Technical skills simulation for postgraduate surgical training



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Abstract

Technical skills are a fundamental component of surgical training. Traditionally, these skills are learnt in an operating theatre under supervision. Access to surgical theatres have been unfavourably affected by several factors, including shift working, demand for service provision, consultant-led operating and working hour restrictions. Opportunities for surgical technical skills training further deteriorated during the COVID-19 pandemic.

Simulation is an effective modality for learning technical skills outside of the operating theatre. Evidence, however, shows the inadequate and inconsistent implementation of simulation into surgical training with barriers such as limited faculty availability, resources, and time constraints for trainees. My research focussed on this gap by exploring how technical skill simulation can be implemented alongside conventional surgical training.

In part I, I explored the evolution of surgical training and simulation, reviewing the evidence available for modalities that could develop technical skills. In part II, I identified the deficiencies in technical skill training and the lack of instruction for the use of simulation through a curriculum review and two systematic reviews. Additionally, I explored the barriers to implementing simulation through a scoping literature review. In part III, I used qualitative methodologies to understand general surgical and obstetrics and gynaecology trainees' experiences when engaging with simulation as part of their routine training. Finally, in part IV, I discussed the broader implications of my findings for both training and further research and the limitations of the research.

My thesis emphasises the importance of innovation in implementing simulation as an adjunct to conventional training for technical skills. I propose a pragmatic approach that enhances the training experience without unduly increasing the trainee or educator burden and aligns with national interests for training and healthcare workforce development.

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So let me begin with a prayer:

सरस्वति नमस्तुभ्यं वरदे कामरूपिणि।विद्यारम्भं करिष्यामि सिद्धिर्भवतु मे सदा ॥

"Salutations to you, Goddess Saraswathi, the giver of boons and the one who fulfils desires.

I begin my pursuit of knowledge with your blessings; may success always be mine."

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Abbreviations

ACGME: Accreditation Council for Graduate Medical Education

AFLP: Acute Fatty Liver of Pregnancy

ALS: Advanced Life Support

ALT: Alanine Transaminase

AR: Augmented Reality

ARM: Artificial Rupture of Membranes

ARCP: Annual Review of Competency Progression

ASPiH: Association for Simulated Practice in Healthcare

AST: Aspartate Aminotransferase

ATLS: Advanced Trauma Life Support

ATSM: Advanced Training Skills Module

BH: Bavithra Hemanth

BP: Blood Pressure

CASP: Critical Appraisal Skills Programme

CBD: Case-Based Discussions

cCRISP: Care of the Critically Ill Surgical Patient

CCT: Certificate of Completion of Training

CEX: Clinical Evaluation Exercises

CiP: Capabilities in Practice

COPE: Pregnancy and early childhood

CRP: C Reactive Protein

CT: Core Training Year

CTG: Cardiotocography

CTPA: CT Pulmonary Angiogram

CTRG: Clinical Trials and Research Governance

EBL: Estimated Blood Loss

EFW: Estimated Foetal Weight

ENT: Otolaryngology

ESS: Endoscopic Sinus Surgery

EWTD: European Working Time Directive

fFN: foetal Fibronectin

FRCS: Fellowship of the Royal College of Surgeons

FRCOpth: Fellowship of the Royal College of Ophthalmologists

FLS: Fundamentals of Laparoscopic Surgery

FY: Foundation Training Year

GDM: Gestational Diabetes Mellitus

GLSC: Global Laparoscopic Suturing Curriculum

GMC: General Medical Council

GPC: Generic Professional Capabilities

Hb: Haemoglobin

HELLP: Haemolysis, Elevated Liver enzymes, Low Platelet count

HS: Hikari Sakuri

IA: Intermittent Auscultation

IOL: Induction of Labour

IQR: Interquartile range

ISB: Speciality Board Exams

ISCP: Intercollegiate Surgical Curriculum Programme

IV: Intravenous

ITU: Intensive Therapy Unit

LOP: Left Occipito Posterior

LSCS: Lower Segment Caesarean Section

MAU: Maternity Assessment Unit

MDT: Multidisciplinary Team

MeSH: Medical Subject Headings

MEOWS: Modified Obstetric Early Warning Score

MLC: Midwifery Led Care

MOH: Major Obstetric Haemorrhage

MRCOG: Membership of the Royal College of Obstetricians and Gynaecologists

MRCS: Membership of the Royal College of Surgeons

NBFD: Neville Barnes Forceps Delivery

NHS: National Health Service

NIH: National Institutes of Health

NMT: Nadia Muspratt Tucker

NOTSS: Non-Technical Skills for Surgeons

NTS: Non-Technical Skills (only used in Table 26)

O&G: Obstetrics and Gynaecology

OMFS: Oral and Maxillofacial surgery

OOPR: Out of Programme for Research

OSAT: Objective Structured Assessment of Technical Skills

OSCE: Objective Structured Clinical Examination

OUH: Oxford University Hospitals

OxSTaR: Oxford Simulation Training and Research

PCR: Protein Creatinine Ratio

PPH: Postpartum haemorrhage

PPROM: Preterm Premature Rupture of Membranes

PR: Pulse Rate

PROMPT: Practical Obstetric Multi-Professional Training

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PROSPERO: International Prospective Register of Systematic Reviews

RCT: Randomised Controlled Trial

RCOG: Royal College of Obstetricians and Gynaecologists

RCS: Royal College of Surgeons

ROBuST: Royal College of Obstetricians and Gynaecology Operative Birth Simulation Training

RR: Respiratory Rate

RT: Run through

SARS: Severe Acute Respiratory Syndrome

SBAR: Situation-Background-Assessment-Recommendation

SGA: Small for Gestational Age

SHARP: Surgical Hands-on Assessment and Rating of Performance

SHO: Senior House Officer

SROM: Spontaneous Rupture of Membranes

ST: Specialist Training Year

STROBE: Strengthening the Reporting of Observational Studies in Epidemiology

SuppoRTT: Supported Return to Training

TS: Technical Skills (only used in Table 26)

Tr: Trainee (Only used in Tables 23, 24, 25)

TURP: Transurethral Resection of Prostate

UK: United Kingdom

USA: United States of America

VE: Vaginal Examination

VR: Virtual Reality

WBC: White Blood Cell

WHO: World Health Organisation

YAG: Yttrium Aluminium Garnet

YO-IFOS: Young Otolaryngologists of the International Federation of Otorhinolaryngological Societies

Definition of terms

- COVID-19 pandemic: Also referred to as COVID or the pandemic in this thesis. Refers to the global outbreak of coronavirus infection. The pandemic roughly spanned from late 2019 to 2021. There were periods of lockdown, when travel and work was disrupted. In hospitals, staff were redistributed to essential areas. Emergency operating continued with some changes and elective operating was completely stopped.
- Resident: Also referred to as Trainee, Senior House Officer (SHO), Registrar, Junior doctor, Core surgical (CT) trainee and Specialist trainee (ST) in this thesis. All of these terms refer to doctors who have completed medical school and two years of Foundation Training and have been appointed to a Speciality Training programme. Depending on their seniority in the training programme, the terms to refer to them can vary. Also, in the UK, the term junior doctor, SHO and registrars are being replaced by the term resident.
- Consultant: Also referred to as an 'Attending'. A doctor who has completed medical school, two years of Foundation Training and Specialist Training. They are responsible for leading patient care and supervising junior members of the team, including organising their training.
- Technical skills: Technical skills, in the context of this thesis, refers to the knowledge and the psychomotor abilities required to perform procedures in a surgical speciality.
- Non-technical skills: Non-technical skills are the cognitive and interpersonal skills that compliment technical skills and are essential for effective team working and patient safety.
- Induction: The training and orientation provided to staff in hospitals before starting a placement.
- Hidden curriculum: The unintended learning experiences in medical education, including values, biases, and beliefs.

- Faculty: Also referred to as educator and trainer in this thesis. They are doctors, often senior members i.e., consultants and senior trainees, who are involved with organising, delivering, and overseeing the training of trainees.
- Training programme director: A consultant who is responsible for the overall organisation and progression of the training provided in a training deanery.
- Competence: In a surgical context, competence is the ability to perform surgical tasks and manage surgical conditions safely and effectively, meeting required standards of skill and knowledge.
- Conventional training: Also referred to as 'traditional training' or 'routine training' in this thesis. In the context of surgical training, refers to mainly learning technical skills in an operating theatre.
- Surgical subspecialities: In this thesis, I have used the terminology as described by Lau et al (1). Specialisation refers to surgery (as opposed to medicine). Subspecialisation refers to the various branches of surgery including general surgery, obstetrics and gynaecology, ophthalmology etc. For each subspecialisation, there are further super-subspecialisations. For e.g., for general surgery, super-subspecialisations are colorectal surgery, upper gastrointestinal surgery, hepatobiliary surgery etc.

Preface

I am an Obstetrics and Gynaecology (O&G) trainee in the final two years of training in the United Kingdom (UK). I have practised medicine in two contexts- in India and the UK, which has shaped my understanding of training in both low resource and high resource settings. I have worked as an educator for several years, providing teaching to undergraduate students and postgraduate trainees but my passion lies in the organisation of education and the efficient use of available resources, including simulation.

When I started this DPhil, the COVID-19 pandemic was ending and there was significant worry about surgical training. Elective operative lists had ceased, emergency operating was mostly consultant led, and most educational activities had stopped. As a trainee in a surgical speciality myself, I could see the impact these decisions had on trainees including myself and the anxiety both trainees and educators had with regards to progression through training. Several publications at the time of the pandemic corroborated our local experience in the Thames Valley deanery (2-4).

There was ambiguity about the measures that would be required to aid the recovery of surgical training post pandemic. There was a sense of urgency among the surgical trainees and educators to implement training that could help bring surgical training back to the status quo that existed before the pandemic. Hence, I started by looking at the impact of the pandemic on surgical training and comparing it to training beforehand. I had assumed that training before the pandemic was the gold standard, and we were aiming to get back to that standard. It soon became apparent to me that this assumption was incorrect as there were significant issues with technical skill training even before the pandemic.

Simulation, though available to many trainees, was not being used in an effective capacity, incorporated alongside conventional training. This discovery represented a large gap in literature; with many avenues I could have pursued. I realised my research question needed to be adapted to focus on the implementation of simulation for technical skills alongside conventional training.

It was crucial to me to understand the trainees' experiences which meant I needed to use qualitative research methodologies for my thesis. To gain the required skills to perform high quality qualitative research, I completed the Post Graduate Certificate in Qualitative Health Research Methods from the University of Oxford with a distinction.

The exploratory work into the barriers for implementing simulation helped me realise that any interventions I planned for my empirical work had to take a pragmatic approach. Any implementation strategies had to use existing resources where possible and be applied in the naturalistic setting of conventional surgical training, without unduly increase faculty or trainee burden.

The intention of using simulation for technical skill training in this thesis was never to replace real world learning in an operating theatre environment. It was rather to use simulation as a valuable adjunct that provides opportunities to learn technical skills outside the increasingly scarce operating theatre sessions. Therefore, simulation should be given appropriate prominence in the modern surgical trainee's busy schedule.

Part I:

Introduction and philosophical positioning of the thesis

Chapter One: Introduction

"A surgeon must have a scholar's mind, a poet's heart and the hands of a craftsman"

The Surgeon (5)

In the preface, I discussed my background and interest in simulation for technical skills training for surgeons and the evolution of the research question of my thesis. In this chapter, I will provide more context about surgical training, technical skills for surgery, the challenges that impact surgical training and simulation as an effective tool for technical skills training. I will introduce the gaps in the literature, and the specific research question this thesis aims to answer.

The evolution of surgical training

Surgical training involves long hours, many years of training, and intense physical demands of operating, while learning to deal with quickly changing clinical situations (6-9). The speciality remains popular, attracting thousands of graduating medical students each year globally, who expect to become experts at operating and managing patients in their respective surgical subspecialities at the end of their training programmes (8, 9).

Surgical training has evolved over time in response to changing circumstances in healthcare. Restrictions on working hours, increased demand for speciality doctors, the intention to standardise training, and the availability of surgical educators are some of the factors that have acted as catalysts for the reformation of modern surgical training (10).

The apprenticeship model of surgical training

The traditional apprenticeship model of technical skill surgical training which existed from the 16th century or possibly earlier relied heavily on clinical exposure (11). Trainees would observe, assist,

and then progressively move towards independent operating under the mentorship of an experienced surgeon (12). The traditional model relied heavily on the volume of cases trainees saw on a day-to-day basis, the long years of training where they operated with increasing autonomy and the presence of a consistent mentor they shadowed for years (13). Progress was judged very subjectively, with a lack of governance within the system (14). There was little emphasis on understanding surgical pathology and ensuring good surgical outcomes (15).

In Britain, the origin of surgical training can be traced back to the 'barber surgeon' with the Company of Barber-Surgeons of London which was established in 1540 (11). Eventually, the Royal College of Surgeons (RCS) in London was set up in 1800 and established itself as an organisation representing medical professionals with surgical skills (16). Surgical training largely remained an apprenticeship at its core, with modifications made to introduce examinations and structure over the years (17).

The Halsteadian model of surgical training

American surgeon William Halstead, inspired by the German training model, developed the residency programme in the 1880s at Johns Hopkins hospital. The residency model was designed to provide more structure to surgical education (18). He famously stated that trainees should "see one, do one, teach one", summing up the progress of trainees through residency, and is considered the father of modern structured surgical training (19, 20).

The Halsteadian model of surgical training did not veer away from the mentor-mentee relationship of the apprenticeship model but rather legitimised it with a structured approach. Trainees, however, were on call 24 hours a day and available 7 days a week, with no set end date for their training. The progress over the years was structured like a pyramid (Figure 1), starting at the bottom as junior assistant residents. Promotions to assistant resident and resident posts were not assured and only a few chosen candidates finished this residency programme (as determined by Halstead himself) (21).

This resulted in only a handful of specialised surgeons emerging from the system, which did not translate well for the modern demands of providing a large surgical workforce that were competent and confident independent practitioners (21, 22). The other obvious drawback of this system was the heavy subjective trainer bias on deciding progression and no standardisation.

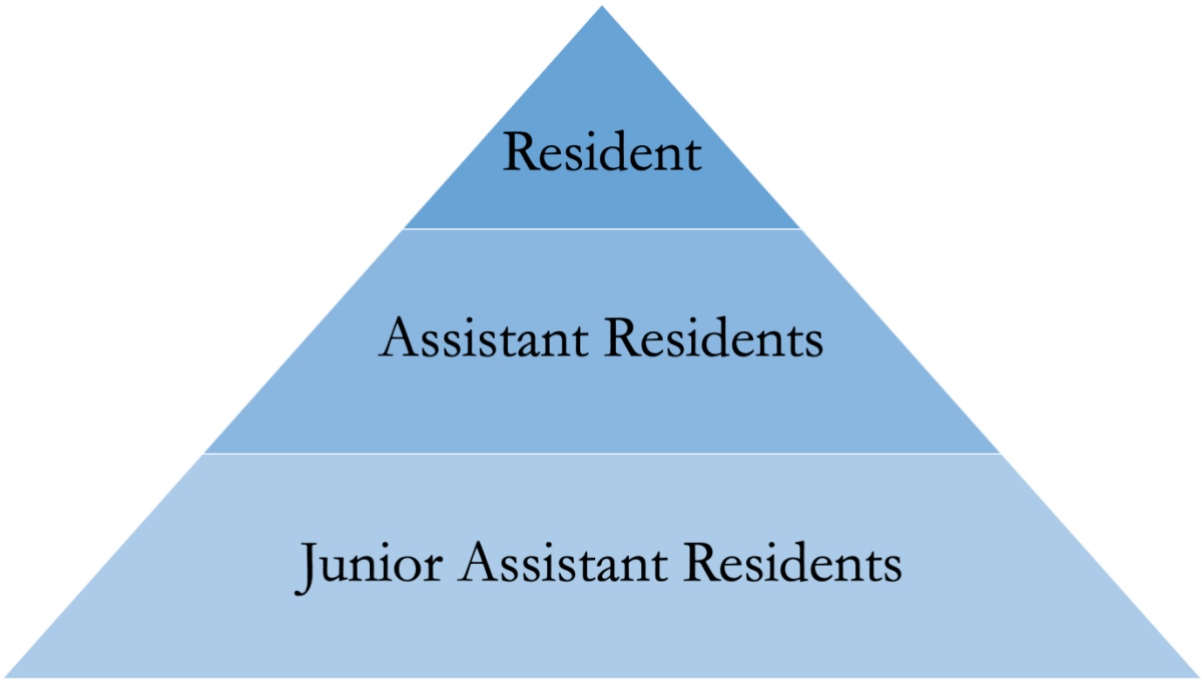


Figure 1 The Halsteadian model of surgical training was structured like a pyramid, with progress from junior assistant residents to assistant residents and finally resident. Trainees could spend multiple years as a junior assistant resident without any chance of progression. There was no objective assessment of competency other than Halstead's own perception of the trainee's performance

The Osler model of surgical training

The modern version of the apprenticeship model was established by William Osler, where multiple residents worked with multiple mentors, moving away from the reliance on one person to mentor a trainee (15). Trainees would rotate around the mentors and learn different techniques from different trainers .The techniques were learnt systematically over a period of time and heavily relied on the numerous years spent in the training programme and the volume of patients operated on (judged by logbooks trainees maintained of their surgical procedures) to get adequate practise.

Transition to competency-based training

In the last decade, the surgical training programmes in the United States of America (USA), Canada and the UK have moved over to a competency-based system of training to compensate for the shortcomings of the previous apprenticeship style training (23, 24). The inadequacies of the previous model included the inability to predict or guarantee the necessary case mix, quality, or quantity (25). Competency-based training was an attempt to mitigate these flaws (26).

Competency based training is a structured approach to surgical training. It involves construction of a comprehensive curriculum which considers the expectations of patients, the regulatory bodies, and the needs of the speciality in terms of knowledge and skill against which trainees are judged (24). Formative and summative assessments are regularly performed through the training year to assess the progress made as well as track the competencies gained by each trainee. This is judged against the curriculum for the respective training year at an annual review of training before a decision is made regarding progress to the next year of training (24). Trainees maintain a logbook of surgical procedures performed as evidence of surgical technical skills experience.

The advantages of competency-based training include transparency in training and a structured approach to training and progression. These programmes, however, have received criticism of reducing training to 'tick box' exercises without a real assessment of quality of training (23, 27).

Current challenges of surgical training

The existing models of surgical training have indeed produced thousands of surgeons. However, there are pressures on any training model in modern times from factors including workload, working structure, complexity of patients, technological advances, training expectations and the expectations of patients seeking treatment (28). Several reports suggest surgical trainees are less prepared than ever before at the end of their training (29-31).

