument to assess perceived health	5	AA	AA HC	AA HC	AA HC	Included

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		status. The full-length SIP consists of 136 items within 12 domains: 1. sleep and rest 2. eating 3. work 4. home management 5. recreation and pastimes 6. ambulation 7. mobility 8. body care and movement 9. social interaction 10. alertness behaviour 11. emotional behaviour 12. communication						
15	Veterans Affairs System of Rating Disabilities (360)	Physician/technician reported outcome measurement instrument used to assess the level of disability for calculation of	2	NA	NA	NA	NA	Unfeasible – physician/ technician reported

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		disability compensation. Each body system is assessed separately for the level of disability, and a combined score is generated.						
16	Veterans RAND 12 Item Health Survey (VR-12) (331)	Patient-reported outcome measurement instrument assesses domains: 1. general health perceptions 2. physical functioning 3. role physical 4. role emotional 5. bodily pain 6. vitality/mental health 7. social functioning 8. change physical 9. change emotional	1	AA HC		AA HC	AA HC	Not applicable to whole of UK open fracture population (i.e. developed for veterans)

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
	Physiological or clinical outcome measurement instruments	Physiological/clinical outcomes include measures of physiological function, signs and symptoms, as well as laboratory (and other scientific) measures relating to physiology and are categorised according to the underlying cause/body system.						
	Musculoskeletal and connective tissue outcome measurement instruments							
17	American Orthopedics Foot and Ankle Society (AOFAS) ankle-hindfoot scale (199)	Patient and clinically reported outcome measurement instrument. Response domains include: 1. pain 2. functional limitation on recreational and daily activities 3. maximum walking distance in blocks 4. walking ability on different surfaces 5. Gait abnormality 6. Sagittal motion 7. hindfoot motion	23	AA HC	AA HC			scale specific to ankle and hindfoot Unfeasible – clinician-reported component to scale

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		8. ankle -hindfoot stability 9. Alignment						
	Appearance outcome measurement instruments							
18	Cosmetic outcome score by O'Toole *et al*. (357)	Patient-reported outcome measurement instrument to assess satisfaction. The patient's cosmetic outcome score was based on the question, ''How satisfied are you with the appearance of your injured leg or artificial leg?'' Participants were asked to respond to each question by using a 5-point scale of descriptors that included ''not at all satisfied,'' ''slightly satisfied,'' ''moderately satisfied,'' ''very satisfied,'' and ''completely satisfied.'' This was a novel instrument only cited in this study	1					Core outcome not measured
19	Vancouver scar scale (358)	Physician reported OMI to assess scare scars and burns. Assessment areas:	1					Core outcome not measured

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		1. Vascularity 2. Height/thickness 3. pliability 4. pigmentation						
20	Association for the Study and Application of the Methods of Ilizarov (ASAMI) criteria (198)	Physician reported outcome measurement instrument. The ASAMI criteria assess two domains: 1. bone results (union, infection, deformity, re-fracture and limb length discrepancy) 2. functional results (active walking, limp, stiffness, knee extension, ankle doors flexion, reflex sympathetic dystrophy, pain, amputation, employment and return to activities of daily living)	24	AA HC	HC	AA HC		Unfeasible – physician/ technician reported
	Bone outcome measurement instruments							

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
21	Definitions of bone union		50					Core outcome not measured
22	Definitions of clinical union		6					Core outcome not measured
23	Definitions of malunion		20					Core outcome not measured
24	Definitions of non-union		16					Core outcome not measured
25	Definitions of radiographic bone union		33					Core outcome not measured
26	Chen grading system (329)	Physician reported outcome measurement instrument to grade the functional status of the lower limb. Domains covered include: 1. return to previous work 2. walking with a normal gait	1		AA HC	AA HC		Unfeasible – physician/ technician reported

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		3. range of movement of the knee and ankle 4. sensation 5. trophic ulcers						
27	Definitions of amputation		5					Core outcome not measured
28	Definitions of pin site loosening		1					Core outcome not measured
29	Disability Rating Index (DRI) (282,283)	Patient-reported outcome measurement instrument assessing the level of disability. It consists of 3 domains with the following 12 response items: 1. basic activities of daily life: dressing, outdoor walks, climbing stairs and sitting a long time. 2. daily physical activities: standing bent over a sink, carrying a bag, making a bed and running.	3		AA HC			Included

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		3. work-related/more vigorous activities: light work, heavy work, lifting heavy objects and participating in exercise/sports.						
30	Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire (330)	Patient-reported outcome measurement instrument specific to the upper-extremity. The DASH is a 30 item symptom scale delivered over 3 domains: 1. degree of difficulty in performing different physical activities because of the arm, shoulder, or hand problem (21 items) 2. the severity of each of the symptoms of pain, activity-related pain, tingling, weakness and stiffness (5 items) 3. the problem's impact on social activities, work, sleep, and self-image (4 items)	3			HC		Scale specific to upper extremity

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
31	Enneking score (180)	Physician reported outcome measurement instrument that includes functional assessment measures. It assesses: 1. pain 2. function 3. emotional acceptance 4. supports (walking aids) 5. walking 6. gait	5	AA HC	AA HC			Unfeasible – physician/ technician reported
32	External fixation index (EFI) (324)	Physician reported outcome measurement instrument. The EFI was calculated by dividing the time (days) in the external fixator by the lengthening achieved (centimeters).	1					Unfeasible – physician/ technician reported
33	Frequency intensity time (FIT) index (331)	Patient-reported outcome measurement instrument assessing a person's level of physical activity over 3 domains:	1					No CO concept

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		1. frequency of exercise 2. intensity of exercise 3. time spent on workout						
34	Functional outcome criteria by Tu *et al*. 1995 (332)	Physician reported outcome measurement instrument assessing functional outcome following open lower limb fractures in the following domains: 1. pain 2. range of motion 3. ability to return to normal work	1	AA HC		AA HC		Unfeasible – physician/ technician reported
35	Hamlyn Mobility Score (HMS) (208)	Physical performance and patient-reported outcome measurement instrument to assess the physical performance of patients doing a timed 6-minute walk test, timed up and downstairs test and a timed up and go test. Standard test metrics are recorded, e.g. time and distance with the addition of estimated step variation using a ear-	1	AA HC	AA HC	AA HC		Unfeasible – physician/ technician reported objective physical performance measure