Expansion of surgical knowledge and diversification of surgical subspecialities

The earliest medical graduates who trained as surgeons specialised in general surgery, performing primarily open surgery (e.g., cholecystectomy, appendicectomy) (32). With the passage of time however, there has been an explosion in surgical knowledge of diseases, treatment options and the technologies that support it. There was an emphasis on evidence based treatment of illness (33).

Surgery became subspecialised with the establishment of various branches such as orthopaedics, plastic surgery, vascular surgery, neurosurgery etc (Figure 2). Surgical training continued to require medical graduates with an interest in a particular surgical speciality to first complete a few years of general surgical training before they could embark on further training in their preferred subspeciality. With this approach, it took longer than a decade for a medical graduate to become a consultant in their chosen subspeciality (34).

In many countries, there were further adaptations to surgical training where trainees could specialise in a branch of surgery from the beginning (after completing their internship or foundation training) or move into their subspeciality quickly after completing two years of core surgical training (1). Further scientific development meant subspecialisation of surgery was not adequate, leading to super-subspecialisations. Trainees pursued fellowships to further super specialise (1), requiring surgical workforce planning to accommodate this and collaborative operating particularly in tertiary units where the case complexity is higher.

A demand for an extremely specialised surgical workforce meant hospitals needed to rework their staffing strategies to deliver a full service, consisting of some generalists and various specialists. The models of training that relied on apprenticeship also had to evolve to match the increased number of trained subspecialists that were required (1).

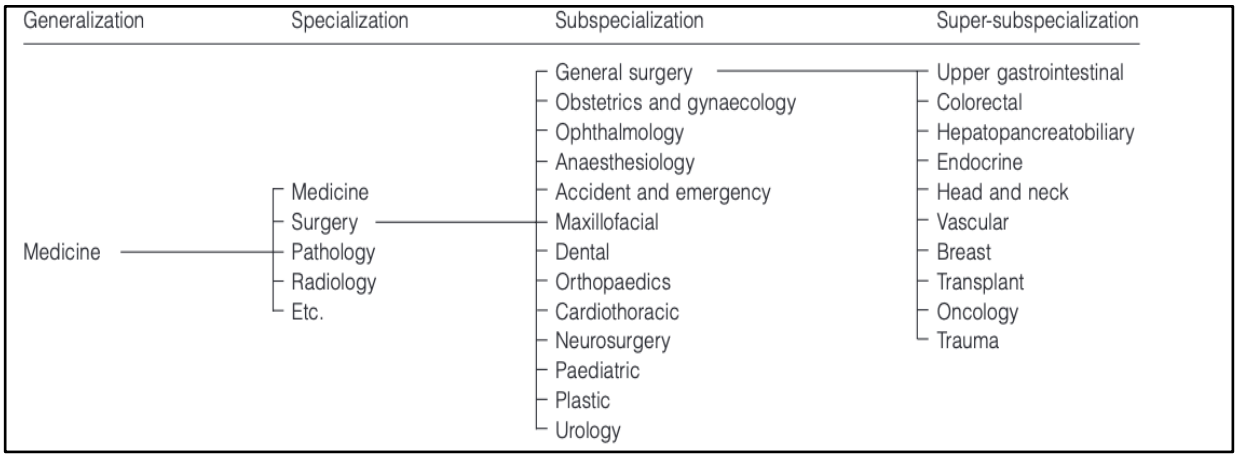


Figure 2 The evolution of the field of medicine and surgery has resulted in an increase in specialised branches for each field. Within the speciality of surgery, there are numerous super-subspecialities. This figure is reproduced from the paper published by Lau et al (1)

European Working Time Directive (EWTD) and changes to the working hours of surgical trainees

The UK had implemented the EWTD working hour restrictions by August 2009. Doctors in training had their working hours reduced to an average of 48 hours per week. For the surgical trainee, this meant moving to a shift based working life with off days to offset the out of hours work(35, 36).

The reduced working hours affected their ability to attend sessions in an operating theatre during regular working hours. Reduced training time meant difficulties in maintaining the mentor- mentee relationship the apprenticeship style training models relied on.

The knock-on effect was a young consultant workforce feeling less confident in their technical skills than their predecessors (36).

The ethical dilemma of trainees operating on patients

"There is no excuse for the surgeon to learn on the patient"

William J. Mayo (33)

Surgical care should be patient centered (37). There is an undeniable requirement to provide the opportunities for surgical trainees to operate and hone their skill, which will only benefit society in the long run(33). But the ethical dilemma is the potential for harm with trainees 'practising' on patients (38). The process of informed consent for patients should involve the disclosure of who will be operating and the level of supervision they will be under (39, 40). Patients have a right to say no to a trainee operating on them. This potentially reduces the number of cases a trainee can operate on, highlighting the need to think carefully about the methods used for technical skill training (37).

The technological advancements and ever-expanding surgical skill set

In the pre-Halsteadian and Halsteadian eras of surgical training, the types of surgeries a trainee had to learn were limited and were nearly entirely through large open incisions (open surgery). Technological and scientific advancement occurred concurrently and expanded not only the types of operations available but a variety of options for access. These options ranged from non-invasive (laser, ultrasound etc), endoscopy through natural orifices, minimally invasive (endoscopic procedures through single or multiple ports, robot assisted procedures) and open surgery (41, 42). The trainees of today are expected to be competent in a number of these procedures in their speciality so as to offer the patients a wide range of treatment options (43).

The technical skills required to perform each type of procedure are unique. The hand eye coordination, loss of depth perception, techniques for tissue dissection and the haptic feedback of laparoscopic surgery is different to open surgery or even robotic assisted surgery, and each has a

different learning curve (44). Microvascular surgery requires operating skills using a microscope compared to regular open surgery. Transferability of these skills between each type of surgical technique is limited (45, 46). Surgical training needs to account for trainees having to learn each of these different types of surgery. Traditional training strategies of 'learning it on the job' are not wholly adequate anymore (47).

Worries about litigation risk with poor surgical outcomes

Medical malpractice lawsuits have risen in England, increased by 30% in 2010-2011 (48). A study in 2006 found that trainees were named as defendant in 30% of the lawsuits (49). These lawsuits highlight the importance of adequate training and supervision of trainees to ensure patient safety(50-52). Litigation also highlight the need for surgeons to be able to prove their competence by showing a record of the cases they have performed and their complication rates (24, 48).

Cost of using the operating theatre for surgical training

"Learning on the job, particularly surgery, is relatively disorganised, it is unpredictable, it is time-consuming, and it is costly"

Carlos A Pellegrini, President of the American Surgical Association (53)

In a study conducted in the USA, it was estimated to cost USD 53 million a year for trainees to learn surgery in the operating theatre using operative theatre time (54). Trainees often take more time to complete an operation than their more experienced consultant colleagues(25). Training operating lists usually have fewer patients to account for the extra time required and yet here is simultaneous pressure on hospitals to improve the efficacy of operating theatre lists (55) and improve cost efficiency.

COVID-19 pandemic

The COVID-19 pandemic was an important event with an detrimental effect on surgical education in the recent past (2, 56-58). Cancellation of elective operating lists, restricted access to emergency operating and loss of training opportunities outside of the operating theatre meant trainees had extreme anxiety about gaining surgical skills on a par with what was expected of them for their stage of training. Progression in training was impacted further by cancellation of exams and courses. The pandemic was instrumental in getting surgical educators to focus on training and evaluate avenues to help trainees catch-up.

Technical skills training for surgeons

Technical skills for surgeons refer to the factual knowledge, clinical judgement, and operating skill required to carry out surgical procedures and optimally manage patients with surgical pathology (59). Better technical skills prowess is directly linked to better patient outcomes, resulting in less post operative infection, less postoperative readmission, less postoperative reoperation and ultimately less patient morbidity and mortality (60). Therefore, it is a worthwhile endeavour to invest time and effort into studying ways to improve technical skills training.

Technical skills are usually specific to each surgical subspeciality or super-subspeciality though there are numerous transferable skills across surgical subspecialities. An excellent example of a transferable surgical technical skill is suturing, a skill required by all surgeons (61).

How do surgical trainees learn technical skills?

Surgery is complex. Each surgical procedure has a series of steps that should be performed in sequence, considering the individual patient's pathology and anatomy, whilst simultaneously responding to changing circumstances within the operative field. The surgical steps themselves

require fine motor skills and fluidity of movement. Learning these complex processes as a novice, in real time in an operating theatre, sometimes with an awake patient and the theatre team around them, adds additional layers of difficulty (62).

The role of clinical exposure for learning surgical technical skills

In the operating theatre where trainees perform operations under supervision, learning occurs through experience and repeated practise. Learning through experience is supported by experiential learning theory (63, 64). Trainees actively engage in the operating theatre and subsequently reflect and critically analyse their performance, often with their supervising colleague, to learn technical skills. In the initial years of training, they perform a limited part of the operation and slowly learn to perform more and more of the procedure, progressively getting more independent. Vygotsky's theory of learning suggests this process uses "proper instruction, scaffolding, advising, and monitoring" which eventually results in the "integration of factual, cognitive, and psychomotor skills in a sequential process" (65). The process is repeated multiple times over the course of their training and their progress can be witnessed with the efficiency of their hand movements, their speed of operating, complication rates, increasing independence and confidence (63).

The role of simulation for learning technical surgical skills

"Simulation gives students permission to fail in a safe environment, so students learn from their mistakes"

Richard Satava, Professor of Surgery, University of Washington Medical Centre. (66)

The issue with relying solely on access to the operating theatre to master technical skills is twofold; difficulty with access to the operating theatre for training(63) and the variable quality of supervision and feedback received (67, 68). Working patterns have changed, with reduced working hours and shift pattern working, access to theatres is less frequent compared to before (69). Logic dictates that

alternative methods of learning technical skills outside of the operating theatre should be incorporated into a surgical trainee's routine. (70).

Surgery can be dangerous when performed by the undertrained (71). Junior surgical trainees are reliant on senior support to supervise and teach when they are learning to perform surgery in the operating theatre. The operating theatre can be a stressful environment due to uncontrollable environmental factors, for example the urgency of the surgery, patient factors that could make a routine procedure more complex, time pressures to complete the operation swiftly, the theatrical aspect of surgery where observation by surrounding staff and the comfort level a trainee has with a supervising senior can impact performance (72-74). The old adage ' the more you sweat in practice, the less you will bleed in battle' is true figuratively for the surgical trainee and literally for the patient when it comes to operating in the operating theatre.

Simulation on the other hand, is an imitation of the real environment or activity where participants can actively participate as they would in real life but without any of the real-world consequences (75). The simulated activity is usually tailored to achieve a specific learning objective. Simulation provides the surgical trainee with a safe space to practise, fail, learn, and improve, and is comparable to standard technical skill training if not better at reducing learning curves, operative time and improving patient safety (76-78).

Effectiveness of technical skill training in surgical subspecialities

Before implementing any changes to surgical training involving technical skills, it is important to be sure that such training is fit for purpose. There is substantial evidence demonstrating the efficacy of simulation as a modality to learn technical skills from all surgical subspecialities using the whole gamut of simulators available (79-82). Technical skills simulation training can specifically improve task efficiency, reduced task completion time, help reduce errors by allowing repeated practise,

performance (79-81, 83) and improved patient outcomes (84). The studies demonstrate trainees can practise steps of an operative procedure is a stress-free environment, without immediate patient safety implications.

Simulation allows for the principles of deliberate practice (practice of a particular skill by a motivated trainee while receiving feedback) to be applied to the acquisition of technical skills (85, 86). Another educational principle that is often applied to simulation based surgical training is mastery learning, where strict criteria is used as a standard to compare a trainee's skill and knowledge to help them improve (87, 88). Irrespective of the fidelity or technology of the simulator, studies have shown equivalent efficacy of the simulators in skill acquisition and equivalence to traditional training (76, 89). This equivalence of efficacy when comparing simulation and traditional surgical technical skills training has been viewed in literature with a negative connotation, implying that simulation should be superior to traditional training for it to be used. I, however, view equivalence of efficacy as a positive feature of simulation as the position I adopt in my doctoral research is to use simulation as a complementary technique that provides technical skills training opportunities out of the operating theatre.

Technical skills simulation does have some limitations. Technological limitations results in a less than realistic experience when practising on simulators(90, 91). The majority of simulators are not technologically advanced enough to allow for practising complex procedures(92, 93). Therefore, surgical trainees attend simulation courses that use animal models and human cadaveric specimens to practise these complex procedures(83, 93, 94). These courses are generally expensive to attend and difficult to organise due to the ethical and practical issues that are associated with the use of animals and human cadavers for science(95, 96).

Additionally, some trainees may experience performance anxiety with simulation use as they may feel observed and their performance critiqued(97, 98).Simulation faculty must be adaptable to tailor

the simulation experience to allow for trainees to feel psychologically safe when using simulation to learn(99).

Further exploration of the barriers to using simulation will be described in Chapter Six.

Transferability of technical surgical skills acquired in simulation to the operating theatre

Skill acquisition in simulation sounds ideal as it has low implication for patient safety whilst trainees practise their surgical skills. There are a number of studies which demonstrate that the skills gained in simulation can be transferred to an operating theatre setting, reducing the learning curves and reducing patient complications and therefore ultimately improve patient outcomes (89, 100-102).

Requirement for this research

The majority of research studies conducted on technical skills simulation for surgical trainees have adopted a positivist approach. The studies were designed for trainees to participate in an intensive boot camp style simulation programme and surrogate markers used to demonstrate improvement of skills such as comparing pre and post test scores, measuring economy of movement, time taken to complete the task or self-evaluation of confidence (103-109). The aim of these studies was often to demonstrate validity of the simulator and effectiveness of the training (110, 111). Whilst these studies certainly were important especially when technical skills simulators were newly introduced into modern surgical training, they were limited in their capacity to help advise educators on how to incorporate them into a busy trainees work and training schedule.

More recent reports from experienced educators and studies showed the need for a combined approach- using simulation with conventional training as it offered more opportunities for technical

skill development than conventional training alone (112). Though the evidence is currently limited, the combination of simulation and conventional training may be superior to conventional training alone.

The research question

When I reviewed the evidence for the use of simulation and had experienced the training difficulties we faced due to the COVID-19 pandemic, I wanted to understand why an effective teaching tool was not being used to its full potential in surgical training. Therefore, addressing this research gap, where implementation of simulation for surgical technical skills training became the central focus of my research.

The main research question of my thesis is:

"How can simulation based technical skills training be implemented for post-graduate surgical trainees?"

This thesis is an exploration of the implementation of simulation for technical skills training for postgraduate surgical trainees. In the context of my research, I define 'implementation of simulation' as the putting into place of simulation training for technical skills within existing surgical training.

Thesis structure

The Thesis will be laid out in 4 parts.

Part I: Introduction and philosophical positioning of the thesis

Part II: The Exploratory Research

Part III: The Empirical Research

Part IV: Discussion

Part I: Introduction and Philosophical Positioning of the Thesis

In this part, I discussed the history, the context and the concerns that motivated me to undertake this research, including the methodological approach. Part I contains two chapters.

Chapter One

Chapter One discussed the evolution of surgical training, the challenges that have compromised technical skills training in surgery, the evidence supporting the use of simulation for technical skills acquisition and the literature gap that exists with regards to the implementation of technical skills simulation for surgical training.

Chapter Two

In Chapter Two, I have discussed the research philosophy that underpins the work I have carried out in this thesis and the rationale behind this choice. I have described my choice of the interpretivist philosophical standpoint and my work which relies on qualitative methodologies, namely case study and rapid ethnography.

Part II: The Exploratory Research

In Part II, I conducted a curricula and literature reviews to understand the deficiencies in technical skill training for surgeons. The findings from these studies were embedded in the interventions I designed for my empirical studies. Part II will be set out in four chapters.

Chapter Three

In Chapter Three, I shared the results of the curricula review I undertook from the 12 surgical subspecialities in the UK to understand the guidance that is available to surgical educators about the use of simulation to deliver technical skills training. The results showed, with the exception of the

ophthalmology and paediatric surgery curricula, there is a lack of direction at a curricular level pertaining to simulation use.

Chapter Four

In Chapter Four, I described the systematic review I conducted where I explore the deficiencies in technical skills training in surgical subspecialities prior to the COVID-19 pandemic. The thematic analysis highlighted the need for a multimodal and structured approach to technical skills training.

Chapter Five

In Chapter Five, I presented the results of the systematic review I carried out on the impact of the COVID-19 pandemic on technical skills training for surgical subspecialities. The results of this review showed the negative impact of the pandemic on technical skills training. I subsequently performed an update of this systematic review.

Chapter Six

In Chapter Six, I discussed the analysis of a scoping literature review I conducted to identify the barriers to the implementation of simulation for postgraduate surgical education. I utilised several findings from this study (including the reduced availability of simulation faculty and the limited time offered to trainees for simulation) in the studies of my empirical research.

Part III: The Empirical Research

Having described the context of diminished training for technical skills in surgical subspecialities and the barriers to using simulation, I had identified a large gap in the literature; namely implementing simulation with conventional surgical training pragmatically, given the constraints faced in modern surgical training environments in the UK National Health Service (NHS).

The empirical studies take a pragmatic approach to the use of simulation in a naturalistic setting of a surgical trainee's daily schedule. I have used qualitative methodologies to gain a deep understanding of the trainees' experiences whilst they participated in these simulations. Part III will be discussed in two chapters.

Chapter Seven

In Chapter Seven, I present the findings of a case study of general surgical trainees using a VR simulator along their routine training. The trainees were followed up eight months later to ascertain the role various simulation modalities played in their surgical training. The case study methodology allowed for an in-depth understanding of the trainees' experiences.

Chapter Eight

In Chapter Eight, I designed a simulation that combines technical and non-technical skills simulation in a simulated labour ward during an obstetric on call. The combination of technical and non-technical skills in one simulation session allowed for a more naturalistic setting for trainees to practise their technical skills, enhancing the learning they could access by attending one training session. I used rapid ethnography to understand the trainees' experience when they participated in the simulation.

Part IV: Discussion

Chapter Nine

In Chapter Nine, I summarised the findings from the studies discussed in parts II and III, comparing and contrasting the conclusions I drew with existing literature. I critically analysed the limitations of my research and considered the implications of introducing my findings into surgical training. I discussed the future research opportunities that can draw on the studies I have presented in this thesis.