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		worn accelerometer. The HMS also consists of 4 questions assessing: 1. use of mobility aids 2. participation in work and leisure activities 3. satisfaction with walking 4. pain						
36	Hospital for Special Surgery (HSS) knee scoring system (333,334)	Physician reported outcome measurement instrument to assess outcome after knee replacement surgery. The HSS knee score assesses 7 domains: 1. pain (rest pain, support required because of pain) 2. stability (measured as total varus-valgus arc, extension) 3. motion (measured as total passive arc)	1	AA HC				Scale specific to the knee

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		4. quadriceps strength (measured as a percentage of normal for age and gender) 5. subtractions (for extension lag, flexion contracture, fixed varus or valgus deformity)						
	Infection outcome measurement instruments							
37	Definitions of deep infection		31					Core outcome not measured
38	Definitions of deep Wound Infection		5					Core outcome not measured
39	Definitions of infected implant		1					Core outcome not measured
40	Definitions of Infection		45					Core outcome not measured

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
41	Definitions of joint sepsis		3					Core outcome not measured
42	Definitions of osteomyelitis		11					Core outcome not measured
43	Definitions of pin site infection		4					Core outcome not measured
44	Definitions of recurrent infection		1					Core outcome not measured
45	Definitions of wound infection		11					Core outcome not measured
	Injury severity outcome measurement instruments	0						
46	Injury Severity Score (ISS) (363,364)	Physician reported outcome measurement instrument to assess the severity of injury over 6 body domains:	2					Core outcome not measured

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		1. head and neck 2. face 3. chest 4. abdomen 5. extremity (including pelvis) 6. external						
47	Mangled Extremity Severity Score (MESS) (365,366)	Physician reported outcome measurement instrument. Used to estimate the viability of an extremity after trauma. It assesses the following domains: 1. limb ischemia for greater than 6 hours 2. limb ischemia 3. patient age 4. shock 5. Injury mechanism	4					Core outcome not measured

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
48	Iowa ankle-evaluation rating system (335)	Physician reported outcome measurement instrument assessing the function of the ankle. Domains assessed include: 1. function (housework or job, stair climbing, carrying heavy objects, ability to run, participate in athletics or heavy labour, walking independently, able to do garden work, difficulty getting in and out of a car) 2. pain 3. gait 4. range of motion	5	AA HC	AA HC	HC		Scale specific to the ankle Unfeasible – physician/ technician reported
49	Johner-Wruhs evaluation (336)	Physician reported outcome measurement instrument assessing surgical outcome following a tibial fracture. Domains assessed: 1. bone union, osteitis or amputation 2. neurovascular disturbances	10	AA HC	AA HC			Unfeasible – physician/ technician reported

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		3. bone deformity 4. range of motion 5. pain 6. gait 7. Participation in strenuous activities						
50	Lower Extremity Functional Scale (LEFS) (166)	Patient-reported outcome measurement instrument to assess a broad range of lower-extremity orthopaedic conditions including the hip, knee, leg ankle or foot. The LFES contains 20-items specifically assessing the International Classification of Functioning, Disability, and Health model (ICF) domains of activity and participation.	3		AA HC	AA HC		Included
51	Lysholm Knee Scale (337)	Patient-reported outcome measurement instrument to assess knee function. Is assess 8 domains including: 1. limp	1	AA HC	AA HC			Scale specific to the knee

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		2. walking support 3. pain 4. instability 5. locking 6. swelling 7. stair-climbing 8. squatting						
52	Maryland foot score (MFS) (338)	Patient and Physician reported outcome measurement instrument to assess foot injuries. Domains include: 1. pain 2. function (gait, distance walked, stability, support, limp and wearing shoes)	3	AA HC	AA HC			Unfeasible – physician/ technician reported component Scale specific to the foot
53	Mazur ankle function evaluation (339)	Patient and physician reported outcome measurement instrument to assess	1	AA HC	AA HC			Unfeasible – physician/ technician reported component

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		ankle function over 12 response items in 2 domains: 1. pain 2. function (limp, walking distance, support, hills up, hills down, stairs up, stairs down, ability to rise on toes, running, range of motion, plantar flexion)						Scale specific to the ankle
54	Musculoskeletal Function Assessment (MFA) (340-342)	Patient-reported outcome measurement instrument assessing musculoskeletal function consisting of 100 response items over the following domains: 1. mobility 2. hand and fine motor 3. housework 4. self-care 5. sleep and rest 6. leisure and recreation 7. family relationships	1	AA HC	AA HC	AA HC		Used only once in the literature

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		8. cognition and thinking 9. emotional adjustment and adaptation 10. employment						
55	Neer knee score (343,344)	Physician reported outcome measurement instrument to assess knee function following a supracondylar fracture. The following domains are assessed: 1. pain 2. function (as before injury, mild restriction, restricted; stairs sideways, cane or severe restriction, crutches or brace) 3. range of motion 4. work 5. gross anatomy 6. roentgenogram	2	AA HC	HC	AA HC		Unfeasible: physician/ technician reported component Scale specific to the knee

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
	Objective physical performance outcome measurement instruments							
56	6-minute walk test (204)	Objective physical performance measurement instrument used to assess functional exercise capacity. the 6 minute walk test measures the distance an individual is able to walk over a total of 6 minutes on a hard, flat surface.	2		AA HC			Unfeasible – physician/ technician reported physical objective measure
57	Definitions of range of movement outcome measurement instruments		6					Unfeasible – physician/ technician reported
58	Timed up and downstairs (206,345)	Objective physical performance measurement instrument to assess physical performance by measuring the time taken to ascend and descend a flight of stairs consisting of 14 steps.	1		AA HC			Unfeasible – physician/ technician reported physical objective measure

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
59	Timed up and go test (207)	Objective physical performance measurement instrument to determine fall risk and measure the progress of balance, sit to stand and walking. An individual is timed standing up from a chair with an armrest, walking 3m, turning around, walking back and sitting down again	1		AA HC			Unfeasible – physician/ technician reported physical objective measure
60	Timed walk test (346)	Objective physical performance measurement instrument to assess mobility by timing a patient to walk 30.5m	1		AA HC			Unfeasible – physician/ technician reported physical objective measure
	Pain outcome measurement instruments							
61	Brief Pain Inventory (BPI) (286)	Patient-reported outcome measurement instrument assessing the severity of a patient's pain and the impact of this pain on the patient's daily functioning. The	2	AA HC				Included

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		BPI consists of 9 items assessing the following: 1. pain other than every day kind of pains 2. location of pain (shading diagram) 3. worst pain in the last 24-hours 4. least worst pain in the last 24-hours 5. Pain on average 6. Pain right now 7. treatments/medications for pain 8. relief of pain from treatment/medication 9. pain interference in the last 24 hours (general activity, mood, walking ability, normal work, relations with other people, sleep, enjoyment of life)						
62	Visual Analogue Scale for Pain (VAS) (287)	Patient-reported outcome measurement instrument to assess pain. The VAS is a unidimensional measure of pain	6	AA HC				Included

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		intensity. Often assessed on a 0-100mm scale.						
63	Olerud and Molander scoring system (347)	Patient-reported outcome measurement instrument assessing symptoms after ankle fracture in 9 domains: 1. pain 2. stiffness 3. swelling 4. stair climbing 5. running 6. jumping 7. squatting 8. supports 9. work and activities of daily living	1	AA HC	AA HC	AA HC		Scale specific to the ankle
64	Paley Criteria (348-350)	Physician reported outcome measurement instrument assessing	12	AA HC	AA HC	AA HC		Unfeasible – physician/ technician reported

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		bone and functional outcomes of the lower leg. Domains assessed: 1. Bone (consolidation, absence of infection, axial defect, limb-length discrepancy, docking site and osteogenesis zone consolidation solid enough not to require protection, non-union and bone infection) 2. Function (pain free, walking, joint stiffness, talocrural or subtalar motion, use of analgesia, and activities of daily living)						
65	Sanders knee score (351,352)	Physician reported outcome measurement instrument assessing knee function following distal femoral fracture assessing the following domains: 1. Range of movement 2. Pain 3. Deformity	1	AA HC	AA HC	AA HC		1. Unfeasible – physician/ technician reported component 2. Scale specific to the knee

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		4. walking ability (walking and stair climbing) 5. return to work (employment/return to pre-injury functioning)						
66	Severn scale scoring system by Puno *et al*. (353)	Physician reported outcome measurement instrument assessing limb salvaged limb function in the following domains: 1. pain 2. activities of daily living 3. range of motion at the ankle and knee 4. residual deformity 5. radiological examination of degenerative joint changes and alignment 6. muscle strength of the foot 7. sensation	7	AA HC	AA HC			Unfeasible – physician/ technician reported component

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
67	Short Musculoskeletal Function Assessment Questionnaire (SMFA) (284)	Patient-reported outcome measurement instrument assessing musculoskeletal function consisting of 46 items reduced from 101 in the MFA. There are two parts to the SMFA: 1. dysfunction index (34 items assessing patient perceptions of functional performance in 4 categories including daily activities, emotional status, function of the arm and hand and mobility) 2. bother index (12 items assessing broad functional areas including recreation and leisure, sleep and rest, work and family)	3	AA HC	AA HC	AA HC		
68	The knee society clinical rating system (354)	physician and patient-reported outcome measurement instrument assessing: 1. pain (on walking and climbing stairs) 2. range of motion 3. stability (medial/lateral and anterior/posterior)	4	AA HC	AA HC			1. Unfeasible – physician/ technician reported component 2. Scale specific to the knee

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		4. deductions for extension lag, flexion contracture, malalignment and pain at rest						
69	Visual Analogue Scale Foot and Ankle (VAS FA) (355,356)	Patient-reported outcome measurement instrument to assess the foot and ankle in the following domains: 1. pain 2. function 3. other complaints	1	AA HC	AA HC	AA HC		Scale specific to the foot and ankle
	Nervous system outcome measurement instruments							
70	Oxford MRC score (325)	Physician reported OMI to assess muscle strength. Response items: 1. flicker of movement 2. through full range actively with gravity counter balanced	2					Core outcome not measured

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
		3. through full range actively against gravity 4. through full range actively against some resistance 5. through full range actively against strong resistance						
	Psychiatric outcome measurement instruments							
	Depression outcome measurement instruments							
71	Patient Health Questionnaire (PHQ-9) (327)	Patient-reported outcome measurement instrument measuring depression against 9 domains for depression taken from the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition.	1					Core outcome not measured

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
	Post-traumatic stress disorder outcome measurement instruments							
72	Post-traumatic Stress Disorder (PTSD) Checklist (328)	Patient-reported outcome measurement instrument assessing the severity of PTSD symptoms. The checklist has 17 response items based on the Diagnostic and Statistical Manual of Mental Disorders-IV criteria for PTSD.	1					Core outcome not measured
	Stress outcome measurement instruments							
73	Definitions of physical and mental stress		1					Core outcome not measured
	Renal and urinary outcome measurement instruments							

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
	Acute Kidney Injury outcome measurement instruments							
74	Definitions of acute kidney injury		2					Core outcome not measured
75	RIFLE Criteria (326)	Physician reported OMI assessing acute kidney injury Assessment areas: 1. Risk of kidney injury 2. Injury to kidney 3. Failure of kidney 4. Loss of kidney function 5. End-stage kidney disease	1					Core outcome not measured
	Economic outcome measurement instruments	Economic: general outcomes (e.g. cost, resource use) not captured within other specific resource use domains.						
76	Definitions of cost		10					Core outcome not measured

	OMI items assessed by Dr Alex Aquilina (AA) and Dr Harry Claireaux (HC) for having face validity in measuring core outcomes							
	Name	Description	Frequency of use	Pain	Walking, gait and mobility	Being able to return to life roles	Quality of life	Reason for rejection
	Hospital outcome measurement instruments	Hospital: outcomes relating to inpatient or day case hospital care (e.g. duration of hospital stay, admission to ICU)						
	Need for intervention outcome measurement instruments	Outcomes relating to medication (e.g. concomitant medications, pain relief), surgery (e.g. caesarean delivery, time to transplantation) and other procedures (e.g. dialysis-free survival, mode of delivery)						
77	Definitions of reoperation		10					Core outcome not measured
	Social or career burden outcome measurement instruments	Outcomes relating to financial or time implications on carer or society as a whole (e.g. need for home help, entry to institutional care, effect on family income)						

8.35 Appendix 35. Physical format of OMIs assessed at the COMIS consensus meeting.

8.35.1 EuroQol 5-Dimensions 3-Levels (EQ-5D-3L) (277)

Health Questionnaire

English version for the UK

(Validated for Ireland)

Sample

UK (English) © 1990 EuroQol Group EQ-5D™ is a trade mark of the EuroQol Group

By placing a tick in one box in each group below, please indicate which statements best describe your own health state today.