Chapter Conclusion

In this chapter, I have discussed the context in which my research is situated, the research gap, the need for research into implementing technical skills simulation for surgical training and a chapter wise summary of this thesis. In the next chapter, I will discuss the philosophical perspective that underpins the qualitative research methodologies.

Chapter Two: Philosophical positioning of the thesis

Chapter Introduction

In Chapter One, I discussed the evolution of surgical training and the challenges that necessitate research into training improvement. I defined the term technical skills with regards to surgical training and deliberated on the learning of technical skills in an operating theatre. I discussed the role of simulation in learning technical skills, the evidence that supports its use and the limitations of the current research. I introduced my research question in the context of the large gap in the literature regarding the implementation of simulation into conventional surgical training. My central research question, as discussed in Chapter One, is *"How can simulation based technical skills training be implemented for post-graduate surgical trainees?"*

In this chapter, I will explain the philosophical paradigm that underpins my research. I will discuss the rationale behind the ontological, epistemological, and axiological viewpoints to which my research is aligned with as they were determined by the context of the research and my research question.

Why do we need qualitative research to be conducted to study surgical training?

Research in the medical field, surgical training and even simulation have traditionally adopted the positivist view, with research questions aligned to proving or disproving hypotheses. Whilst studies using quantitative methodologies are important for demonstrating efficacy, improvement, and validity, this approach is not suitable for every research question. Indeed, not every research question requires a randomised controlled trial (RCT) (113, 114).

Existing evidence convincingly shows the usefulness of technical skills surgical simulation (79-82). Despite this, technical skills simulation is not being used in a consistent, meaningful way on a routine basis alongside conventional training. (115-117).

While tentative steps have been taken to understand why simulation is not being used widely, by studies that have discussed the barriers to simulation implementation, there is little work done to explore and attempt to mitigate the impediments(118, 119). The existing evidence base is less useful at understanding the subjective training experience when participating in simulation (120). Incorporating simulation into surgical training would require positive engagement from trainees as they are one of the major stakeholders.

The limited evidence available from the trainees' perspective emphasised the need to embrace qualitative research, acknowledging the subjective nature of participating in simulation whilst engaged in a busy work schedule with multiple training related pressures (121). Qualitative research provided a deeper understanding of trainees' perspectives, supporting the innovation required to implement simulation with conventional training.

I will further explain my reasons for choosing qualitative methodologies as I describe my axiological, ontological, and epistemological approach to the thesis.

Axiology, Ontology and Epistemology

Axiology in research is about values and the role values plays in the research, influencing every aspect of the research process from choosing the research question, data interpretation and the sharing of findings (122, 123). As an O&G trainee, I have first-hand experience as a trainee in a surgical speciality who has both participated in and organised simulation teaching.

I believe in the value of using simulation to reduce my cognitive load when I learn a new skill. Using simulation also adds value by improving my surgical technique and allowing me to practise management of difficult and rare clinical situations. I also know from speaking to my colleagues and peers that simulation can be difficult to access and motivation to participate can vary.

As a researcher, my personal experiences with both quantitative and qualitative research influence what I value, including my research interest, my study designs, and my interpretation of the data. Over the years I have slowly transitioned from relying only on quantitative research to value the rich contribution of qualitative research to answer questions about experiences, real world impediments to using simulation and understanding how experiences can influence our behaviour.

Therefore, my axiological view aligns best with interpretivism. I acknowledge the part I play in the subject being researched and what I value in my research when I ask the question "what ought to be?" when thinking about surgical simulation and training (122, 123). My research is not free from value and is not pragmatistic about what I value, so I rejected positivism and pragmatism. I considered the possibility of realism based on cultural and social value but interpretivism was a better fit considering my role as researcher.

The term ontology refers to the "study of the nature of reality" which may be realism or relativism (123). An ontological perspective of realism believes reality has one truth and is experienced in the same way by everyone. In contrast, relativism refers to the belief that reality is subjective and can vary based on experience and context. My ontological perspective is relativist, as I believe the experiences of trainees when participating in or interacting with a simulator or in a simulation scenario is subjective and is influenced by numerous factors. These factors may depend on a trainee's level of experience, previous simulation experience, and their personal views on training to name a few. Adopting a realism ontological perspective will discount these nuances in experience and will not serve my research aims.

Epistemology is the "study of the process of knowing", and is considered as objective or subjective (123). Objectivism as an epistemological standpoint refers to fixed discernible knowledge where there is only one reality. Subjectivism acknowledges that what constitutes knowledge is heavily influenced by peoples' perception of experiences and reality, constructed continually by the participant and the researcher and is not free from bias. Trainees can have vastly different experiences, training needs, ambitions and have experiences unique to them even if they are all training in the same region and in the same speciality. Additionally, the participant training year is likely to influence their interaction with teaching and simulation.

Therefore, my research which is focussed on understanding trainee experiences and implementing simulation into conventional training recognises the subjective nature of the experiences and adopts a subjective epistemological standpoint.

Research paradigm

A research paradigm is an overarching set of beliefs that inform our approach to research, influencing every stage in the research process from the framing of the research question, methodology, methods, data collection, analysis, and interpretation (124).

It encompasses the ontological, epistemological, and axiological views providing a coherent approach to research that is vital for maintaining rigour. Trainees perceive experiences differently based on their value systems and previous experience and therefore their construction of reality and truth can differ from each other. This view aligns best with interpretivism as opposed to positivism (one reality and one truth). Social constructivism, where truth is socially constructed, was a possibility I considered. But, as participation is simulation can be an individualistic experience, interpretivism was better suited.

Whilst this is not a new view to take within education research, interpretivism deviates from the traditional view of positivism common in most of medicine related research. Interpretivism inherently accounts for the naturalistic approach I have taken to the design of my empirical studies.

Reflexivity and positionality

Reflexivity and positionality are the cornerstones of maintaining rigour in qualitative research (125-127). A qualitative researcher is not separate to their research. Their knowledge, background, experience, assumptions they may have made, the position they assume, and biases influences every aspect of their studies.

Reflexivity is the process of the researcher reflecting on the role they played in the research and the influence they could have had in the interpretation of the research data.
Positionality describes the researcher's worldview and standpoint when conducting their study (127, 128).

In this section, I will discuss the overall role I have played in the research I conducted during my DPhil. Within the specific study chapters, I reflect more in detail and more specifically for each study.

As an O&G doctor who has spent a decade in training, I have had the opportunity of participating in, then teaching on and finally organising teaching for undergraduate and postgraduates from medicine and paramedical fields. As an obstetrics trainee, I have first-hand experience of the benefits of simulation training for learning a variety of skills: technical skills (e.g., forceps delivery, suturing), non-technical skills (e.g., communication on labour ward), working in a Multidisciplinary Team (MDT) and managing emergencies (e.g., management of eclampsia).

Simulation training helped me hone my technical skills and helped me feel less anxious in emergency situations as I progressed through my training. So, even at the start of my DPhil journey I was convinced of the important role simulation could play for surgical training when used appropriately. I was, however, perplexed by the infrequent use of simulation within not only my own training but also within the training programmes of my other surgical colleagues. I was also confused by the difficulty in accessing simulation facilities and the lack of adequate numbers of trained faculty. There was also an undervaluing of an effective resource and stepmotherly treatment of simulation as an inconvenient add on to conventional training.

The choices I made during the research I conducted and the interventions I designed were guided by the findings of the exploratory work and my personal experience with simulation and training.

I also considered the influence of the Hawthorne effect on my findings (129). The Hawthorne effect refers to the potential influence the presence of the researcher could have on the behaviour of the participants (129). Both the general surgical and obstetric trainees who took part in the empirical studies (Chapters Seven and Eight) knew I would be following them up or observing them during the simulation, possibly influencing their behaviour during the studies different to how they would have performed outside of the study setting.

I used multiple data sources, non-judgemental questioning and an eight-month follow-up of the general surgical trainees to triangulate my findings and reduce this effect where possible. Within each of the empirical studies, I have provided further details about my involvement.

I have presented an assessment of the quality of my qualitative work using the eight "Big-Tent" criteria in Appendix One (130).

Chapter Conclusion

In this chapter, I discussed the philosophical approach to my research for this thesis. I have explored the various possibilities I considered in the context of my experience of surgical training, simulation, and the research question I have proposed, and I have provided reasons for the choices I made. I also clarified my positionality within my research and the biases I might hold and have provided a plan for how I maintain rigour for all the studies I have discussed in this thesis.

In Part II of the thesis, I have discussed four exploratory studies that focus on identifying the deficiencies in technical skill training for surgical trainees through a lens of measures that could aid improvement, namely a curricula review (Chapter Three), systematic reviews about technical skill training before (Chapter Four) and during the COVID-19 pandemic (chapter five) and a scoping literature review (Chapter Six) to identify barriers for the implementation of simulation.

Part II: The Exploratory Research

This section is focussed on the four studies conducted to get an understanding of technical skill training in surgical subspecialities before and during the COVID-19 pandemic, and the instruction provided to educators at a curricular level. The fourth study described in part II provides insight into the barriers that have prevented the consistent and regular use of simulation for technical skill training for postgraduate surgical trainees.

Chapter Three: A descriptive analysis of simulation and training for technical skills in postgraduate surgical curricula in the UK

Note on publication of Chapter Three

The research from this chapter was submitted as a paper to Current Surgery Reports on the 26 June 2025. It is currently under peer review. The paper that was submitted was titled "Simulation use in technical skills training in the UK: A review of postgraduate surgical curricula". I have adapted the paper in line with the University's requirements to avoid self-plagiarism. The abstract can be found in Appendix Two.

Contribution statement

I was the lead researcher who conceptualised, designed, conducted, and wrote up this work. My supervisors acted as the second reviewers. All authors approved of the final manuscript before submission, and all have approved the inclusion of this research in my thesis.

Chapter Introduction

In part I of my thesis, I provided context to the concerns I had around how technical skills training was delivered for postgraduate surgical trainees. When considering the direction to take for this research, a comprehensive understanding of the problem was required before the right solutions could be designed and implemented. I began by considering the first steps to understanding the issues with training. A surgical curricula review was an ideal starting point, as it provided an overview of the instruction available to surgical educators in the UK. This context was particularly

relevant to the studies I planned for my empirical work which focussed on technical skill training and the use of simulation.

Training medical professionals in any speciality requires a carefully structured plan. This blueprint, that encompasses the educational, behavioural and skill goals for each speciality, is a curriculum (131). A well-designed curriculum goes beyond describing the milestones for a trainee; it should provide guidance for trainers on the methods best used to deliver these objectives (132-134).

Components of surgical curricula in the UK

The General Medical Council (GMC), the UK regulatory body for doctors, has defined the Generic Professional Capabilities (GPC) required to deliver safe and effective care. GPCs are in three domains: professional knowledge, professional skills, and professional values (135). The domains were adapted and adopted by each speciality into their specific curricula in addition to speciality specific skills. Each of the GPCs were distilled into learning outcomes that a 'day one consultant' should possess called Capabilities in Practice (CiP).

This integrates a combination of knowledge, technical and professional skill (136). The learning outcomes include managing outpatients, inpatients, theatre lists, the emergency on call and working as a leader in an MDT. Each learning outcome represents a CiP that integrates technical skills (such as knowledge and the skill to perform procedures) and non-technical skills (such as communication, leadership skills, situational awareness, team working etc.).

Surgeons require technical skills and specific knowledge in their chosen speciality (137). Curricula, therefore, have exhaustive lists of procedures and conditions that trainees are required to be experts in by the end of their training, keeping with the requirements of a competency-based training model (138, 139).

Techniques for learning technical skills

Technical skills are learnt through a combination of modalities, including clinical practice with real patients, in simulation, formal classroom based learning, and through self-study (140). Simulation, with its ability to provide a safe learning environment for trainees to practise technical skills repetitively without negative consequences to their patients, is a valuable tool that should be utilised where possible to augment clinical learning (141, 142).

Simulation, however, may not provide optimum results if used infrequently, without the opportunity for deliberate practice (112, 143). A well designed curriculum should indicate the optimal methods for achieving each learning objective to help trainers and education programme directors plan their teaching programmes whilst balancing local resources and trainee clinical exposure (144, 145).

Research question

"How do postgraduate surgical curricula in the UK describe the teaching of technical skills, and in what ways is simulation referred to within these curricula?"

Aim and objectives

This study sought to explore how the postgraduate surgical curricula in the UK describe the teaching of technical skills, with particular attention to the role of simulation training.

To achieve this aim, the study had the following objectives:

1. To explore the nature and scope of the advice provided at a curricular level for educators supporting postgraduate surgical trainees in developing technical skills.
2. To identify and describe how simulation is referred to within the curricula, including the context in which it appears, and the level of detail provided.

Methods

The Royal Colleges in the UK were reviewed, and all 12 surgical subspecialities were included in this review. The 12 subspecialities were Cardiothoracic surgery, O&G, Ophthalmology, Otolaryngology (ENT), General surgery, Neurosurgery, Oral and maxillofacial surgery (OMFS), Orthopaedics, Paediatric surgery, Plastic surgery, Urology and Vascular surgery. All the UK postgraduate surgical curricula (n=15) were identified from these subspecialities and downloaded from the various Royal College websites in December 2023.

A Microsoft Excel spreadsheet was created for data extraction. Each curriculum was manually searched initially, using the keywords 'simulation' and 'technical skills' to explore how simulation was described in the context of technical skill training. Each curriculum was subsequently read through in its entirety and predefined categories of data, such as the purpose of the curriculum, structure of the training programme, details regarding educational components of the training (e.g., CiPs) were extracted. Strategy for delivering the curriculum which included any details that described teaching, training, and delivery of technical skill training, including simulation use, were documented.

This review did not collect primary qualitative data; rather, it involved a document based descriptive analysis of curricula. Suggestions to collect interviews, focus groups or reflective accounts are proposed as follow-on work to explore how curricular guidance is enacted in practice and to capture trainees' learning experiences and the 'hidden curriculum'.

A descriptive analysis of the results from the perspective of educators and of organising education for surgical trainees was performed, with particular attention to the identification of positive examples that could inform future curricular design. The results were presented using a narrative summary.

Results

Fifteen curricula of the surgical subspecialities were reviewed, with a total of 1570 pages. The curricula included core surgical training (i.e., starting from the first year of postgraduate surgical training after completing foundation training) and speciality training (usually starting from third year of postgraduate surgical training until completion of training) for the included surgical subspecialities.

The term 'simulation' appeared infrequently across the text and was used 269 times in total, with an average of 18 times per curriculum. The use of the term 'simulation' ranges from least mentioned in the O&G curricula (seven times) to most used in the paediatric surgery curriculum (78 times). Ten of the 12 subspecialities had curricula from the Intercollegiate Surgical Curriculum Programme (ISCP) and were near identical in structure and content (Table 1).

Document title	Number of pages	Version analysed
Cardiothoracic Surgery Curriculum (ISCP) (146)	108	2021
ENT Curriculum (ISCP)(147)	117	2021
General Surgery Curriculum (ISCP) (148)	97	2021
Neurosurgery Curriculum (ISCP) (149)	161	2021
Oral and Maxillofacial Surgery Curriculum (ISCP) (150)	134	2021
Trauma and Orthopaedic Surgery Curriculum (ISCP) (151)	104	2021
Paediatric Surgery Curriculum (ISCP) (152)	116	2021
Plastic Surgery Curriculum (ISCP) (153)	160	2021
Urology Curriculum (ISCP) (154)	85	2021
Vascular Surgery Curriculum (ISCP) (155)	87	2021
A new core curriculum for Obstetrics and Gynaecology (RCOG), CiPs and Programme Assessment (156)	42	2019
Core Curriculum for Obstetrics and Gynaecology Definitive Document (RCOG) (157)	62	2019
Advanced Training in Obstetrics and Gynaecology Definitive Document (RCOG) (158)	180	2019
Guide for delivery of Ophthalmic Specialist Training (RCO), Version 3.5 (159)	32	2018
Core surgical training curriculum (ISCP) (160)	85	2021

Table 1 List of surgical subspecialities included in this study and the version of the curriculum analysed. Abbreviations: ISCP- The Intercollegiate Surgical Curriculum Programme, RCOG- Royal College of Obstetricians and Gynaecologists, RCO- Royal College of, ENT- Otolaryngology

Purpose of the curriculum

All of the curricula studied aimed to develop consultants who delivered safe, high-quality specialist care, with the appropriate knowledge and speciality specific professional capabilities at the end of their training. A common phrase used in the ISCP curricula to describe the goal of the training programmes at certification is 'competent doctors with the generic and speciality specific professional capabilities needed to manage patients presenting with the full range of acute and general elective conditions, as well as to develop a special interest within the speciality' (146-155). This highlights the dual focus on broad competence as well as specialised expertise, which frames the expectations for surgical trainees. The core surgical curricula is aimed at getting the trainee ready for higher speciality surgical training (160).

The O&G curriculum had a similar approach with an aim for their doctors to "advise and treat people presenting with a wide range of general obstetric and gynaecological conditions" (157) and the advanced curriculum in O&G to help develop special interests (158). The Ophthalmology curriculum "defined learning outcomes which relate directly to providing safe and high-quality patient care" (159).

Overall, though the specific descriptions differed between the ISCP and non- ISCP (O&G, Ophthalmology) curricula, the purposes were similar in essence.

Structure of surgical training in the UK

In the UK, surgical training can be provided by either Run through (RT) or Uncoupled (UC) programmes. RT programmes recruit doctors, after the two years of foundation training, directly into the first year of speciality training. The trainees are assessed at the Annual Review of Competency Progression (ARCP) where their engagement with the portfolio and training is evaluated. If their progress is satisfactory, they commence the next year of training and so on and so forth until the completion of training (CCT) (149). In contrast, with UC surgical training

programmes, where doctors apply to enter core surgical training (2 years) separately to higher speciality training (which starts at speciality training year 3, ST3) (160). The Membership of Royal College of Surgeons (MRCS) exam is usually a requirement for applying to higher speciality surgical training programmes (148, 150).

Both in Core Training and in the Higher Speciality Training of the uncoupled programmes, trainees are assessed using the same ARCP process until CCT. The aim of the uncoupled program is to allow trainees to have more time and experience different surgical subspecialities before they choose their preferred area of specialisation. The RT program does provide generic surgical competencies in the first two years, but they are often focussed on a theme that would eventually benefit the trainee in their chosen area of specialisation (e.g., a OMFS trainee will rotate in head and neck themed subspecialities such as ENT, plastic surgery, and neurosurgery).