Mobility

I have no problems in walking about ❑

I have some problems in walking about ❑

I am confined to bed ❑

Self-Care

I have no problems with self-care ❑

I have some problems washing or dressing myself ❑

I am unable to wash or dress myself ❑

Usual Activities *(e.g. work, study, housework, family or leisure activities)*

I have no problems with performing my usual activities ❑

I have some problems with performing my usual activities ❑

I am unable to perform my usual activities ❑

Pain / Discomfort

I have no pain or discomfort ❑

I have moderate pain or discomfort ❑

I have extreme pain or discomfort ❑

Anxiety / Depression

I am not anxious or depressed ❑

I am moderately anxious or depressed ❑

I am extremely anxious or depressed ❑

Sample

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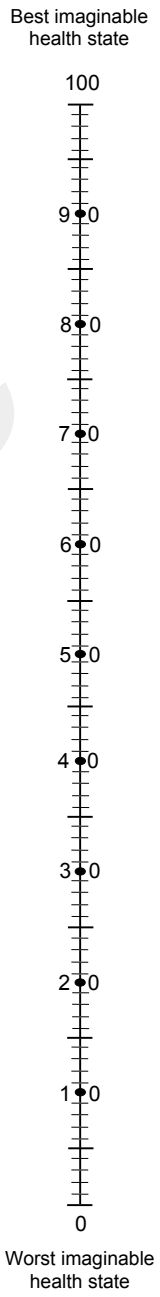
To help people say how good or bad a health state is, we have drawn a scale (rather like a thermometer) on which the best state you can imagine is marked 100 and the worst state you can imagine is marked 0.

We would like you to indicate on this scale how good or bad your own health is today, in your opinion. Please do this by drawing a line from the box below to whichever point on the scale indicates how good or bad your health state is today.

Your own health state today



Sample

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8.35.2 EuroQol 5-Dimensions 5-Level (EQ-5D-5L) (200)

Health Questionnaire

English version for the UK

Sample

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Under each heading, please tick the ONE box that best describes your health TODAY.

MOBILITY

I have no problems in walking about ❑
I have slight problems in walking about ❑
I have moderate problems in walking about ❑
I have severe problems in walking about ❑
I am unable to walk about ❑

SELF-CARE

I have no problems washing or dressing myself ❑
I have slight problems washing or dressing myself ❑
I have moderate problems washing or dressing myself ❑
I have severe problems washing or dressing myself ❑
I am unable to wash or dress myself ❑

USUAL ACTIVITIES *(e.g. work, study, housework, family or leisure activities)*

I have no problems doing my usual activities ❑
I have slight problems doing my usual activities ❑
I have moderate problems doing my usual activities ❑
I have severe problems doing my usual activities ❑
I am unable to do my usual activities ❑

PAIN / DISCOMFORT

I have no pain or discomfort ❑
I have slight pain or discomfort ❑
I have moderate pain or discomfort ❑
I have severe pain or discomfort ❑
I have extreme pain or discomfort ❑

ANXIETY / DEPRESSION

I am not anxious or depressed ❑
I am slightly anxious or depressed ❑
I am moderately anxious or depressed ❑
I am severely anxious or depressed ❑
I am extremely anxious or depressed ❑

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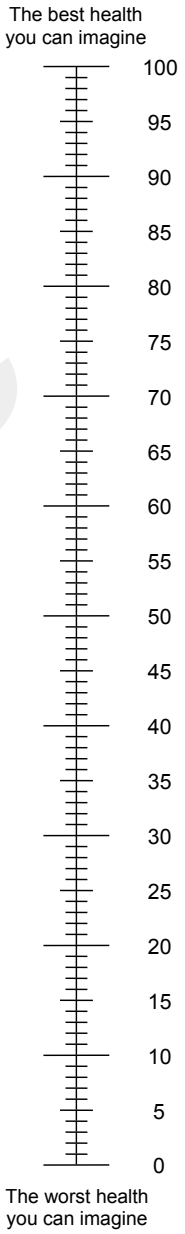
Sample

- We would like to know how good or bad your health is TODAY.
- This scale is numbered from 0 to 100.
- 100 means the best health you can imagine.
  0 means the worst health you can imagine.
- Mark an X on the scale to indicate how your health is TODAY.
- Now, please write the number you marked on the scale in the box below.

YOUR HEALTH TODAY = ☐



Sample

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8.35.3 Short Form-12 (SF-12) (281)

SF-12® Patient Questionnaire

Patient Initials _____ _____ _____ **Date of Birth:** ___/___/___ **Patkey:** _____

Surgeon Name: _____ **Date:** _____

Examination Period:
_____ Preop (1)
_____ Immediate Postop (2)
_____ 1 Year (3)
_____ 3 Year (4)
_____ 5 Year (5)
_____ Other (specify) (6): _____

SF-12®:
This information will help your doctors keep track of how you feel and how well you are able to do your usual activities. Answer every question by placing a check mark on the line in front of the appropriate answer. It is not specific for arthritis. If you are unsure about how to answer a question, please give the best answer you can and make a written comment beside your answer.

1. In general, would you say your health is:
   _____ Excellent (1)
   _____ Very Good (2)
   _____ Good (3)
   _____ Fair (4)
   _____ Poor (5)

The following two questions are about activities you might do during a typical day. Does YOUR HEALTH NOW LIMIT YOU in these activities? If so, how much?

2. MODERATE ACTIVITIES, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf:
   _____ Yes, Limited A Lot (1)
   _____ Yes, Limited A Little (2)
   _____ No, Not Limited At All (3)

3. Climbing SEVERAL flights of stairs:
   _____ Yes, Limited A Lot (1)
   _____ Yes, Limited A Little (2)
   _____ No, Not Limited At All (3)

During the PAST 4 WEEKS have you had any of the following problems with your work or other regular activities AS A RESULT OF YOUR PHYSICAL HEALTH?