Surgical speciality training programmes, whether UC or RT, have many similarities in structure and duration of training (Table 2). Training is delivered in three 3 phases. The first phase is one-to-two-years of core surgical training for basic surgical skills, along with exposure to a wide array of clinical situations. Training occurs under supervision. The Core Training syllabus can be generic as it is for general surgery and orthopaedic surgery or tailored to the surgical speciality (e.g., O&G, ophthalmology) (151, 157, 159, 160). Phase two, particularly in the UC training programmes, is the start of higher speciality training. Phase two is between three to five years, where speciality specific skills are learnt with an exposure to a wide range of super- subspecialities to get a broad understanding of the conditions within the speciality. Trainees progress from direct supervision to indirect supervision by the end of this phase. All the knowledge required for a day one consultant in the subspeciality, and most of the required technical skills are developed in this phase.

Most surgical training programmes require the Intercollegiate Speciality Board exams (ISB) or membership/fellowship exam for the relevant Royal College to be completed at the end of this phase. Phase three is advanced specialist training, which can last for one to two years with the focus

on acquiring skills of the chosen super-subspeciality or developing a special interest. The aim of phase three is usually to prepare the trainee to finish the training programme as an independent competent practitioner who can safely manage, both medically and surgically, the majority of conditions that occur within their chosen surgical subspeciality.

Surgical Subspeciality	**Type of training programme: Run through (RT), Uncoupled (UC)**	**Phase 1 Core**	**Phase 2 Intermediate**	**Phase 3 Advanced**
Cardiothoracic Surgery (146)	RT and UC	RT 3 years, UC 2 years. GPC in both cardiac and thoracic surgery	RT 2 years, UC 2 years. Train in either cardiac or thoracic surgery ISB exam to progress to phase 3	RT 2 years, UC 2 years. Develop a special interest
ENT (147)	RT and UC	2 years for both RT and UC. Aligned to core surgical training. Complete MRCS exam	RT and UC 4 years. Complete the ISB exam	RT and UC 1 to 2 years. Complete general training and 1 special interest
General Surgery (148, 160)	UC, though RT was piloted in a select few programmes (Improving Surgical Training Pilot)	UC and RT 2 years, core surgical training. Complete MRCS exam	UC 4 years. 1 year spent gaining exposure to special interest. ISB exam	UC 2 years. 2 special interest modules
Neurosurgery (149)	RT with either ST1 or ST2 entry	RT 1-2 years. Aligned with core surgical training	RT 5 years. Complete the ISB exam	RT 1 year. Acquires microsurgical skills and 1-2 special interest areas of practice, including fellowships in specialist centres

Surgical Subspeciality	**Type of training programme: Run through (RT), Uncoupled (UC)**	**Phase 1 Core**	**Phase 2 Intermediate**	**Phase 3 Advanced**
Oral and Maxillofacial Surgery (150)	RT and UC	UC and RT 1-2 years, core surgical training. Complete MRCS	UC and RT 4 years. Complete the ISB exam	UC and RT 1 year
Trauma and Orthopaedic Surgery (151)	UC though RT was piloted in a select few programmes (Improving Surgical Training Pilot)	UC 2 years, core surgical training. Trainees in the RT pilot must attend the ST3 national selection interviews to evaluate the RT pilot programme. Complete MRCS	UC 4 years. Complete the ISB exam	UC 2 years. Develops 1-2 special interest areas
Paediatric Surgery (152)	RT and UC	RT and UC 2 years, core surgical training	RT and UC 4 years. Complete FRCS exam	RT and UC 2 years. To medically manage all patients on an unselected on-call and manage 90% of patients surgically independently
Plastic Surgery (153)	RT and UC	UC and RT 2 years, core surgical training. Complete MRCS	UC and RT 4 years. Complete ISB exam	UC and RT 2 years

Surgical Subspeciality	**Type of training programme: Run through (RT), Uncoupled (UC)**	**Phase 1 Core**	**Phase 2 Intermediate**	**Phase 3 Advanced**
Urology (154)	UC though RT was piloted in a select few programmes (Improving Surgical Training Pilot)	UC and RT 2 years, core surgical training. Complete MRCS	UC and RT 4 years. Complete ISB exam	UC and RT 2 years
Vascular Surgery (155)	RT and UC	UC and RT 2 years, core surgical training. Complete MRCS	UC and RT 4 years. Complete ISB exam	UC and RT 2 years
Obstetrics and Gynaecology (156-158)	RT, though a few trainees are recruited at ST3 entry each year	RT 2 years. Complete MRCOG part 1 exam	RT 3 years. Complete MRCOG part 2 and part 3 exams	RT 2 years. Develops 2 special interest areas (ATSM)
Ophthalmology (159)	RT	RT 2 years. Complete part 1 FRCOpth	RT 2 years Complete part 2 FRCOpth	RT 3 years

Table 2 Duration, type, and basic structure of training programmes for each surgical subspeciality included in this study. Abbreviations: ATSM- Advanced Training Skills Module, ENT- Otolaryngology, FRCopth exams- Fellowship of the Royal College of Ophthalmologists exams, FRCS- Fellowship of the Royal College of Surgeons, GPC- Generic Professional Capabilities, ISB- Intercollegiate Speciality Board, MRCS- Membership of the Royal College of Surgeons, RT- Run through training, UC- Uncoupled training

Educational components of surgical training

All of the surgical curricula described 2 educational components:

a. GPC

b. Speciality specific competencies

GPC (161)

The GMC described nine generic capabilities that were considered as essential for a doctor to develop, for delivering safe, effective, and high-quality care. The principles and professional responsibilities have been translated into educational outcomes that were incorporated into postgraduate curricula in all medical and surgical subspecialities. The educational outcomes in the GPC framework were further distilled into CiPs to monitor trainees' achievement including managing an out-patient clinic, the unselected emergency take, ward rounds, the on-going care of inpatients, an operating list and multi-disciplinary working.

Speciality specific competencies

Each surgical specialty reviewed had identified critical conditions vital to patient safety. By the end of their training, trainees were expected to be proficient in identifying and treating these conditions. Their abilities were expected to be assessed through Case-Based Discussions (CBD) and Clinical Evaluation Exercises (CEX). Additionally, each speciality outlined specific technical skills in the form of index procedures- common operations considered essential for delivering safe patient care, providing an exhaustive list in the appendix of each curriculum.

Strategy for delivering the curriculum: exploring the nature and scope of advice provided at a curricular level for educators supporting postgraduate surgical trainees

All of the ISCP curricula described three strategies for technical skill training: self-directed learning, learning from practice, and learning in formal situations (Figure 3)(146-155, 160):

1. **Self-directed learning**: This strategy involved activities initiated by trainees, such as journal clubs, peer review, study groups, and personal study or reflection.
2. **Learning from practice**: Trainees gained experience during supervised clinical activities, gradually taking on more responsibility. This hands-on learning was coupled with continuous systematic feedback, personal reflection, and the maintenance of a logbook.
3. **Learning from formal situations**: Classroom sessions and simulation training organised by training programme directors or hospital staff.

Though the ISCP provided general advice, suggesting the use of all available teaching methods to cover the breadth of the curriculum, specific guidance on implementation was absent from the curricula reviewed.

Two non-ISCP specialties—O&G and Ophthalmology—were also included in this review. Both recommended a similar flexible approach to training, aligning with service needs while supporting each trainee's individual development plan (156-159).

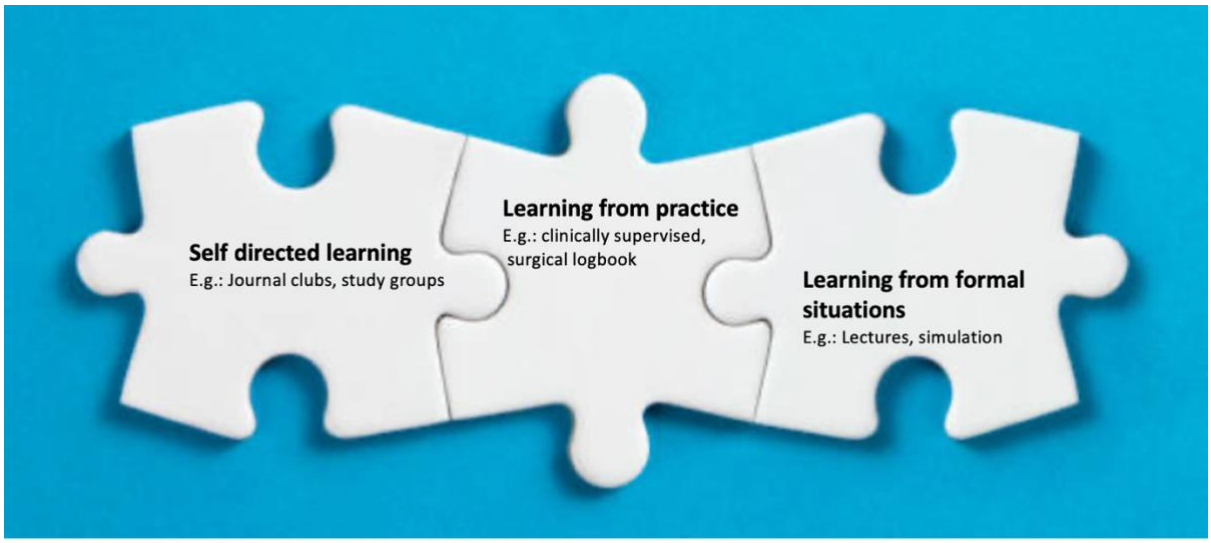


Figure 3 The ISCP curricular approach advised the flexible use of three learning strategies, namely self-directed learning, learning from practice, and learning from formal education, to meet technical skills training needs. The examples provided for each strategy are drawn directly from the ISCP curricula reviewed. This image visually represents the key elements discussed. Abbreviation: ISCP – Intercollegiate Surgical Curriculum Programme

Simulation: description of how simulation is referred to within the curricula

The ISCP curricula described simulation as one of the training modalities educators could use to provide formal training. It was defined as "any reproduction or approximation of a real event or process or set of conditions or problems which can be used to train individuals or teams" (146-155, 160). The curricula recommended a blended approach, using simulation with clinical practice to meet learning objectives. However, the guidance on simulation were brief, generic, and identically described in all the ISCP curricula, with the exception of the paediatric surgery (Box 1). Notably, three specialties- paediatric surgery, O&G, and ophthalmology- deviate from the standard, offering more specific recommendations for the use of simulation in training.

Simulation

Teaching in formal situations often involves the use of simulation. In this context simulation can be any reproduction or approximation of a real event, process or set of conditions or problems e.g., taking a history in clinic, performing a procedure, or managing post-operative care. Trainees have the opportunity of learning in the same way as they would in the real situation but in a patient-free environment. Simulation can be used for the development of both individuals and teams. The realism of the simulation may reflect the environment in which simulation takes place, the instruments used or the emotional and behavioural features of the real situation. Simulation training does not necessarily depend on the use of expensive equipment or complex environments e.g., it may only require a suturing aid, or a role play with scenarios.

Simulation training has several purposes:

- supporting learning and keeping up to date
- addressing specific learning needs
- situational awareness of human factors which can influence people and their behaviour
- enabling the refining or exploration of practice in a patient-safe environment
- promoting the development of excellence
- improving patient care.

The use of simulation in surgical training is part of a blended approach to managing teaching and learning concurrent with supervised clinical practice. The use of simulation on its own cannot replace supervised clinical practice and experience or authorise a doctor to practise unsupervised. Provision of feedback and performance debriefing are integral and essential parts of simulation-based training. Simulation training broadly follows the same pattern of learning opportunities offering insight into the development of technical skills, team-working, leadership, judgement, and professionalism. Education providers should use all teaching methods available, including simulation teaching, to ensure that the full breadth of the syllabus is covered. Where there is a need for specific intensive courses to meet specific learning outcomes, there may be a number of equivalent providers.

Box 1 The ISCP curricula have a generic description of simulation described as a formal method of learning. No specific details are available on the many simulation modalities available and the use of them, with the exception of the paediatric surgery curriculum. Abbreviation: ISCP- Intercollegiate Surgical Curriculum Programme

The paediatric surgery curriculum (Table 3) instructed educators to consider simulation for every speciality relevant topic detailed in the syllabus (152). However, it did not provide any further guidance on the specific types or modalities of simulation that could be used to achieve the learning objectives.

Topic	**Head and neck swellings**	**Areas in which simulation should be used to develop relevant skills**
Category	General surgery of childhood	
Sub-category	Management of benign surgical conditions	
Objective	To be able to assess a child presenting to the outpatient clinic or acutely with a head/neck swelling as the primary presenting symptom To be able to formulate a differential diagnosis and an investigation and management plan To be able to treat the child appropriately up to and including operative intervention if required To be able to communicate the above information at the required level to patients/ parents/patients/ parents/another team members/ referral source	
Knowledge	Patterns of symptoms and relation to likely pathology, relevant anatomy, and age of child Relevance of embryonic development of head and neck structures Differential diagnosis Place and value of investigations	
Clinical Skills	Ability to assess child Ability to form a viable investigation and treatment plan Ability to communicate with all relevant groups	

Topic	**Head and neck swellings**	**Areas in which simulation should be used to develop relevant skills**
Technical Skills and Procedures	ST5 and 6: Excision skin lesion Excision/biopsy of lymph nodes Surgery for thyroglossal cyst Surgery for branchial cysts and branchial remnants ST7 and 8: Excision skin lesion Excision/biopsy of lymph nodes Surgery for thyroglossal cyst Surgery for branchial cysts and branchial remnants	

Table 3 An example from the paediatric surgery curriculum (found on page 47 of the paediatric surgery curricular document) where every topic in the syllabus, detailed in the curriculum's Appendix Two, prompts educators to consider simulation as an educational tool to develop the relevant skill (152). The column to the right has been left blank for the educators to complete after considering their local simulation facilities. Abbreviations: ST- Specialist Trainee

The ophthalmology curriculum had a unique approach to technical skill training found in the document titled "Guide to delivery of Ophthalmology Specialist Training" (159). Particularly unique when compared to the other curricula in this review was the emphasis placed on the learning of microvascular surgery using simulation and the completion of a Royal College run microsurgical simulation course before trainees could perform these procedures on real patients. There was emphasis within the curriculum on induction where basic surgical skills would be taught with the use of simulation before trainees commenced in their clinical roles.

The curriculum also reiterated the importance of the maintaining technical skills throughout training with the use of simulation. The curriculum recommended simulation practice with a laser before performing procedures such as the Yttrium Aluminium Garnet (YAG) laser capsulotomy. The different types of simulation available to trainees were described in detail – wet and dry lab, laser, team based involving the MDT, immersive simulation with technology (e.g., VR simulation). Additionally, simulation training was highlighted as particularly beneficial to trainees returning to training after a break.

In the O&G curriculum, the emphasis was on MDT simulation, with the requirement for mandatory team-based training (156-158). For technical skill training, the curriculum advised the use of simulation from the beginning of training, with a list of recommended courses for trainees to attend (e.g., the Royal College of Obstetricians and Gynaecologists Operative Vaginal Birth Simulation training, the ROBuST course). For senior trainees undertaking specialist modules that require extensive laparoscopic operating skills (e.g., for benign abdominal surgery), the curriculum was vague in its description of simulation use, with the advice for trainees to provide evidence of laparoscopic and hysteroscopic simulation training without any specification of the frequency, type or regularity of instruction using simulation (158).

There was little discussion on faculty development for providing the simulation teaching in any of the curricula. The ophthalmology curriculum discussed the requirement for trainees to teach undergraduates, their peers and paramedical staff but did not include simulation as an area that requires deliberate faculty development (159).

Discussion

The aim of this review was to gain an understanding of the guidance available to educators on delivering technical skills training in surgical subspecialities in the curricula, with particular attention to the role of simulation training. The most startling finding of this review was the lack of specificity in curricular instruction for technical skills training and the poor descriptions used to describe simulation use.

Curricular design: nature and scope of the advice provided at a curricular level for educators supporting postgraduate surgical trainees in developing technical skills

It is well established that technical skills are important for surgeons, representing an integral skill set for providing high quality and safe care to our patients (60, 162, 163). With the evolution of surgical training from apprenticeship models to competency-based training, there must be sufficient emphasis on the design of a curriculum that reflects, and addresses concerns trainees and educators have about technical skills training (164-167).

George Hrivnak in his essay about curricular design talks about answering three questions when designing a curriculum; " What do our students need to learn?", "How can we best help our students to learn?" and "How do we know our students have learnt?" (168). This review focusses on how well the surgical curricula are written to answer the second question- " How can we best help our students to learn?" (168, 169).

The review demonstrated the curricular content (i.e.. what do our students need to learn?) was detailed and appropriate for each speciality. The content which is determined by the GMC, the specific speciality and the Royal Colleges who have worked backwards from the goal- equipping trainees with the skills a day one consultant in the speciality needs to perform their job safely (170). The data from this review showed that this step of the curricular design was carried out well, with thorough lists for procedures and skills trainees required for each speciality.

All the curricula had an in depth plan for reviewing trainee performance, including the examinations trainees take at particular points in their training and the assessments they complete to showcase achievement and progress, fulfilling the final question "How do we know our students have learnt?" (168).

Although this review did not collect primary qualitative data, future qualitative enquiry- such as semi-structured interviews, focus group discussions, or reflective accounts- could provide additional insight into whether trainees have achieved the intended learning outcomes. Such approaches would allow exploration of variation in trainees' learning experiences and examination of aspects of the hidden curriculum, defined as the implicit transmission of beliefs, values, and practices. This richer, context-sensitive understanding could in turn inform and strengthen the design, delivery, and evaluation of curriculum-recommended training and simulation provision (171, 172).

The curricula described three avenues to gain skills (self-directed learning, learning from practice, and learning from formal situations), all of which were viewed as interchangeable at the curricular level with inadequate instruction on how best to use each method. In contrast, studies have shown using an evidence-based approach that incorporates adult learning theories and educational theories improves the learners skills (173). For example, if educational theory had been applied to curricular design, learning technical skills in simulation would first be advised based on the principles of deliberate practice (174, 175). The ophthalmology curriculum certainly models this to an extent by

advising trainees to learn certain technical skills, like using the laser, first in simulation before they perform the procedure in the operating theatre (159).

One of the issues with poor instruction at a curricular level is that the interpretation is left to local educators, meaning there is a potential for a large discrepancy between "the planned curriculum" and the "delivered curriculum", which may lead to significant variation in surgical training across the UK (170). Issues with training may be compounded by a lack of resources across the UK, particularly in terms of access to theatre lists and diminishing opportunities for 'on the job' learning (176, 177). These challenges contribute to increased inequity and negatively affect the 'experienced curriculum'. This concept refers to the learner's interaction with the curriculum, the education provided and the healthcare system they train in (170).