4. ACCOMPLISHED LESS than you would like:
   _____ Yes (1)
   _____ No (2)

5. Were limited in the KIND of work or other activities:
   _____ Yes (1)
   _____ No (2)

Surgeon Initials _____ **Date:** _____

SF-12®

Patient Initials _____ _____ _____ **Date of Birth:** ___/___/___ **Patkey:** _____

Surgeon Name: _____ **Date:** _____

Examination Period:
_____ Preop (1)
_____ Immediate Postop (2)
_____ 1 Year (3)
_____ 3 Year (4)
_____ 5 Year (5)
_____ Other (specify) (6): _____

SF-12® Cont'd:

During the PAST 4 WEEKS, were you limited in the kind of work you do or other regular activities AS A RESULT OF ANY EMOTIONAL PROBLEMS (such as feeling depressed or anxious)?

6. ACCOMPLISHED LESS than you would like:
   _____ Yes (1)
   _____ No (2)

7. Didn't do work or other activities as CAREFULLY as usual:
   _____ Yes (1)
   _____ No (2)

8. During the PAST 4 WEEKS, how much did PAIN interfere with your normal work (including both work outside the home and housework)?
   _____ Not At All (1)
   _____ A Little Bit (2)
   _____ Moderately (3)
   _____ Quite A Bit (4)
   _____ Extremely (5)

The next three questions are about how you feel and how things have been DURING THE PAST 4 WEEKS. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the PAST 4 WEEKS –

9. Have you felt calm and peaceful?
   _____ All of the Time (1)
   _____ Most of the Time (2)
   _____ A Good Bit of the Time (3)
   _____ Some of the Time (4)
   _____ A Little of the Time (5)
   _____ None of the Time (6)

Surgeon Initials _____ **Date:** _____

SF-12® Page 3 of 3

Patient Initials _____ _____ _____ **Date of Birth:** ___/___/___ **Patkey:** _____

Surgeon Name: _____ **Date:** _____

Examination Period:
_____ Preop (1)
_____ Immediate Postop (2)
_____ 1 Year (3)
_____ 3 Year (4)
_____ 5 Year (5)
_____ Other (specify) (6): _____

SF-12® Cont'd:

10. Did you have a lot of energy?
    _____ All of the Time (1)
    _____ Most of the Time (2)
    _____ A Good Bit of the Time (3)
    _____ Some of the Time (4)
    _____ A Little of the Time (5)
    _____ None of the Time (6)

11. Have you felt downhearted and blue?
    _____ All of the Time (1)
    _____ Most of the Time (2)
    _____ A Good Bit of the Time (3)
    _____ Some of the Time (4)
    _____ A Little of the Time (5)
    _____ None of the Time (6)

12. During the PAST 4 WEEKS, how much of the time has your PHYSICAL HEALTH OR EMOTIONAL PROBLEMS interfered with your social activities (like visiting with friends, relatives, etc.)?
    _____ All of the Time (1)
    _____ Most of the Time (2)
    _____ A Good Bit of the Time (3)
    _____ Some of the Time (4)
    _____ A Little of the Time (5)
    _____ None of the Time (6)

Surgeon Signature_____ **Date**_____

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8.35.4 Short Form-36 (SF-36) (165)

SF-36 QUESTIONNAIRE

Name:_____ **Ref. Dr:**_____ **Date:** _____

ID#: _____ **Age:** _____ **Gender: M / F**

Please answer the 36 questions of the **Health Survey** completely, honestly, and without interruptions.

GENERAL HEALTH:
In general, would you say your health is:
Excellent Very Good Good Fair Poor

Compared to one year ago, how would you rate your health in general now?
Much better now than one year ago
Somewhat better now than one year ago
About the same
Somewhat worse now than one year ago
Much worse than one year ago

LIMITATIONS OF ACTIVITIES:
The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports.
Yes, Limited a lot Yes, Limited a Little No, Not Limited at all

Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf
Yes, Limited a Lot Yes, Limited a Little No, Not Limited at all

Lifting or carrying groceries
Yes, Limited a Lot Yes, Limited a Little No, Not Limited at all

Climbing several flights of stairs
Yes, Limited a Lot Yes, Limited a Little No, Not Limited at all

Climbing one flight of stairs
Yes, Limited a Lot Yes, Limited a Little No, Not Limited at all

Bending, kneeling, or stooping
Yes, Limited a Lot Yes, Limited a Little No, Not Limited at all

Walking more than a mile
Yes, Limited a Lot Yes, Limited a Little No, Not Limited at all

Walking several blocks
Yes, Limited a Lot Yes, Limited a Little No, Not Limited at all

Walking one block
Yes, Limited a Lot Yes, Limited a Little No, Not Limited at all

Bathing or dressing yourself
Yes, Limited a Lot | Yes, Limited a Little | No, Not Limited at all

PHYSICAL HEALTH PROBLEMS:
During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

Cut down the amount of time you spent on work or other activities
Yes | No

Accomplished less than you would like
Yes | No

Were limited in the kind of work or other activities
Yes | No

Had difficulty performing the work or other activities (for example, it took extra effort)
Yes | No

EMOTIONAL HEALTH PROBLEMS:
During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

Cut down the amount of time you spent on work or other activities
Yes | No

Accomplished less than you would like
Yes | No

Didn't do work or other activities as carefully as usual
Yes | No

SOCIAL ACTIVITIES:
Emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

Not at all | Slightly | Moderately | Severe | Very Severe

PAIN:
How much bodily pain have you had during the past 4 weeks?

None | Very Mild | Mild | Moderate | Severe | Very Severe

During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

Not at all | A little bit | Moderately | Quite a bit | Extremely

ENERGY AND EMOTIONS:
These questions are about how you feel and how things have been with you during the last 4 weeks. For each question, please give the answer that comes closest to the way you have been feeling.

Did you feel full of pep?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Have you been a very nervous person?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Have you felt so down in the dumps that nothing could cheer you up?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Have you felt calm and peaceful?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Did you have a lot of energy?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Have you felt downhearted and blue?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Did you feel worn out?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Have you been a happy person?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

Did you feel tired?
- All of the time
- Most of the time
- A good Bit of the Time
- Some of the time
- A little bit of the time
- None of the Time

SOCIAL ACTIVITIES:
During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?