To my knowledge, there are no other surgical curricula reviews for technical skills that have been published. The implication is that efforts are not being made to critically appraise our own educational practices, even though there has been widespread concern about surgical technical skills training, especially in the aftermath of the COVID-19 pandemic (57). Consequently, recovery efforts which are expensive may not be designed optimally and may not result in the desired positive outcomes. Chapter Five will provide further information about the impact of the COVID-19 pandemic on surgical training.

Description of simulation use in the curricula

A notable finding of this review was the lack of explicit direction for the use of simulation despite evidence that simulation is an effective resource for surgical technical skills training and can help bridge the gap caused by reduced clinical exposure(178-180). One of the barriers to using simulation was the poor guidance provided to educators at the curricular level (181, 182), a consistent finding in our review as well. Similarly, a review that was conducted analysing non-technical skills training

across all medical and surgical curricula also demonstrated a lack of explicit teaching instructions, which means all types of simulation training is still in the nascent stages of being introduced (183).

Without clear direction from the training body on the appropriate use of simulation to help achieve the skills, local training units are unlikely to adopt this resource effectively. There are multiple simulation modalities that could be adopted to practise technical skills (e.g., VR simulators, box trainers, Augmented Reality AR simulators, wet lab simulation etc) and a nuanced and detailed curriculum should be explicit when advising educators on which modalities would be best suited for each skill listed in the curriculum. An example would be to learn laparoscopic suturing using a box trainer but using VR simulation or cadaveric simulation to practise a complex procedure (184).

Compounding factors such as a lack of local simulation resources, regional variation in simulation facilities, less availability of trained simulation faculty and ultimately lack of long-term sustainability planning for the use of simulation could further impact the use of simulation (185-187). But importantly, lack of curricular direction and instruction has a detrimental impact in using simulation regularly for technical skills training and makes the review of local facilities difficult, as there is no set standard to compare the technical skills training delivered by one unit to another (186).

Of course, it is worth noting the positive exceptions in the curricula reviewed. Better description of simulation use for technical skill training was seen in two curricula: ophthalmology and paediatric surgery (188, 189). There is no discernible reason for the discrepancies between the curricula that I could identify, other than the possibility that some subspecialities are early adopters of simulation and are able to appreciate the benefits at a national level decision making (190). This is particularly true for ophthalmology that includes microsurgery, a skill that when learnt on the simulator is readily transferable to the operating theatre, with less errors and better patient outcomes (190, 191). The paediatric surgery curriculum only provides a prompt for educators to consider simulation for each technical skill but does not delineate the breadth of simulation options that are available (152).

Comparison to non-surgical specialities that were early adopters of simulation like Anaesthesia helps us understand the scope for further improvement (192). In the Royal College of Anaesthetists' curriculum, simulation is recommended for use from Core Training onwards for gaining technical skills alongside scenario-based simulation for developing non-technical skills.

For every training objective ('key capabilities'), there is a description of the type of simulation that can be used. The Royal College of Anaesthetists have developed a simulation strategy which categorically states the importance of being explicit about the curricular areas where simulation can and should be used to gain technical skills (193). This document also covered other aspects of simulation use to consider- assessment, faculty development, quality control and audits etc. The only similar document available for surgical subspecialities is the 'Guide to delivery of Ophthalmology training' which is not specific to simulation and could be expanded to include a similar range of guidance.

For surgical subspecialities, there are numerous stand-alone simulation curricula (194-198). The existing simulation curricula however are not always officially adopted by the training bodies of the surgical subspecialities and require educators to be aware of their existence and be motivated enough to incorporate into the training strategies at a regional level. Many regional training programmes have recognised this gap, and it does explain the regional variations we see in surgical training, potentially contributing to inaccessibility to high quality training in less funded regions. This is evidenced by the example of the lived experience of training in some surgical subspecialities like orthopaedics as indicated by the published studies give the impression that trainees are more familiar with simulation than can be delineated from the orthopaedic curriculum itself (151, 199-202). This is further evidence that curricular design needs to reflect the real world and vice versa.

The aim however should be to achieve standardisation of training in the UK for each speciality.

Therefore, a recommendation of this review would be to move away from developing a separate curricula for simulation but rather rethink and rewrite existing curricula being very specific and explicit in all the techniques that could be used to deliver technical and non-technical skills training via simulation for the individual subspecialities. This should be complementary and alongside traditional training.

Technical skill training in a broader perspective

Surgical training sits within the larger context of healthcare staffing and workforce planning at a national level where training of staff is one of three main priorities (203, 204). Also, the value of simulation is recognised nationally with national strategies to encourage the use of simulation to improve NHS outcomes (203, 205). There is some evidence as well that indicates a multimodal approach that incorporates simulation with conventional training is better than conventional training alone (112). This review has highlighted the flaws that exist in surgical curricular design indicating the foundational work that needs to be carried to align with national strategies and incorporate the principles of evidence-based healthcare.

This study provides the answer for the research question *"How do postgraduate surgical curricula in the UK describe the teaching of technical skills, and in what ways is simulation referred to within these curricula?"* by systematically exploring the content of the UK postgraduate surgical curricula, identifying the nature and scope of advice provided for technical skills training, and describing how simulation is referred to, including the contexts in which it appears and the level of detail offered.

Limitations

To align with the context of my empirical work, the decision was made to include only postgraduate surgical curricula from the UK, ensuring the results were specific to the focus of my thesis. Whilst this decision improved the specificity of the findings, the generalisability of the results may be

limited. Therefore, context must be kept in mind when interpreting the results. Also, some of the curricula (e.g., O&G) have been updated since this review was conducted.

There was no validated tool that was available to critically appraise the curricula and therefore I relied on qualitative methodologies using a narrative approach to present the results. The interpretation of the results therefore relied on the limited details present within the data itself, my experience as a surgical trainee in the UK, my experience as an educator both in the context of simulation and of technical skills in non-simulation environments, as well as the experience of my supervisors of simulation and education. I was cognisant of the aim of the review throughout the process, so that I would not deviate away in neither the data collection nor the interpretation of the results. Further research into curricular development should focus on the development of a validated tool to critically appraise the curricula to ensure nationally created curricula are robust and meet agreed standards.

Chapter Conclusion

The curricula review presented in this chapter was performed to understand the advice provided for teaching technical skills to surgical educators with particular emphasis on using simulation, establish the research gap and to contextualise the interventions designed for part III of this thesis (the empirical studies).

This chapter has practical implications for a wide group of individuals and organisations. Firstly, the trainees who access the curriculum to understand the training requirements. Secondly, the educators who plan training activities based on the guidance the curriculum provides. Thirdly, the Royal Colleges, who author the curriculum and the national bodies that are involved with workforce planning.

The lack of specificities for technical skills training in postgraduate surgical curricula means unless educators are inherently aware of all the technical skill training options and simulation modalities that exist, their default position would be to heavily rely on the learning trainees will receive in an operating theatre environment. Educators cannot leverage simulation effectively without clear guidance on its use, highlighting the need for explicit curricular design.

We know that access to operating theatres is an issue (see Chapters Four and Five for further information) and a multimodal approach is superior to the traditional approach of learning only in an operating theatre. Therefore, curricular reform is vital, where a multimodal approach is taken to providing training and simulation is woven into the foundational fabric of the curricula itself.

Chapter Four: A systematic review and thematic analysis to identify the deficiencies in technical skills training in post-graduate surgical subspecialities before the COVID-19 pandemic

Note on publication of Chapter Four

The research from this chapter was submitted as a paper to Current Surgery Reports on the 20June 2025. It is currently under peer review. The paper that was submitted was titled "Exploring the deficiencies in technical skills postgraduate surgical training prior to the COVID-19 pandemic: A systematic review and thematic analysis". I have adapted the paper in line with the University's requirements to avoid self-plagiarism. The abstract can be found in Appendix Two.

Contribution statement

I was the lead researcher who conceptualised, designed, conducted, and wrote up this work. NMT and HS acted as the second reviewer for the systematic review to screen papers for the title/abstract review as well as the full text review. My supervisors acted as the arbitrator and provided advice in their role as my DPhil supervisors. All authors approved of the final manuscript before submission, and all have approved the inclusion of this research in my thesis.

Chapter Introduction

In Chapter Three, I elaborate on the specific instruction available to educators at a curricular level for technical skills training and specifically focus on the lack of advice regarding the explicit use of simulation. The next logical step, therefore, was to explore the state of surgical training (focussing on technical skills training in the various surgical subspecialities) to understand if the deficiencies

found at a curricular level reflected in the everyday education and practice. As described in the preface of this thesis, this chapter focuses on technical skills training before the COVID-19 pandemic as I had initially assumed that the ideal goal for post pandemic training recovery efforts should be directed towards restoring training to the pre-pandemic standard.

This review started with the view to establish the standard of technical skills training before the COVID-19 pandemic. I was particularly interested in identifying if there were any surgical technical skills training deficiencies that existed before the pandemic. I viewed the post-pandemic recovery efforts as an opportunity for foundational redesign rethinking of surgical training itself.

Background

Technical skills for surgeons require the combination of knowledge and physical proficiency(47, 206, 207). Surgical trainees are expected to learn technical skills through clinical experience, operating in the operating theatre, receiving feedback on their knowledge and operating skills from their clinical supervisors and through simulation-based education (63).

The recent interest in reforming surgical education is a consequence of the COVID -19 pandemic, the impact of which is discussed in the next chapter. However, cognisance must be given to the issues surgical training had prior to the pandemic, otherwise any measure for improvement may not fully address the issues.

Several factors have affected surgical training, such as work hours restrictions for doctors in several countries (USA, Canada, UK, etc), adopting the competency-based training format and RT training pathways. All of these measures have reduced or altered the expected clinical and surgical exposure for trainees and have negatively impacted technical skill acquisition (208-210).

The most visible event in recent memory, of course, was the COVID-19 pandemic that had detrimental consequences for surgical training, increasing educator and trainee anxiety about the acquisition of skills and progression. Without a critical analysis of the issues with training (both pre- and post-pandemic), any changes to surgical training will not be evidence based and may not result in the desired improvements (211, 212).

Research question, aim and objectives

The research question posed for this systematic review was *"What were the challenges and deficiencies in technical skills training for postgraduate surgical trainees prior to the COVID-19 pandemic?"*

The aim of the systematic review was to systematically review and synthesise evidence on technical skills training in postgraduate surgical education before the COVID-19 pandemic, in order to identify deficiencies in training and explore strategies for improvement.

The objectives of the review were:

1. To examine deficiencies with technical skills training for postgraduate surgical trainees prior to the COVID-19 pandemic.
2. To develop themes that inform the development of strategies to improve technical skills training in postgraduate surgical education.

Methods

I followed the guidelines set by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (213) and registered the systematic review protocol with the International Prospective Register of Systematic Reviews (PROSPERO) a priori (registration number: CRD42022304218).

The protocol included inclusion and exclusion criteria for the studies based on the aim of the systematic review. Studies that were included fulfilled the following criteria:

a. The study was about doctors in a postgraduate surgical training programme, in any year of their training.
b. The studies were about technical skills training in any surgical speciality and were published between 2016 to 2018.

Any papers that were letters of correspondence, personal viewpoints, or editorial reviews were excluded

I considered several possible timeframes for this review and ultimately chose to include publications from 2016 to 2018, a three-year period (214). This period was selected for several reasons: the UK surgical curriculum was updated in 2016, ensuring that included studies reflect the most current structure and content of surgical training; restricting the review to this timeframe provides findings that are relevant to modern postgraduate training and useful for informing current strategies; and pragmatically, this period produced a manageable volume of studies for detailed analysis. Additionally, this timeframe aligns closely with the period immediately preceding the COVID-19 pandemic, providing a relevant baseline for understanding technical skills training prior to the disruptions caused by the pandemic.

Search Strategy

After initial discussions with my supervisors and second reviewers, I consulted with a librarian at the University of Oxford to formulate my search strategy (Box 2). I conducted a search of MEDLINE and EMBASE on 7January 2022. Conference abstracts (identified through EMBASE), theses databases via the Oxford University library search engine and reference lists were searched to identify any grey literature. ENDNOTE X9 was used for data management and duplicate studies were removed electronically and by manual searching.

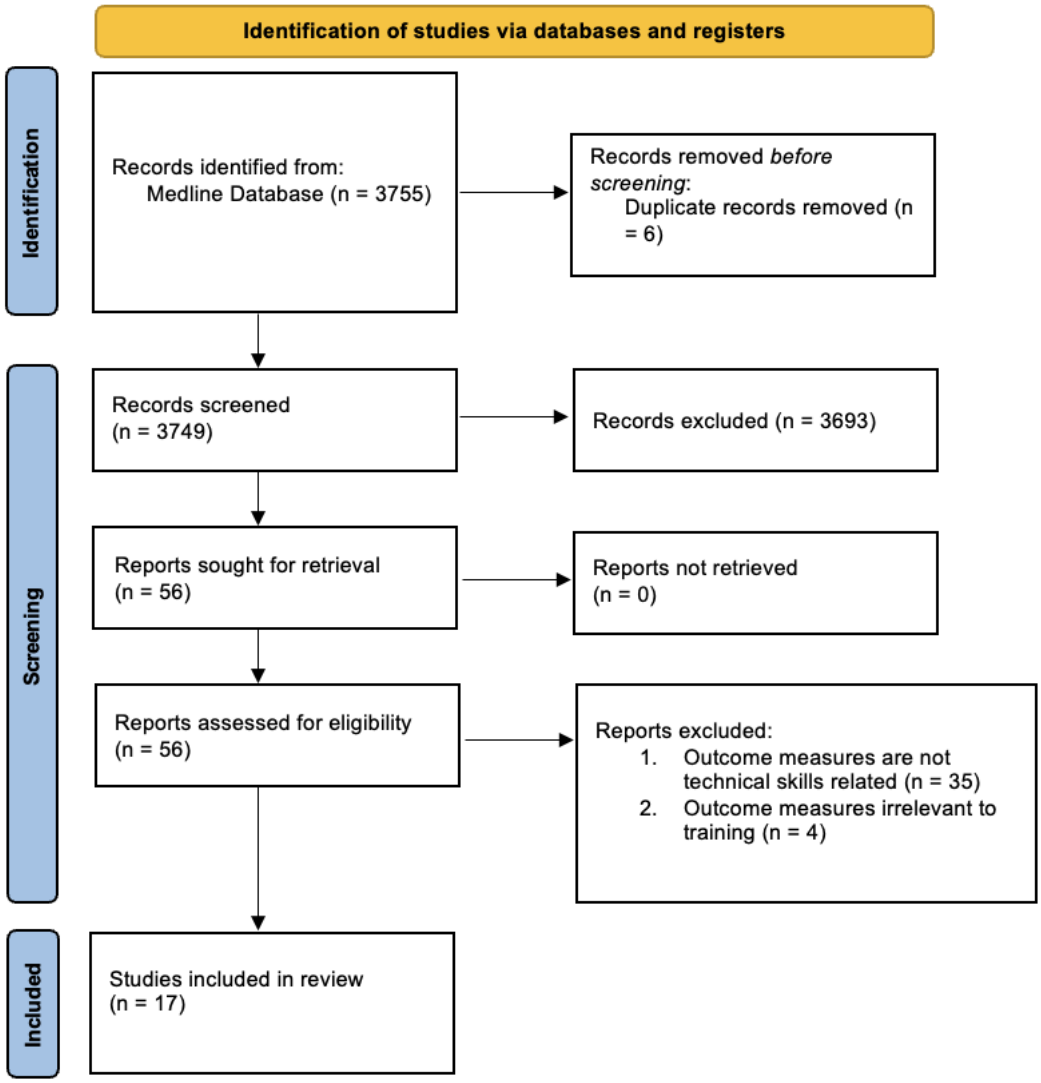
The search strategy intentionally used the .tw field (title/abstract) to balance sensitivity and specificity; this choice was made in consultation with the university librarian to focus retrieval on records where the concepts were central and to provide a manageable yet comprehensive set of records for screening.

1	exp Education, Medical, Graduate/
2	limit 1 to yr="2016 - 2018"
3	((Postgrad* or post grad*) adj3 (train* or learn* or educat* or teach*)).ti,ab.
4	((Postgrad* or post grad*) adj3 (train* or learn* or educat* or teach*)).tw.
5	Residen*.tw.
6	Intern*.tw.
7	Specialist trainee*.tw.
8	Registrar*.tw.
9	1 or 3 or 4 or 5 or 6 or 7 or 8
10	2 and 9
11	exp Specialties, Surgical/
12	(Surg* or operat* or procedur*).tw.
13	Neurosurg*.tw.
14	Obstetric*.tw.
15	Gynaecolog*.tw.
16	Gynecolog*.tw.
17	ENT.tw.
18	Otolaryngol*.tw.
19	Orthopaedic*.tw.
20	Orthopedic*.tw.
21	Urolog*.tw.
22	Ophthalmol*.tw.
23	11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22
24	10 and 23

Box 2 The search strategy included synonyms for resident and all 12 surgical subspecialities

Screening of the studies

I reviewed the titles and abstracts of all the 3749 studies identified, after duplicates were removed. Nadia Muspratt Tucker (NMT) and Hikari Sakurai (HS)screened the titles and abstracts independently as second reviewers, each reviewing half of the papers. My supervisors acted as the arbitrator for any disagreements and decisions were made after discussion among all the reviewers. Full text reviews were also conducted independently by me and NMT/HS as second reviewers. Seventeen studies were deemed eligible for data extraction (Figure 4).



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Figure 4 The PRISMA flow diagram for the systematic review on surgical training (215)

Data extraction

Data was extracted into a pre-designed extraction sheet on Microsoft Excel™ focussing on study design, surgical speciality, participant population, demographics, country of the study and technical skills training related outcome measures. I performed the data extraction. The other reviewers and my supervisors reviewed my data extraction table and verified that all relevant data had been extracted.

Quality assessment

The National Institute of Health (NIH) quality assessment tool for Observational, Cohort and Cross-sectional studies tool, which has 14 items to consider judging quality, was applied to all the included studies. The risk of bias of the studies were determined as good, fair or poor (216).

Data Analysis

Once the data extraction was completed, the data was inductively coded, and a thematic analysis was performed. This was an iterative process, referring to the aim and going back to the data to ensure the coding and thematic analysis was representative of the data. Further analysis involved a synthesis of the results to develop themes and a conceptual model (217, 218). These steps involved discussions and iteratively going back and forth between the primary data set, the aim of the review, the codes and themes that emerged.