- All of the time
- Most of the time
- Some of the time
- A little bit of the time
- None of the Time

GENERAL HEALTH:
How true or false is each of the following statements for you?

I seem to get sick a little easier than other people
Definitely true | Mostly true | Don't know | Mostly false | Definitely false

I am as healthy as anybody I know
Definitely true | Mostly true | Don't know | Mostly false | Definitely false

I expect my health to get worse
Definitely true | Mostly true | Don't know | Mostly false | Definitely false

My health is excellent
Definitely true | Mostly true | Don't know | Mostly false | Definitely false

8.35.5 Sickness Impact Profile (SIP) (202,203)

The Sickness Impact Profile (SIP)

The SIP is a generic measure used to evaluate the impact of disease on both physical and emotional functioning it has been widely used following its development by Gilson and Bergner in 1975 [1] and revision in 1981 2. The SIP is a self-administered questionnaire consisting of two domains; physical and psychosocial. There are 136 items contained within 12 categories (see Table 1.) Patients are asked to respond to the items as they are on that day with either yes or no. The SIP is scored to provide an overall score, 2 domain scores, and 12 category scores; items are weighted according to a standardised weighting scheme. The SIP takes between 20 and 30 minutes to complete.

Unfortunately, the SIP is subject to copyright restrictions and the full score could not be sourced. Please see Table 1 below for the SIP domains, categories and example items for each category.

TABLE 1. Sickness Impact Profile Categories and Selected Items

Dimension	Category	Items Describing Behavior Related to:	Selected Items
Independent Categories	SR	Sleep and rest	I sit during much of the day I sleep or nap during the day
	E	Eating	I am eating no food at all, nutrition is taken through tubes or intravenous fluids I am eating special or different food
	W	Work	I am not working at all I often act irritable toward my work associates
	HM	Home management	I am not doing any of the maintenance or repair work around the house that I usually do I am not doing heavy work around the house
	RP	Recreation and pastimes	I am going out for entertainment less I am not doing any of my usual physical recreation or activities
I. Physical	A	Ambulation	I walk shorter distances or stop to rest often I do not walk at all
	M	Mobility	I stay within one room I stay away from home only for brief periods of time
	BCM	Body care and movement	I do not bathe myself at all, but am bathed by someone else I am very clumsy in body movements
II. Psychosocial	SI	Social interaction	I am doing fewer social activities with groups of people I isolate myself as much as I can from the rest of the family
	AB	Alertness behavior	I have difficulty reasoning and solving problems, for example, making plans, making decisions, learning new things I sometimes behave as if I were confused or disoriented in place or time, for example, where I am, who is around, directions, what day it is
	EB	Emotional behavior	I laugh or cry suddenly I act irritable and impatient with myself, for example, talk badly about myself, swear at myself, blame myself for things that happen
	C	Communication	I am having trouble writing or typing I do not speak clearly when I am under stress

1. Gilson BS, Gilson JS, Bergner M, Bobbit RA, Kressel S, Pollard WE, et al. The sickness impact profile. Development of an outcome measure of health care. Am J Public Health. 1975 Jan 1;65(12):1304–10.
2. Bergner M, Bobbitt RA, Carter WB, Gilson BS. The Sickness Impact Profile: development and final revision of a health status measure. Medical Care. 1981 Aug;19(8):787–805.

8.35.6 Lower Extremity Functional Scale (LEFS) (166)

The Lower Extremity Functional Scale

We are interested in knowing whether you are having any difficulty at all with the activities listed below **because of your lower limb problem** for which you are currently seeking attention. Please provide an answer for **each** activity.

Today, *do you* or *would you* have any difficulty at all with:

	Activities	Extreme Difficulty or Unable to Perform Activity	Quite a Bit of Difficulty	Moderate Difficulty	A Little Bit of Difficulty	No Difficulty
1	Any of your usual work, housework, or school activities.	0	1	2	3	4
2	Your usual hobbies, re creational or sporting activities.	0	1	2	3	4
3	Getting into or out of the bath.	0	1	2	3	4
4	Walking between rooms.	0	1	2	3	4
5	Putting on your shoes or socks.	0	1	2	3	4
6	Squatting.	0	1	2	3	4
7	Lifting an object, like a bag of groceries from the floor.	0	1	2	3	4
8	Performing light activities around your home.	0	1	2	3	4
9	Performing heavy activities around your home.	0	1	2	3	4
10	Getting into or out of a car.	0	1	2	3	4
11	Walking 2 blocks.	0	1	2	3	4
12	Walking a mile.	0	1	2	3	4
13	Going up or down 10 stairs (about 1 flight of stairs).	0	1	2	3	4
14	Standing for 1 hour.	0	1	2	3	4
15	Sitting for 1 hour.	0	1	2	3	4
16	Running on even ground.	0	1	2	3	4
17	Running on uneven ground.	0	1	2	3	4
18	Making sharp turns while running fast.	0	1	2	3	4
19	Hopping.	0	1	2	3	4
20	Rolling over in bed.	0	1	2	3	4
	Column Totals:					

Minimum Level of Detectable Change (90% Confidence): 9 points **SCORE: _____/ 80 (fill in the blank with the sum of your responses)**

Source: Binkley et al (1999): The Lower Extremity Functional Scale (LEFS): Scale development, measurement properties, and clinical application. Physical Therapy. 79:371-383.

8.35.7 Short Musculoskeletal Function Assessment Questionnaire (SMFA) (284)

Short Musculoskeletal Function Assessment

Name: _____ Signature: _____ Date: _____

Instructions: We are interested in finding out how you are managing with your injury or arthritis this week. We would like to know about any problems you may be having with your daily activities because of your injury or arthritis. Please answer each question by putting a check in the box corresponding to the choice that best describes you.

These questions are about how much difficulty you may be having this week with your daily activities because of your injury o arthritis.