Changes to the registered protocol

The registered protocol was exploratory and had a broad range of outcomes, including both technical and non-technical skills. On further discussion with surgical trainees and educators, it became obvious that in the aftermath of the COVID-19 pandemic (when I started my doctoral studies) technical skills training was the cause of most concern. Therefore, I narrowed the scope of my thesis to examine surgical technical skills training and modified the systematic review protocol accordingly. Additionally, I had initially intended to use the Critical Appraisal Skills Programme

(CASP) checklist for the quality assessment of the studies but as the methodologies of the included studies varied widely, I decided to use the NIH quality assessment tool for Observational, Cohort and Cross-sectional studies tool instead(216).

Results

The titles and abstracts were screened for 3749 studies, of which 56 studies were selected for full text screening. Of the 56 studies, 17 were accepted for data extraction (Figure 4). All of the included studies were about technical skills training in surgical subspecialities. A few of the included studies, though published between 2016 and 2018, reviewed surgical training from 1991 onwards (138, 219, 220). The majority of the studies (88%) were conducted in high income countries (Table 4) (221). Notable was the absence of studies from low-income countries. Fifty three percent of the studies were from general surgery and orthopaedics (Table 4). None of the included studies were from OMFS, ENT, Paediatric surgery, or Vascular surgery. Eighty-two percent of the studies employed quantitative methods, with nearly half of the studies (47%) relying on self-reported data collected through surveys (Table 5).

The World Bank classification of countries	**Included studies (n=17)**
High Income countries	15 (88%)
Upper middle-income countries	1 (6%)
Lower middle-income countries	0
Low-income countries	0
Global: High income and upper middle income	1 (6%)
Subspecialities	**Included studies (n=17)**
Cardiothoracic surgery	1 (6%)
General surgery	5 (29%)
Neurosurgery	1 (6%)
Oral and Maxillofacial surgery (OMFS)	0
ENT	0
Paediatric	0
Plastic surgery	0
Orthopaedics	4 (24%)
Urology	1 (6%)
Vascular	0
Obstetrics and Gynaecology	1 (6%)

The World Bank classification of countries	**Included studies (n=17)**
Ophthalmology.	1 (6%)
Bariatric surgery	1 (6%)
Multiple surgical subspecialities	2 (12%)

Table 4 Classification of countries where the studies were conducted by socio-economic status based on the World Bank world development indicators (221)and analysis of the surgical subspecialities that are represented in the studies included in this review. Abbreviations- ENT- Otolaryngology, OMFS- Oral and Maxillofacial surgery

Methodology	**Methodology used in the studies (n=17)**
Quantitative	14 (82%)
Qualitative	3 (18%)
Mixed Methods	0
Further analysis of methodology	
Quantitative methodology	
Self-reported data: Surveys	8 (47%)
Non-self-reported data: Operative logs, workplace-based assessments, calculation of costs etc.	5 (29%)
Review of literature	1 (6%)
Qualitative methodology	
Self-reported: Interviews etc	1 (6%)
Review of literature	2 (12%)

Table 5 Methodology of the studies included in the review. This table also details further analysis of the methodologies based on the sources of data

Risk of bias assessment

The NIH quality assessment tool for Observational, Cohort and Cross-sectional studies (216) was used to assess the risk of bias and quality of each study as good, fair or poor (Tables 6, 7, 8 and 9). Studies were not excluded if they were of poor quality, but consideration was given to the quality of the study when interpreting the results.

Results of the thematic analysis

The thematic analysis was conducted to identify deficiencies in postgraduate surgical technical skills training and to explore potential strategies for improvement. The objectives of this review were the identification of deficiencies in technical skills training for postgraduate surgical trainees and the development of strategies to improve technical skills training in postgraduate surgical education. Two central themes emerged from the analysis: the use of a multimodal approach to training and the adoption of a structured approach to technical skills education (Figure 5). Within these themes, subthemes highlighted specific strategies for improving training: providing adequate supervision and feedback and implementing innovative solutions to support regular simulation use. An additional subtheme reflected concerns that trainees were less independent in performing surgical procedures than expected at the completion of training.

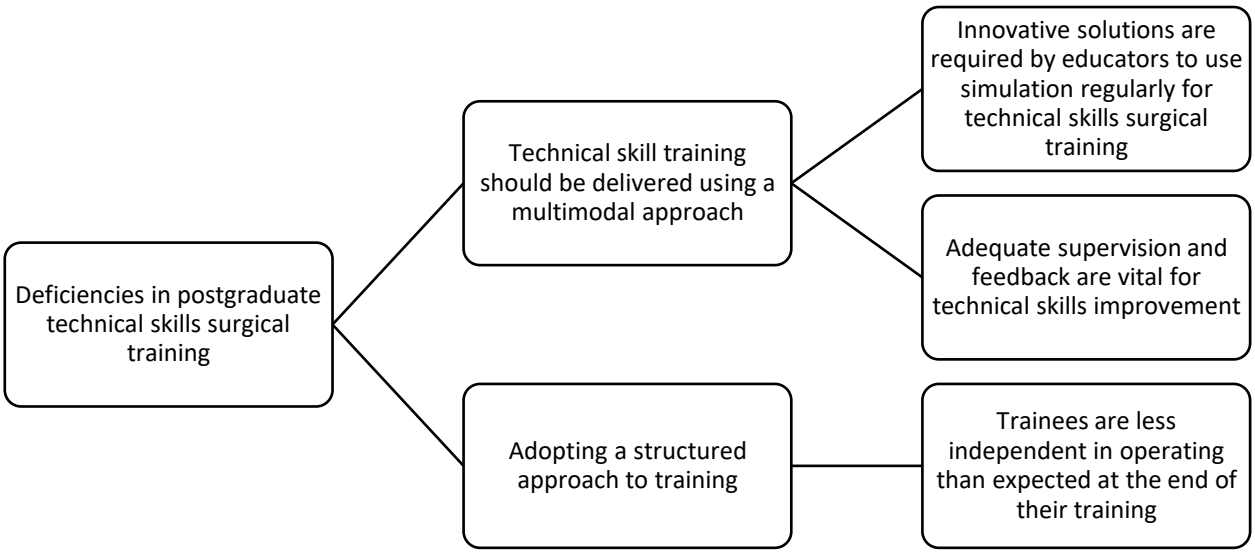


Figure 5 A conceptual framework showing the results of the thematic analysis with two themes and three subthemes (218)

Theme: Technical skills training should be delivered using a multimodal approach (Tables 6 and 7)

A multimodal approach for technical skills training refers to a combination of approaches used in tandem to help trainees learn their operative skills without relying completely on experience gained in theatre alone. Modalities to consider are different types of simulation (laparoscopic box trainers, VR simulators, AR simulators, cadaveric simulation etc.) and operating in the operating theatre under decreasing amounts of supervision.

Irrespective of the modality used, providing feedback on performance is vital to trainees to help them develop their technical skills. The theme emerged from data derived from nine of the 17 papers in this review (53%)(219, 222-229).

Subtheme: Adequate supervision and feedback are vital for technical skills improvement (Table 6)

A large cohort of trainees in the included studies expressed their wish for increased supervision and feedback whilst learning technical skills. More than half the trainees felt they would did not receive adequate clinical supervision and that feedback would have been beneficial for technical skills learning. Direct feedback was helpful for assessing performance in simulation (228, 229)

Title, Year of publication, Country, Speciality	**Study Design**	**Results**	**Risk of bias**
Objective Structured Assessments of Technical Skills (OSATS) Does Not Assess the Quality of the Surgical Result Effectively , 2016, (228), USA , Orthopaedics	Prospective comparative study at two institutes with 21 students. Assessed with OSATs on fracture reduction performed on simulation models	The majority of residents could perform the fracture fixation to adequate standards. However, OSATs scores did not correlate well with the quality of the articular reduction. Direct feedback by measuring the articular reduction during the simulation helped assess the resident's performance	Fair
What are the Training Gaps for Acquiring Laparoscopic Suturing Skills?, 2017, (224), Canada, General surgery	Prospective study using qualitative grounded theory methodology of senior residents, faculty, and fellows	Some of the themes that emerged were the lack of feedback (teaching without guided supervision or effective feedback), differing expectations (discrepancy between the performance metrics in simulation and those in the clinical environment)	Good
Self-perceived readiness to perform at the attending level following surgical specialist training in Denmark, 2017, (229), Denmark, General surgery, Gastrosurgery	Retrospective mixed methods study. Survey of all Danish surgical residents graduating from in 2012 and 2013	57% (n = 17) felt they had not received adequate supervision during their specialist training. 80% (n = 24) felt increased supervision would have increased their self-perceived competencies to serve as a surgical specialist. Self-perceived readiness to perform at the attending level was significantly associated with supervision during training (p = 0.02)	Good

Table 6 Theme: Technical skill training should be delivered using a multimodal approach, subtheme: Adequate supervision and feedback are vital for technical skill improvement. Abbreviations: OSATS- Objective Structured Assessments of Technical Skills, USA- United States of America

Subtheme: Innovative solutions are required by educators to use simulation regularly for surgical technical skills training (Table 7)

The reviewed studies collectively indicate that frequent and regular use of simulation provides a valuable opportunity to help trainees gain and maintain technical skills outside the operating theatre (222-227). A diverse range of simulation modalities could be employed depending on local resources and availability. For simulation training to be a regular and consistent feature of technical skills training despite their busy training schedules, innovative measures are required.

Title, Year of publication, Country, Speciality	**Study Design**	**Results**	**Risk of bias**
Simulation for Teaching Orthopaedic Residents in a Competency based Curriculum: Do the Benefits Justify the Increased Costs?, 2016, (219), Canada, Orthopaedics	Cost and faculty work-hours analysis of implementing simulation as a teaching and evaluation tool	The total number of hours spent teaching and assessing using simulation in the training program before the competency-based curriculum was implemented (2008–2009) was 96 hours . The total number of hours spent teaching and assessing using simulation after the introduction of the competency-based curriculum was 317 hours	Fair
Resident Training in Bariatric Surgery—A National Survey in the Netherlands, 2017, (222), Netherlands, Gastrosurgery	Prospective cross-sectional survey of 19 centres	All surgeons (n=27) mandated completion of a basic laparoscopic training course (100%). One of the trainers reported giving supervised laparoscopic box training before starting in vivo training. Each of the three groups studied adopted a different approach to surgical training: unstructured, performing smaller parts of the surgery first and learning the steps of the surgery in chronological order respectively, showing large variation in the training residents received. Recommendations included ex-vivo laparoscopic dexterity training (unsupervised box training and supervised box training with formative feedback) and cadaver simulation training for specific	Fair

Title, Year of publication, Country, Speciality	Study Design	Results	Risk of bias
The role of simulation in urological training. A quantitative study of practice and opinions, 2016, (223), UK, Urology	Prospective cross-sectional survey of 91 residents and 172 specialists	Trainees and specialists who had simulation experience in technical skills training: basic surgical skills (60% vs 48%), cystoscopy (30% vs 28%), urethroscopy (54% vs 42%), TURP (45% vs 38%), percutaneous renal surgery (22% vs 27%), nephrectomy (38% vs 39%). Specialists agreed that trainees should be competent in performing the procedure in a simulation setting before being allowed to perform on patients, yet the majority had no prior simulation experience. There was no consistency in the use of simulation	Good
What are the Training Gaps for Acquiring Laparoscopic Suturing Skills?, 2017, (224), Canada, General surgery	Prospective qualitative grounded theory study of 15 surgical trainees and ten experts in minimally invasive surgery from eight centres	Themes related to simulation were misalignment of the timing of clinical training with simulation training, lack of regular exposure to operative experience requiring laparoscopic suturing, lack of regular training in simulation	Good

Title, Year of publication, Country, Speciality	Study Design	Results	Risk of bias
Comparison of Canadian and Swiss Surgical Training Curricula: Moving on Toward Competency-Based Surgical Education, 2016, (225), Switzerland, Canada, General surgery	Prospective cross-sectional survey (n=105) of residents and consultants at 2 university hospitals	There was a large discrepancy between the two hospitals regarding the number of hours of teaching the residents received (9% vs 2%). Majority of consultants and residents of both units considered training outside the operating rooms (e.g., VR stimulation training and surgical laboratory-based skills training) as an important component of surgical education. They considered the benefits as improved patient safety, patient outcomes and surgical skills. There were disparity with simulation use between the two institutes	Good
Where do we start? The first survey of surgical residency education in Japan, 2016, (226), Japan, General surgery, Gastrosurgery, Cardiovascular and Thoracic surgery	Prospective cross-sectional survey of programme directors in 76 teaching hospitals	86% of the institutes had structured programmes for technical skill training- taught through patient centred activities or in seminars. 44% had simulation centres or sim labs at their institutes. 94% had box trainers for laparoscopy, 38% used animal tissue, 19% had procedure specific simulators, 13% had high fidelity mannequins. Only 2 institutes (13%) integrated simulation-based training into their routine curriculum. All the other institutes used simulation irregularly	Good

Title, Year of publication, Country, Speciality	Study Design	Results	Risk of bias
Resident education in orthopaedic trauma, 2016, (227), UK, Canada, USA, Orthopaedics	Literature review of competency-based education for orthopaedics	The national training bodies mandate the availability of simulation space for surgical skills training with mandated laboratory based surgical skills and simulation training for first-year orthopaedic residents. A task force has been formed to develop a simulation curriculum which has 17 modules focused on basic skills and uses low-cost, low-tech simulations aimed at junior-level learners	Poor

Table 7 Theme: Technical skill training should be delivered using a multimodal approach, subtheme: Innovative solutions are required by educators to use simulation regularly for technical skill surgical training. Abbreviations CCT- Certificate of completion of training, TURP- Transurethral Resection of Prostate, UK- United Kingdom, USA- United States of America), VR- Virtual Reality

Theme: Adopting a structured approach to training (Tables 8 and 9)

There is significant variability in the training programmes reviewed globally (138, 220, 222, 223, 229-235). The differences included length of training and operative experience required to demonstrate competence at the end of the surgical training.

The studies highlight the need for training to be based on a well-structured framework so that tracking progress becomes straightforward which fosters a positive learning environment. This finding is particularly relevant to educational bodies who design the curriculum as well as local educators who interpret the curriculum to plan training.

Though the introduction of competency-based training signals a desire to adopt a structured approach to surgical training, these results indicate that inadequacies existed in technical skills training globally even before the COVID-19 pandemic.

Title, Year of publication, Country, Speciality	Study Design	Results	Risk of bias
Cardiothoracic surgery training in Israel: A critical look at the past, aiming for a better future, 2016, (230), Israel, Cardiothoracic surgery	Literature and census review	There is no mandate to log general surgery cases. There are case log requirements for the speciality related that should be met by the residents in order to complete the training programme.	Poor
Meta-analysis of operative experiences of general surgery trainees during training, 2016, (138), Global, General surgery	Systematic review, 24 studies covered training from 1991 to 2013	Mean total operative experience in training varied from 783 procedures in Thailand to 1915 in the UK. Large variation in operative numbers between units and countries.	Good
Changes in UK ophthalmology surgical training: analysis of cumulative surgical experience 2009–2015, 2017, (220), UK, Ophthalmology	Retrospective review of records of those who received CCT from the Royal College of Ophthalmologists from 2009- 2015	The overall median for the 7-year study period was 592 cases. There were two types of surgical training programmes in the study period- 4.5-year higher speciality training and 7-year ophthalmology specialist training. The longer training programme had more surgical cases performed for the majority of procedures when the logbook data was compared.	Good

Title, Year of publication, Country, Speciality	Study Design	Results	Risk of bias
Orthopaedic Surgery Residents and Program Directors Agree on How Time Is Currently Spent in Training and Targets for Improvement , 2016, (236), USA, Orthopaedics	Prospective cross-sectional survey of residents and programme directors about how training is structured	Senior residents spend more time as the primary surgeon than interns and juniors (statistically significant difference). Majority of programme directors felt the time allocated to the operating theatre should be equal for all training years.	Good
Neurosurgical Resident Training in Germany, 2017, (232), Germany, Neurosurgery	Prospective cross-sectional survey to neurosurgical trainees between June 2014 and March 2015	German residents (n= 94) were 94% as likely as non-German European trainees (n= 437) to be satisfied with hands-on operative training at their teaching facility. They were 68% as likely to be satisfied with microsurgical training (p=0.110), 11% as likely to be satisfied with simulator training (p=0.003), 12% as likely to be satisfied with cadaver training (p < 0.001), and 79% as likely to be satisfied with decision making (p= 0.455). In general, 89% of European residents indicated to perform their first surgical procedure as primary surgeon within the first year of training.	Fair

Table 8 Theme: Adopting a structured approach to training. Abbreviations: CCT- Certificate of Completion of Training , UK- United Kingdom, USA- United States of America

Subtheme: Trainees are less independent in operating than expected at the end of their training (Table 9)

Both trainees and educators have independently noted that the level of operative independence achieved at the end of training programmes does not always meet the expectations set out in national curricula and certification standards (e.g. CCT or equivalent). These expectations typically require trainees to be able to perform defined index operations without direct supervision. Several studies included in this systematic review reported gaps between these expectations and trainees' self-perceived or demonstrated competence at the completion of training (222, 223, 229, 233, 234).