	Not at all Difficult A	A Little Difficult B	Moderately Difficult C	Very Difficult D	Unable to do E
1. How difficult is it for you to get in or out of a low chair?	☐	☐	☐	☐	☐
2. How difficult is it for you to open medicine bottles or jars?	☐	☐	☐	☐	☐
3. How difficult is it for you to shop for groceries or other things?	☐	☐	☐	☐	☐
4. How difficult is it for you to climb stairs?	☐	☐	☐	☐	☐
5. How difficult is it for you to make a tight fist?	☐	☐	☐	☐	☐
6. How difficult is it for you to get in or out of the bathtub or shower?	☐	☐	☐	☐	☐
7. How difficult is it for you to get comfortable to sleep?	☐	☐	☐	☐	☐
8. How difficult is it for you to bend or kneel down?	☐	☐	☐	☐	☐
9. How difficult is it for you to use buttons, snaps, hooks, or zippers?	☐	☐	☐	☐	☐
10. How difficult is it for you to cut your own fingernails?	☐	☐	☐	☐	☐
11. How difficult is it for you to dress yourself?	☐	☐	☐	☐	☐
12. How difficult is it for you to walk?	☐	☐	☐	☐	☐
13. How difficult is it for you to get moving after you have been sitting or lying down?	☐	☐	☐	☐	☐
14. How difficult is it for you to go out by yourself?	☐	☐	☐	☐	☐
15. How difficult is it for you to drive?	☐	☐	☐	☐	☐
16. How difficult is it for you to clean yourself after going to the bathroom?	☐	☐	☐	☐	☐
17. How difficult is it for you to turn knobs or levers (for example, to open doors or to roll down car windows)?	☐	☐	☐	☐	☐
18. How difficult is it for to write or type?	☐	☐	☐	☐	☐
19. How difficult is it for you to pivot?	☐	☐	☐	☐	☐
20. How difficult is it for you to do your usual physical recreational activities, such as bicycling, jogging, or walking?	☐	☐	☐	☐	☐
21. How difficult is it for you to do your usual leisure activities, such as hobbies, crafts, gardening, card-playing, or going out with friends?	☐	☐	☐	☐	☐
22. How much difficulty are you having with sexual activity?	☐	☐	☐	☐	☐
23. How difficult is it for you to do light housework or yard work, such as dusting, washing dishes, or watering plants?	☐	☐	☐	☐	☐
24. How difficult is it for you to do heavy housework or yard work, such as washing floors, vacuuming, or mowing lawns?	☐	☐	☐	☐	☐
25. How difficult is it for you to do your usual work, such as a paid job, housework, or volunteer activities?	☐	☐	☐	☐	☐

These next questions ask how often you are experiencing problems this week because of your injury or arthritis.

	None of the Time A	A Little of the Time B	Some of the Time C	Most of the Time D	All of the Time E
26. How often do you walk with a limp?	☐	☐	☐	☐	☐
27. How often do you avoid using your painful limb(s) or back?	☐	☐	☐	☐	☐
28. How often does your leg lock or give way?	☐	☐	☐	☐	☐
29. How often do you have problems with concentrating?	☐	☐	☐	☐	☐
30. How often does doing too much in one way affect what you do the next day?	☐	☐	☐	☐	☐
31. How often do you act irritable toward those around you(for example, snap at people, give sharp answers, or criticize easily)?	☐	☐	☐	☐	☐
32. How often are you tired?	☐	☐	☐	☐	☐
33. How often do you feel disabled?	☐	☐	☐	☐	☐
34. How often do you feel angry or frustrated that you have this injury or arthritis?	☐	☐	☐	☐	☐

These questions are about how much you are bothered by problems you are having this week because of your injury or arthrit

	Not at All Bothered A	A Little Bothered B	Moderately Bothered C	Very Bothered D	Extremely Bothered E
35. How much are you bothered by problems using your hands, arms, or legs?	☐	☐	☐	☐	☐
36. How much are you bothered by problems with your back?	☐	☐	☐	☐	☐
37. How much are you bothered by problems doing work around your home?	☐	☐	☐	☐	☐
38. How much are you bothered by problems with bathing, dressing, toileting, or other personal care?	☐	☐	☐	☐	☐
39. How much are you bothered by problems with sleep and rest?	☐	☐	☐	☐	☐
40. How much are you bothered by problems with leisure or recreational activities?	☐	☐	☐	☐	☐
41. How much are you bothered by problems with your friends, family, or other important people in your life?	☐	☐	☐	☐	☐
42. How much are you bothered by problems with thinking, concentrating, or remembering?	☐	☐	☐	☐	☐
43. How much are you bothered by problems adjusting or coping with your injury or arthritis?	☐	☐	☐	☐	☐
44. How much are you bothered by problems doing your usual work?	☐	☐	☐	☐	☐
45. How much are you bothered with feeling dependent on others?	☐	☐	☐	☐	☐
46. How much are you bothered with stiffness and pain?	☐	☐	☐	☐	☐

Name: _____ Page 2 of 2 Date: _____

8.35.8 Disability Rating Index (DRI) (282,283)

Disability Rating Index (#.....)

Date:..... Name:.....

Without difficulty — Example — Not at all

With some difficulty—With difficulty—With great difficulty

How do you manage the following activities?

After each question, please mark ONE POINT on the line

Please answer ALL questions

	Without difficulty	Not at all
Dressing (without help).....	⊢	⊣
Out-door walks.....	⊢	⊣
Climbing stairs.....	⊢	⊣
Sitting longer time.....	⊢	⊣
Standing bent over a sink.....	⊢	⊣
Carrying a bag.....	⊢	⊣
Making a bed.....	⊢	⊣
Running.....	⊢	⊣
Light work.....	⊢	⊣
Heavy work.....	⊢	⊣
Lifting heavy objects.....	⊢	⊣
Participating in exercise/sports	⊢	⊣

(DRI.2.E)

8.35.9 Wales Lower Limb Trauma Recovery (WaLTTR) scale (213,214)

Date of Questionnaire Completion [_ _ /_ _ /_ _]

Please answer the following according to how you feel today.