Title, Year of publication, Country, Speciality	**Study Design**	**Results**	**Risk of bias**
Resident Training in Bariatric Surgery-A National Survey in the Netherlands, 2017, (222), Netherlands, Gastrosurgery	Prospective cross-sectional survey of 19 centres	At the end of residency only 16% of residents were able to perform bariatric surgery independently	Fair
The role of simulation in urological training- A quantitative study of practice and opinions, 2016, (223), UK, Urology	Prospective cross-sectional survey of 91 residents and 172 specialists	Sufficiency of technical skills levels were assessed, with approximately 88% of specialists agreeing that their training was sufficient for their first day in the speciality, compared to only 25% of trainees	Good
Self-perceived readiness to perform at the attending level following surgical specialist training in Denmark, 2017, (229), Denmark, General surgery, Gastrosurgery	Retrospective mixed methods analysis of data collected by survey of all Danish surgical residents graduating from the national surgery residency programme in 2012 and 2013	At the end of their 5-year programme, 47% felt ready for independent specialist practice. Self-perceived readiness to perform at the attending level was significantly associated with supervision during training ($p = 0.02$)	Good

Title, Year of publication, Country, Speciality	Study Design	Results	Risk of bias
Preparedness of Obstetrics and Gynaecology Residents for Fellowship Training, 2016, (233), USA, Obstetrics and Gynaecology	A mixed methods, prospective cross-sectional survey of 218 fellowship programme directors exploring preparedness for fellowship between June 2014 and August 2014	50% of incoming fellows were rated as not able to perform 30 minutes of a major procedure with their attending outside the room (for all super- subspecialities except materno-foetal medicine<0.001). Despite this deficiency on entry to fellowship, 88% of fellowship directors agreed that fellows were able to perform independently by the end of fellowship. Only 20% of incoming fellows could independently perform a vaginal hysterectomy, 17% a vaginal bilateral salpingo-oophorectomy, 23% an anterior colporrhaphy, and 30% a posterior colporrhaphy	Good
Are 2 Years Enough? Exploring Technical Skills Acquisition Among General Surgery Residents in Brazil, 2016, (234), Brazil, General surgery	Prospective observational study of 60 residents who were assessed performing 11 types of operations	88% percent of residents were rated as able to perform the low-difficulty operations. Operations of medium difficulty, the overall proportion of residents judged-proficient was 66%. Only 17% of all residents were rated as proficient in the most difficult operations. Only 17% of residents would be considered eligible for Board Certification. There were statistically significant differences in performance between residents in the 4-year programme and the 2-year programme, with the former outperforming in all operations	Good

Title, Year of publication, Country, Speciality	**Study Design**	**Results**	**Risk of bias**
Operative Experience vs. Competence: A Curriculum Concordance and Learning Curve Analysis, 2016, (235), UK, General surgery	Retrospective review of head of school annual reports and operative logs of 69 general surgical trainees between August 2007 and 2014, to ascertain the relationship between competence and operative volume	Only 8 trainees achieved all required competencies for certificate of CCT, and another 7 trainees had achieved CCT competences in 5 of the 6 procedures. 18 trainees met target numbers for all 6 procedures. All procedures required more operating than the recommended procedure numbers to achieve competence. Hartmann's procedure required more than three times the number (p=0.009)	Good

Table 9 Theme: Adopting a structured approach to training, subtheme: Trainees are less independent in operating than expected at the end of their training. Abbreviations: CCT- Certificate of Completion of Training, UK- United Kingdom, USA- United States of America

Discussion

The aim was specifically to identify areas for improvement in technical skills training for doctors in postgraduate surgical training programs prior to the COVID-19 pandemic and included evidence gathered from 17 papers. A thematic analysis helped develop higher order concepts that identified areas of improvement and changes to technical skills training that were required. The studies were mainly conducted in high income countries, with no representation of middle- or low-income countries. We found that challenges existed with technical skills training prior to the start of the COVID-19 pandemic, indicating the issues are systemic, not caused only by a single event.

Multimodal approach to technical skills training

The evidence from this review aligns with existing evidence indicating that surgical trainees continue to encounter challenges in acquiring all of the competencies and skills expected within the duration of their training (237). The competing demands on a trainee's time include balancing service provision with training needs, potentially contributing to the difficulties with achieving the competencies needed (238, 239). Although pressures and time constraints are difficult to avoid, endeavours must be made to optimise the time trainees do spend in training by adopting a multimodal approach, using a combination of simulation and learning in the operating theatre for gaining technical skills (89, 240).

Simulation facilities are increasingly readily available due to the discussion around the changes to surgical training including the reduced working hours and the impact on technical skills training opportunities such as attending the operating theatre (25, 241). There is also plenty of evidence that demonstrates the efficacy of simulation for technical skills learning as discussed in Chapter One of this thesis (25, 242, 243).

This review advocates for the use of a multimodal approach to training, incorporating various simulation training modalities regularly in conjunction with operating on patients to gain surgical technical skills, which is supported by existing evidence (244-247). Importantly, though there are definite evidence-based benefits to using simulation, our review suggests it is infrequently and inefficiently used to provide training.

Adopting a structured approach to training

Several studies highlight the differences in surgical training across countries including the length of training and the number of procedures required to achieve each competency (248, 249). A move towards competency-based training was especially noted in high income countries. A competency based training is likely to be a more objective and standardised system (248). However, trainees continue to feel unprepared for consultant jobs at the end of their training (31, 250). Adequate support, mentoring, regular assessments and feedback are all required to improve the structural framework of surgical training to bridge this gap (47). Validated tools are available, such as the Surgical Hands-on Assessment and Rating of Performance (SHARP) tool, that help educators provide accurate and objective operative feedback (251) and educators should be encouraged to routinely use such tools. Additionally, the regular review of progress and achievement motivates trainees to engage frequently and readily with training sessions (252, 253).

Implications for the future of surgical training

The findings and themes from this review challenge the belief that surgical training was exclusively impacted by the COVID-19 pandemic alone and uncovered an opportunity to address pre-existing deficiencies. We will explore the impact of the pandemic further in the next chapter to understand the extent to which surgical training was impacted. Any interventions to improve surgical training should involve incorporating simulation regularly, embedding structure to providing feedback and the establishment of clear, standardised competency requirements across surgical specialties.

Limitations and Future Directions

The quality of studies included in the review had an impact on the reliability of findings. For example, there were no RCTs, and the majority of studies relied on self-reported data collected through surveys. I accounted for this by using qualitative measures to identify the themes that emerged from the data, developing a conceptual model. Restricting publications to English may have also affected the scope and generalisability of the review. Additionally, there were no publications from low-income countries, potentially indicating a publication bias and affecting the applicability of the findings to low-income countries where the availability of simulation facilities could be variable.

Not all surgical subspecialities are represented in this review and the studies report on training from as early as 1991. There could be training discrepancies between countries even though the majority of training programmes in developed countries have moved towards competency-based training. There has been simultaneous evolution in simulation technologies (with the availability of VR and AR simulation) and a growing positive attitude towards simulation in this time frame. Additionally, it was difficult to identify all the sources of grey literature due to the large number of surgical subspecialities that were included which meant identifying relevant conferences and handsearching the abstracts impractical. Instead, conference abstracts were identified through the EMBASE search. Also, reference lists were hand searched, and the theses database was searched via the Oxford library website. All of these factors may have influenced the themes developed from the thematic analysis. Therefore, the results must be reviewed in context of where the training interventions will be applied.

The research question for this study was: *"What were the challenges and deficiencies in technical skills training for postgraduate surgical trainees prior to the COVID-19 pandemic?"* In summary, this review highlighted several reported deficiencies in technical skills training, including limited opportunities for technical skills practice, variable supervision and feedback, and a desire for structured approach to training.

The thematic analysis suggested potential strategies for addressing these gaps, such as adopting multimodal and structured training methods, enhancing supervision and feedback, and supporting regular simulation.

Chapter Conclusion

This systematic review clarifies that challenges in surgical technical skills training existed before the COVID-19 pandemic, an important finding to keep in mind when planning training reform.

Surgical technical skills training reform requires a multimodal and structured approach to training, incorporating simulation and consistent feedback to ensure trainees are appropriately supported in meeting the standardised competency requirements.

Future research should focus on evidence-based restructuring of surgical curricula to incorporate the routine and regular use of simulation with emphasis on faculty development in order for the changes to be sustainable in the long term.

Chapter Five: A systematic review exploring the impact of the COVID-19 pandemic on postgraduate technical skills training in surgical subspecialities

Note on publication of Chapter Five

The research from this chapter was submitted as a paper to Current Surgery Reports on the 20th of June 2025. It is currently under peer review. The paper that was submitted was titled "Investigating the impact of the COVID-19 pandemic on postgraduate surgical technical skills training: a systematic review". I have adapted the paper in line with the University's requirements to avoid self-plagiarism. The abstract can be found in Appendix Two.

Contribution statement

I was the lead researcher who conceptualised, designed, conducted, and wrote up this work. NMT and HS acted as the second reviewer for the systematic review and BH acted as second reviewer for the update, to screen papers for the title/abstract review as well as the full text review. My supervisors acted as the arbitrator and provided advice in their role as my DPhil supervisors. All authors approved of the final manuscript before submission, and all have approved the inclusion of this research in my thesis.

Chapter Introduction

In Chapter Three, I established the lack of instruction at a curricular level for technical skills training and the use of simulation. In Chapter Four, I recognised that concerns existed about technical skills training in surgical subspecialities prior to the COVID-19 pandemic and explored the deficiencies with the development of a conceptual framework for surgical training reform. If we are to improve

technical skills training for surgeons, we need to have a thorough understanding of the current environment in which surgical trainees work and learn. As surgical educators we must acknowledge that any surgical training reform planned will be implemented in the post-pandemic era, a time when trainee morale and satisfaction have declined (254). Therefore, it is vital that in this chapter we explore the impact of a major global event in modern times and its impact on surgical training- the COVID-19 pandemic.

There were a few notable milestones that have impacted surgical training in the last two decades. Some of these milestones included:

1. The adoption of work hour restrictions, EWTD or the Accreditation Council for Graduate Medical Education (ACGME) restrictions, that have reduced the weekly hours a doctor can work
2. The introduction of competency-based training, fixed training pathways and RT programmes(208-210)
3. The COVID 19 Pandemic

Surgical training was affected during the pandemic due to several factors, including the postponement of professional exams, fewer hands on surgical training opportunities, cancelling of educational courses, reduced simulation training and redeployment and workforce restructuring (255). The concerns trainees and educators had during the pandemic are reflected by the increase in publications related to surgical training. For example, when using the search terms "technical skills training" and "surgery" on PubMed, the number of publications per year showed an upward trend over the last two decades (Figure 6) and reached a peak at the time of the pandemic (256). There was also uncertainty about which educational interventions to use in recovery planning (257, 258).

A few systematic reviews on surgical training from different surgical subspecialities were published during and immediately after the pandemic (2, 259, 260). The reviews, however, either

did not provide enough detail about technical skills training, did not include all 12 surgical subspecialities, had included medical students and residents, were geographically restricted or had a wide range of outcome measures that were not sufficiently specific to allow detailed understanding of technical skills training.

I wanted to have an in-depth understanding of the impact of the pandemic on technical skills training for postgraduate doctors and to specifically include all 12 surgical subspecialities in the search criteria, hence the rationale for this review.

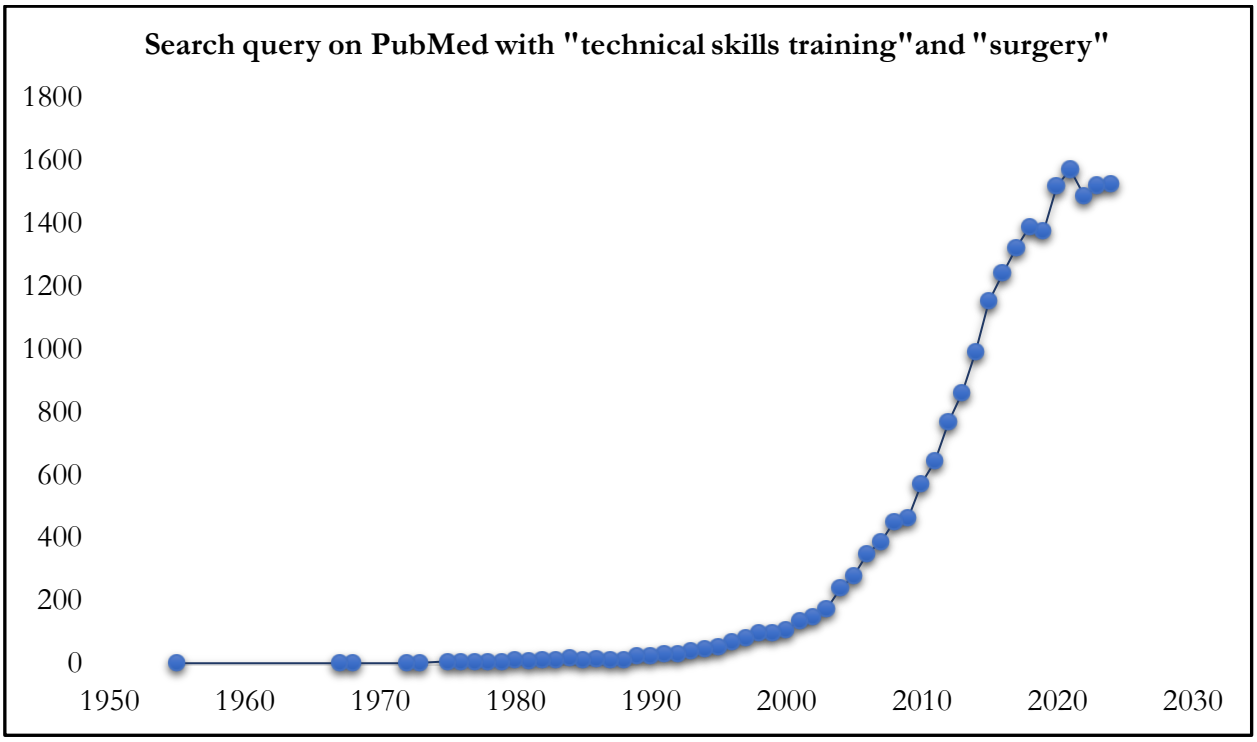


Figure 6 The number of publications per year from PubMed using the search terms "technical skills training" and "surgery". The data highlights an upward trend in publications from 1999 onwards, reflecting increasing research interest in this area. Notably, a peak is observed around the time of the COVID-19 pandemic, likely secondary to the sudden changes to the surgical service that affected trainee education. The x axis shows the year of publication, and the y axis represents the number of publications (256)

The research question for this systematic review was

" What was the impact of the COVID-19 pandemic on postgraduate technical skills training in surgical subspecialties?"

The aim was to explore the impact of the COVID-19 pandemic on post-graduate technical skills training in surgical subspecialities.

The objectives of the systematic review were:

- To evaluate the impact of the COVID-19 pandemic on opportunities for technical skills acquisition in postgraduate surgical training, including changes in operative exposure, case volume, and levels of operative autonomy.
- To examine the use of simulation and alternative technical training modalities during the pandemic, including access to and engagement with these approaches during the pandemic.
- To explore surgical trainees' perceptions of the impact of the pandemic on their technical skills, confidence, satisfaction with training, and progression towards independent practice, including concerns regarding competency attainment and training delay.

Methods

This systematic review was conducted in two parts; the first search was conducted concurrently with the systematic review presented in Chapter Four and the second search to update the systematic review was conducted on 24 October 2025. The systematic reviews (Chapters Four and Five)are methodologically similar including a common systematic review protocol that was registered a priori with PROSPERO (registration number: CRD42022304218). I conducted the systematic review and the subsequent update following the guidelines set out by PRISMA (213).

Changes to the registered protocol

The registered protocol was exploratory and had a broad range of outcomes, including both technical and non-technical skills. On further discussion with surgical trainees and educators, it became obvious that in the aftermath of the COVID-19 pandemic (when I started my doctoral studies) technical skills training was the cause of most concern. Therefore, I narrowed the scope of

my thesis to examine surgical technical skills training and modified the systematic review protocol accordingly. Additionally, I had initially intended to use the Critical Appraisal Skills Programme (CASP) checklist for the quality assessment of the studies but as the methodologies of the included studies varied widely, I decided to use the NIH quality assessment tool for Observational, Cohort and Cross-sectional studies tool instead (216).

Inclusion criteria

Studies were eligible for inclusion if they investigated doctors in postgraduate surgical training programmes across any surgical specialty or subspecialty. Studies were required to be conducted and published during the COVID-19 pandemic. Eligible studies were expected to report outcomes relevant to the acquisition, maintenance, or perceived impact of technical surgical skills. These included:

Primary outcomes

1. Operative exposure and case volume
2. Operative autonomy and role in theatre
3. Engagement with simulation or alternative technical training modalities

Secondary outcomes

1. Perceived decline in technical skills and confidence
2. Satisfaction with technical skills training and perceived impact on progression

All study designs employing quantitative, qualitative, or mixed-methods approaches were eligible for inclusion. Letters, correspondence, individual opinion pieces, and editorial reviews were excluded.

Search Strategy

To develop the search strategy, I was assisted by a specialist librarian from the University of Oxford. I developed the search strategy after due consideration to Medical Subject Headings (MeSH) terms and synonyms that could be used for words like "trainee" and "resident" (Box 3). A comprehensive search of MEDLINE and EMBASE was undertaken on 7January 2022, which included grey literature from conference abstracts. ENDNOTE X9 was used to store the search results and automatic de-duplication was performed. Further de-duplication was done by hand. Further attempts were made to identify grey literature by searching the theses databases via the Oxford University library search engine and handsearching reference lists.

The search strategy intentionally used the .tw field (title/abstract) to balance sensitivity and specificity; this choice was made in consultation with the university librarian to focus on retrieval of relevant studies and provide a manageable yet comprehensive set of articles for screening.

Systematic review update

To perform the systematic review update, I consulted with the specialist librarian from the University of Oxford and modified the search strategy in Box 3 to include the timeframe of 2022 and 2023 publications. The search of MEDLINE and EMBASE databases was undertaken on 24October 2025. ENDNOTE X9 was used to store the search results and automatic de-duplication was performed. Further de-duplication was done by hand.

1 exp Education, Medical, Graduate/	1 exp Education, Medical, Graduate/
2 ((Postgrad* or post grad*) adj3 (train* or learn* or educat* or teach*)).ti,ab.	2 ((Postgrad* or post grad*) adj3 (train* or learn* or educat* or teach*)).ti,ab.
3 ((Postgrad* or post grad*) adj3 (train* or learn* or educat* or teach*)).tw.	3 ((Postgrad* or post grad*) adj3 (train* or learn* or educat* or teach*)).tw.
4 Residen*.tw.	4 Residen*.tw.
5 Intern*.tw.	5 Intern*.tw.
6 Specialist trainee*.tw.	6 Specialist trainee*.tw.
7 Registrar*.tw.	7 Registrar*.tw.
8 1 or 2 or 3 or 4 or 5 or 6 or 7	8 1 or 2 or 3 or 4 or 5 or 6 or 7
9 exp Specialties, Surgical/	9 exp Specialties, Surgical/
10 (Surg* or operat* or procedur*).tw.	10 (Surg* or operat* or procedur*).tw. 4509845
11 Neurosurg*.tw.	11 Neurosurg*.tw.
12 Obstetric*.tw.	12 Obstetric*.tw.
13 Gynaecolog*.tw.	13 Gynaecolog*.tw.
14 Gynecolog*.tw.	14 Gynecolog*.tw.
15 ENT.tw.	15 ENT.tw.
16 Otolaryngol*.tw.	16 Otolaryngol*.tw.
17 Orthopaedic*.tw.	17 Orthopaedic*.tw.
18 Orthopedic*.tw.	18 Orthopedic*.tw.
19 Urolog*.tw.	19 Urolog*.tw.
20 Ophthalmol*.tw.	20 Ophthalmol*.tw.
21 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20	21 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20
22 8 and 21	22 8 and 21
23 COVID-19/ or Coronavirus/ or SARS-CoV-2/	23 COVID-19/ or Coronavirus/ or SARS-CoV-2/
24 22 and 23	24 22 and 23
	25 limit 24 to yr="2022 - 2023"

Box 3 Search terms used for the systematic review (left) and the systematic review update (right) to examine the impact of COVID-19 pandemic on technical skills training in surgical subspecialities.