How strongly do you agree or disagree with the following statements (Please tick one option for each question)

	Strongly disagree (0)	Disagree (1)	Neither agree or disagree (2)	Agree (3)	Strongly agree (4)
1. I live in fear that I will get another injury	☐	☐	☐	☐	☐
2. I am very reliant on others	☐	☐	☐	☐	☐
3. I earn less now because of my injury	☐	☐	☐	☐	☐
4. I am unable to walk around the shops due to my injury	☐	☐	☐	☐	☐
5. I have aches in my leg all during the day	☐	☐	☐	☐	☐
6. I am pleased with my recovery	☐	☐	☐	☐	☐
7. I have avoided large groups of people/social gatherings as a result of my injury	☐	☐	☐	☐	☐
8. I tend to wear clothing to hide my injured leg	☐	☐	☐	☐	☐
9. I am happy to participate in all the things I used to do before the injury	☐	☐	☐	☐	☐
10. I have no significant pain in my leg	☐	☐	☐	☐	☐

In your own words, can you describe how you feel today?

Office use only:
If missing more than 2 responses → exclude all responses
If missing 1 or 2 responses → substitute score of "2" for missing responses
Total score = 28 - Q1 - Q2 - Q3 - Q4 - Q5 - Q7 - Q8 + Q6 + Q9 + Q10

/40

WaLLTR
WALES LOWER LIMB TRAUMA RECOVERY SCALE

For Review Only

The Bone & Joint Journal

Date of Questionnaire Completion [_ _ /_ _ /_ _]

During an average week of **7 days**, on how many days do you use the following mobility aids (please choose the mobility aid which is used for the majority of the day)?

Stick _____ Crutches/2 sticks _____ Zimmer frame _____ Wheelchair _____

Did you suffer other injuries (not to your legs) which are impacting on your recovery?
Yes ☐ No ☐

Occupation: _____

Unemployed ☐ Retired ☐

If you are not currently in work, is this solely due to your injury?
Yes ☐ No ☐

If you are back in work, is this in the EXACT same capacity as before the injury?
Yes ☐ No ☐

Has your ability to drive been changed by the injury?
Yes ☐ No ☐

Are you currently receiving any sick pay or sickness benefit as a result of your injury?
Yes ☐ No ☐

Are you currently involved in any legal or insurance claims following your injury?
Yes ☐ No ☐

Please add your comments regarding areas of your recovery which you felt we have not covered in this questionnaire

Many thanks for your time. All answers will be treated in confidence.

For Review Only

8.35.10 Brief Pain Inventory (BPI) (286)

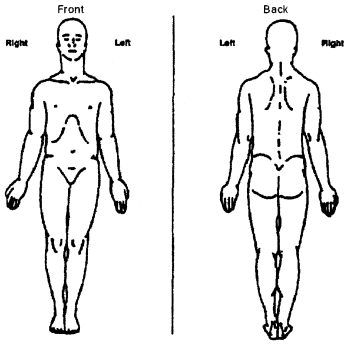
Clin J Pain • Volume 20, Number 5, September/October 2004 *BPI Documenting the Outcomes of Noncancer Pain Patients*

APPENDIX: BRIEF PAIN INVENTORY (SHORT FORM)

1. Throughout our lives, most of us have had pain from time to time (such as minor headaches, sprains, and toothaches). Have you had pain other than these everyday kinds of pain during the last week?

   ☐ Yes ☐ No

2. On the diagram, shade in the areas where you feel pain. Put an **X** on the area that hurts the most.



3. Please rate your pain by circling the one number that best describes your pain at its ***worst*** in the last week.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

4. Please rate your pain by circling the one number that best describes your pain at its ***least*** in the last week.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

5. Please rate your pain by circling the one number that best describes your pain on the ***average.***

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

6. Please rate your pain by circling the one number that tells how much pain you have ***right now.***

0	1	2	3	4	5	6	7	8	9	10
No Pain										Pain as bad as you can imagine

7. What treatments or medications are you receiving for your pain?

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8. In the last week, how much relief have pain treatments or medications provided? Please circle the one percentage that most shows how much ***relief*** you have received.

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Relief										Complete Relief

9. Circle the one number that describes how much, during the past week, pain has interfered with your:

A. General Activity

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

B. Mood

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

C. Walking Ability

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

D. Normal Work (includes both work outside the home and housework)

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

E. Relations with other people

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

F. Sleep

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

G. Enjoyment of life

0	1	2	3	4	5	6	7	8	9	10
Does not Interfere										Completely Interferes

Scoring:

Pain Severity Score = Mean of items 3–6 (pain at its worst, pain at its least, average Pain Interference Score = Mean of items 9A–9G (interference of pain with: general activity, mood, walking, normal work, relations, sleep, enjoyment of life)

For permission to use the BPI, pleast contact Dr. Charles Cleeland at ccleeland@mail.mdanderson.org.

Note: The short form of the Brief Pain Inventory is presented with permission of Charles Cleeland, PhD.

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8.35.11 Visual Analogue Scale for Pain (VAS) (287)

Visual Analogue Scale (VAS)

A Visual Analogue Scale (VAS) is a measurement instrument that tries to measure a characteristic or attitude that is believed to range across a continuum of values and cannot easily be directly measured. For example, the amount of pain that a patient feels ranges across a continuum from none to an extreme amount of pain. From the patient's perspective this spectrum appears continuous – their pain does not take discrete jumps, as a categorization of none, mild, moderate and severe would suggest. It was to capture this idea of an underlying continuum that the VAS was devised.

Operationally a VAS is usually a horizontal line, 100 mm in length, anchored by word descriptors at each end, as illustrated in Fig. 1. The patient marks on the line the point that they feel represents their perception of their current state. The VAS score is determined by measuring in millimetres from the left hand end of the line to the point that the patient marks.

How severe is your pain today? Place a vertical mark on the line below to indicate how bad you feel your pain is today.

No pain |_____| Very severe pain

There are many other ways in which VAS have been presented, including vertical lines and lines with extra descriptors. Wewers & Lowe (1990) provide an informative discussion of the benefits and shortcomings of different styles of VAS.

As such an assessment is clearly highly subjective, these scales are of most value when looking at change within individuals, and are of less value for comparing across a group of individuals at one time point. It could be argued that a VAS is trying to produce interval/ratio data out of subjective values that are at best ordinal. Thus, some caution is required in handling such data. Many researchers prefer to use a method of analysis that is based on the rank ordering of scores rather than their exact values, to avoid reading too much into the precise VAS score.

Further reading

Wewers M.E. & Lowe N.K. (1990) A critical review of visual analogue scales in the measurement of clinical phenomena. ***Research in Nursing and Health*** **13,** 227–236.

NICOLA CRICHTON

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