Screening process

I was the primary reviewer for this systematic review and the update and screened all the abstracts and titles. NMT and HS acted as second reviewers for the initial systematic review; each independently screening half of the papers identified after the initial search. Bavithra Hemanth (BH) acted as second reviewer for the updated review performed in October 2025.Any disagreements regarding the inclusion or exclusion of papers were resolved after discussion and with the help of my supervisors who acted as the arbitrators. Full text reviews were also conducted independently in duplicate.

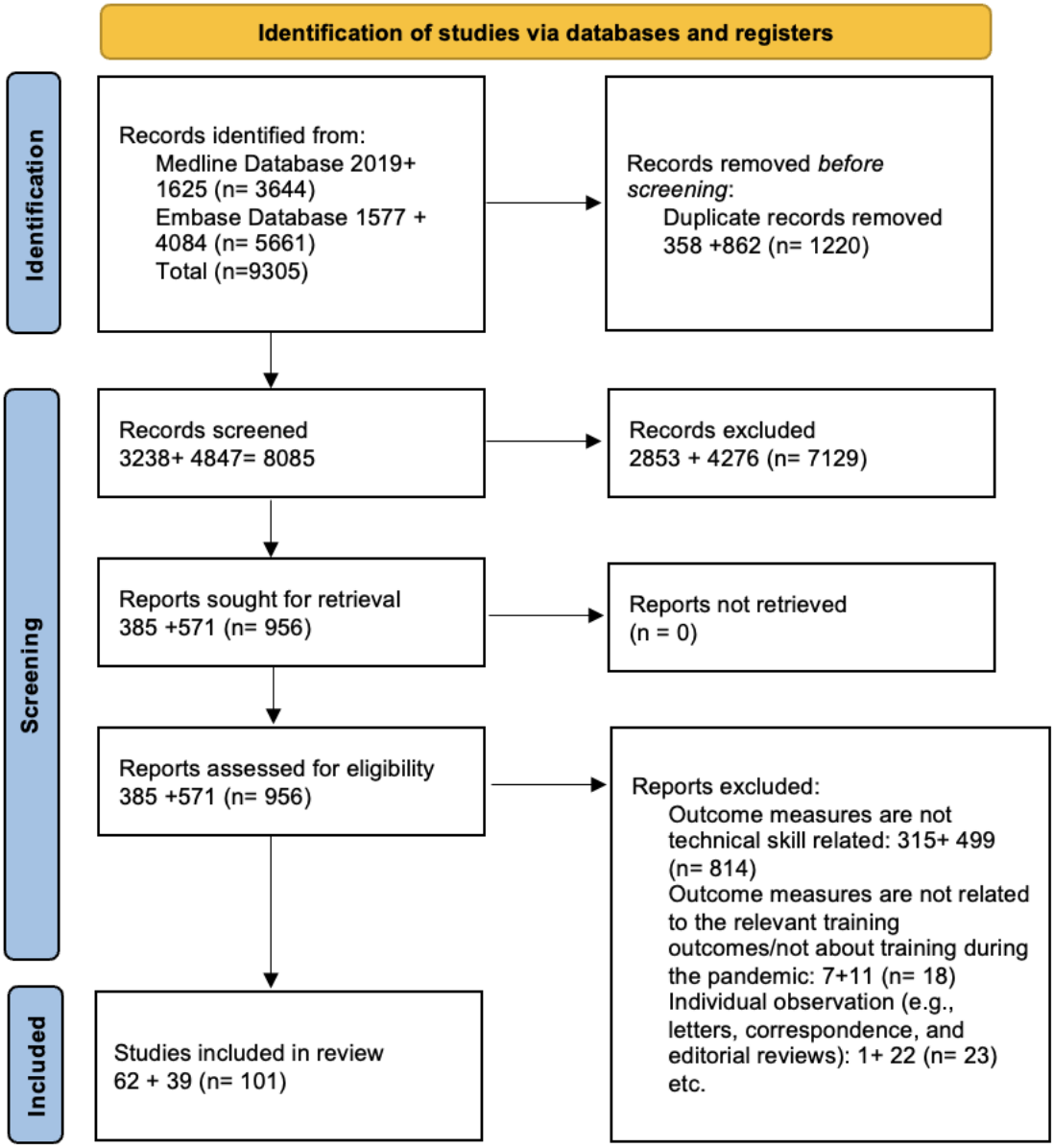


Figure 7 PRISMA flowchart for the systematic review on the impact of COVID-19 on training in a surgical specialties. The flowchart presents the search results from the initial systematic review and the subsequent update, with numbers shown separately at each stage and then totalled across the review process (215)

Data extraction and analysis

A total of 8085 papers were screened by title and abstract and 956 papers underwent full text screening. One hundred and one studies fulfilled the inclusion criteria and data was extracted onto a Microsoft Excel™ spreadsheet. Information regarding the study design, the surgical speciality, participant population and demographics, the country the study was conducted in, the outcome measures used to describe technical skills, and a summary of the results and conclusions were noted.

An initial thematic synthesis was undertaken for the systematic review completed in 2022. The review was updated in 2025 and the data from both the original review and the update were re-analysed and organised according to the outcome measures specified in the inclusion criteria. This reanalysis was undertaken for clearer alignment between the stated objectives, reported outcomes, and presentation of results.

The outcome measures were:

Primary outcomes

1. Operative exposure and case volume
2. Operative autonomy and role in theatre
3. Engagement with simulation or alternative technical training modalities

Secondary outcomes

1. Perceived decline in technical skills and confidence
2. Satisfaction with technical skills training and perceived impact on progression

Appraisal of study quality

Risk of Bias assessment was conducted using the NIH quality assessment tool for Observational, Cohort and Cross-sectional studies tool (216) and was recorded alongside in the data extraction Microsoft Excel spreadsheet.

Results

The full texts of 956 studies were reviewed and 101 were found to meet the inclusion criteria of this systematic review (Figure 7). The majority of included studies were conducted in high-income countries (68%), with no studies conducted exclusively in low-income countries (Table 10).

The World Bank classification of countries	**The studies included in the systematic review (n=62 + 39=101)**
High Income countries	44 +25= 69(68%)
Upper middle-income countries	7+ 6= 13 (13%)
Lower middle-income countries	6 +0= 6 (6%)
Low-income countries	0
Global	5 +8= 13(13%)

Table 10 Socio-economic classification of countries in which included studies were conducted, based on World Bank World Development Indicators. Data are presented separately for studies included in the original systematic review and the review update, and then combined to give cumulative totals for all included studies(221).

Thirteen studies were classified as global, reporting data from more than one country (Table 11). These studies included countries classified as high-income, upper middle-income, and lower middle-income according to the World Bank classification. Two global studies explicitly included low-income countries alongside higher-income settings, while several studies described global participation without specifying individual countries or income classification.

Studies that were classified as global in Table 10	**Countries where the study was conducted**	**The World Bank classification of countries**
COVID-19 and cardiothoracic surgery: Effects on training and workforce utilisation in a global pandemic (261)	USA, Canada, Columbia, Finland, Australia, South Korea, Nigeria	High Income and lower middle income
The effect of COVID-19 on trainee operative experience at a multihospital academic neurosurgical practice: A first look at case numbers (262)	USA, Egypt	High income and lower middle income
The impact of COVID-19 on surgical training: a systematic review (2)	France, UK, Canada, USA, Kuwait, Saudi Arabia, Serbia, Italy, Chile, India, Pakistan, Latin America	High income, upper middle income, lower middle income
Reshaping ophthalmology training after COVID-19 pandemic (263)	Slovenia, Mexico, Argentina, Ukraine, Morocco, Croatia, Poland, India, France, USA, Israel, Turkey, Philippines, Spain, Netherlands, UK, Italy, Belgium, Chile, Germany, Latvia, Greece, Switzerland, Ireland, Jordan, Pakistan, Singapore, Austria, Bosnia, Herzegovina, Bulgaria, Estonia, Guatemala	High income, upper middle income, lower middle income
What is the impact of the COVID-19 pandemic on residency training: a systematic review and analysis (259)	UK, USA, Italy, India, Saudi Arabia, Nigeria, Pakistan, Peru, Canada, Germany, Taiwan, South Korea	High income, upper middle income, lower middle income
Orthopaedic training during COVID-19 pandemic: should action be taken? (264)	76 countries across six continents	High income, upper middle income, lower middle income and low income

Studies that were classified as global in Table 10	**Countries where the study was conducted**	**The World Bank classification of countries**
Impact of COVID-19 to Neurosurgical Education: A Systematic Review (265)	Canada, USA, Kuwait, Saudi Arabia, Italy, Serbia, Morocco, Algeria, Tunisia, Egypt, Libya, Niger, Mali, Senegal, Cote d'Ivoire, Ghana, Nigeria, Cameroon, Sudan, Uganda, Kenya, Tanzania, Mozambique, Malawi, Zimbabwe, Botswana, South Africa, Madagascar, Indonesia, Malaysia, Thailand, Philippines, Singapore	High income, upper middle income, lower middle income and low income
Global virtual strabismus surgery teaching for ophthalmology residents during COVID-19 (266)	5 countries, names not specified	Not specified
An international consensus for mitigation of the detrimental effects of the COVID-19 pandemic on laparoscopic training(267)	UK , Australia, Spain, China, India, Belgium, Hong Kong, Greece	High income, upper middle income, lower middle income
Surgeon experience of mixed reality headset technology during the COVID-19 pandemic (268)	Belgium, Brazil, Bolivia, France, Germany, India, Mexico, Morocco, South Africa, Ukraine, UAE, UK, USA	High income, upper middle income, lower middle income
International expert opinion on mitigating COVID-19 impact on surgical training (269)	Not specified. Semi structured interviews of 11 international educationalists	Not specified
Improving surgical teaching for junior trainees internationally (270)	More than 30 countries but countries are not specified	Not specified
Latin American Residents' Surgical Education after the Pandemic(271)	Chile, Colombia, Brazil, Argentina, Peru, Mexico	High income, upper middle income, lower middle income

Table 11 Details of the countries that were included in the global studies listed in Table 10. Abbreviations: UK- United Kingdom, USA- United States of America

The majority of included studies (Table 12) were from general surgery (27 studies, 27%), followed by neurosurgery (16 studies, 16%). Several subspecialties were sparsely represented, with cardiothoracic surgery, OMFS, plastic surgery, and vascular surgery each represented by two studies (2%),and paediatric surgery (1 study, 1%).

Subspecialities	**The studies included in the systematic review (n = 62 + 39 = 101)**
Cardiothoracic surgery	2 + 0 = 2 (2%)
General surgery	16+ 11 = 27(27%)
Neurosurgery	13 + 3 =16 (16%)
OMFS	1 + 1 = 2 (2%)
ENT	3 + 3 = 6 (6%)
Paediatric surgery	1 + 0 = 1 (1%)
Plastic surgery	1 + 1 = 2 (2%)
Orthopaedics	4 + 7 = 11 (11%)
Urology	8 + 2 = 10 (10%)
Vascular surgery	0 + 2 = 2 (2%)
O&G	1 + 4 = 5 (5%)
Ophthalmology	8 + 2 = 10 (10%)
Multiple surgical subspecialities	4 + 3 = 7 (7%)

Table 12 Analysis of the surgical subspecialities that are represented in the studies included in this review. Data are presented separately for studies included in the original systematic review and the review update and then combined to give cumulative totals for all included studies. Abbreviations: ENT- Otolaryngology, O&G- Obstetrics and Gynaecology, OMFS- Oral and Maxillofacial surgery

Methodology of the studies

The majority of included studies employed quantitative methodologies (87/101, 86%). Most studies relied on self-reported data, including surveys and interviews (56/101, 55%), while non-self-reported data such as operative logs, workplace-based assessments, and administrative or cost data were used in 31 studies (31%). A smaller proportion of studies combined both self-reported and non-self-reported data (8/101, 8%). Qualitative approaches were used in 8 studies (8%), and mixed-methods designs were employed in six studies (6%) (Table 13).

Methodology	**Studies included in this review (n = 62 + 39 = 101)**
Quantitative	61 + 26 = 87 (86%)
Qualitative	0 + 8 = 8 (8%)
Mixed methodology	1 + 5 = 6 (6%)
Subgroup analysis	
Self-reported data (surveys, interviews)	37 + 19 =56(55%)
Non-self-reported data (operative logs, workplace-based assessments)	20 + 11 = 31 (31%)
Both self-reported and non-self-reported data	3 + 5 = 8(8%)
Review of literature	2 + 4 = 6 (6%)

Table 13 Methodology and subgroup analysis of methodologies of the studies included in this review. Data are presented separately for studies included in the original systematic review and the review update and then combined to give cumulative totals for all included studies

Primary outcome: Operative exposure and case volume

A consistent finding across the included studies was a reduction in operative exposure for postgraduate surgical trainees during the COVID-19 pandemic, although the magnitude and pattern of that reduction varied by speciality, country, centre and trainee seniority (Table 14). Multiple studies using objective operative log data reported marked declines in case numbers. Institutional and multi-centre case-log analyses demonstrated large short-term drops. For example, one study noted a 42.5% fall in operative volume during the initial COVID period compared with the same months in 2019(272). Representative examples include national and institutional operative log analyses showing a 34% reduction in major cases (273) and a 51% reduction in selected trainee groups (274), a single-centre reduction of approximately 30%from 1,328 to 914 cases and two academic neurosurgical centres reporting a 77% reduction in weekly procedures during the pandemic(275).

Reductions were not uniform. Some centres and countries reported smaller or transient declines and, in a few reports, preserved or even increased operating for particular cohorts. A two-centre comparison found a statistically significant fall in the UK centre but no change in the German centre over the same interval(276).One ENT programme documented an increase in trainee led operative cases during the pandemic period at that site(277).Single-centre publications showed service innovations that were creative local responses, for example expansion into independent sector lists or remote mentoring, which allowed for preservation of hands-on exposure for some trainees (278, 279).

Elective surgery was the most affected domain across most reports, whereas emergency and oncological activity were relatively more preserved. Numerous speciality-specific surveys reported near-complete suspension of elective lists with smaller effects on emergency operating(280-284). Several national and multi-centre surveys echoed this pattern: trainees experienced disproportionate losses in elective and medium-complexity cases- the operations in which trainees commonly act as primary operators(285-287).The effect was frequently greater for certain grades of trainee. Senior

trainees and those expected to perform higher-complexity index cases were often reported as more adversely affected in both surveys and operative log analyses(288-290).Conversely, some junior grades or specific rotations (for example on-call emergency lists) retained more exposure in selected contexts(288, 290). Not all evidence relied on subjective recall. Studies using administrative case logs and operative databases yield stronger objective evidence of case-volume loss(282, 291-293).Although volume of operating reduced, some centres resumed trainee operative roles (e.g., registrars as primary operators in >50% of laparoscopic cholecystectomies in a post-COVID cohort) and that targeted simulation programmes allowed continued supervised primary-operator practice in specific procedures(294, 295)

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
By the numbers analysis of effect of COVID-19 on a neurosurgical residency at the epicentre, 2020, USA, Neurosurgery (296)	Comparative analysis of operative volume between 2020 and 2019 (a 7-week period in each year)	The case volume decreased from 530 operations in 2019 to 448 operations in 2020 and from 340 endovascular operations since 2019 to 253 in 2020. Operative activity continued throughout the pandemic at a mean of 1.4 cases per day	Poor
Impact of COVID-19 on the surgical volume of general surgery residents as main surgeons in a National Training Program in Costa Rica, 2021, Costa Rica, General Surgery (297)	Comparative analysis of operative volume of 10 residents between March 2020 to June 2020 with December 2019 to March 2020	Operative volume decreased from 291 procedures pre-pandemic to 241 during the pandemic. Year 2 trainees increased their proportion of operative participation (19% pre-pandemic vs 27% during the pandemic; $p = 0.028$). Year 3 trainees performed breast and foregut procedures during the pandemic that they had not performed before. Year 4 trainees demonstrated a statistically significant increase in breast surgery (1.3% vs 8.2%; $p = 0.008$) and emergency surgery (27.1% vs 50.9%; $p < 0.001$)	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
A tale of two cities: residents' operative experience in the United Kingdom and Germany during the coronavirus disease 2019 pandemic, 2021, Germany and UK, Neurosurgery, (298)	Comparative analysis of operative volume between 2 centres and between 2019 and 2020 (3-month period in each year)	A statistically significant reduction in operative volume from the pre-COVID months to the COVID months in the UK centre ($p< 0.001$). No significant difference in the operative volume in the German centre ($p =0.61$)	Good
Effect of the COVID-19 pandemic on Otorhinolaryngology residency training, 2021, conference abstract, USA, ENT, (277)	Retrospective comparative analysis of operative volume between 2019 and 2020 (3 months in each year)	From March 15, 2020, to May 31, 2020, residents participated in 331 procedures compared with 63 procedures between the same period in 2019, noting an increase in operating during the pandemic at this centre	Poor

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
COVID-19 and neurosurgical training and education: an Italian perspective, 2020, Italy, Neurosurgery, (299)	Prospective cross-sectional survey of neurosurgical residents about their training experience from March to May 2020. 58% response rate (192/331)	78.6% performed less operations and 16.1% did not perform any operations at all	Fair
Impact of COVID-19 pandemic on general surgery training program: An Italian experience, 2020, Italy, General Surgery, (300)	Comparative analysis of operative volume of postgraduate year 6 trainees between March to May 2020 to January to March 2020	Statistically significant decrease in operations performed during the second period of the study ($p= 0.033$), especially of medium-complexity surgeries usually performed by the year 6 residents as first operator	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Impact of COVID-19 on Saudi neurosurgery residency: Trainers' and trainees' perspectives, 2021, Saudi Arabia, Neurosurgery, (292)	Prospective comparative survey of residents and programme directors of training during COVID and pre-COVID from March to May 2020. Response rate was 100% from programme directors and 95% from residents	Before the pandemic, 53.3% of the residents were involved in 2 to 3 surgeries per week, but during the pandemic, 69.5% were attending 0 to 1 case per week, showing a loss of operative volume	Fair
Residents' perceived impact of COVID-19 on Saudi Ophthalmology training programs: A survey, 2020, Saudi Arabia, Ophthalmology, (301)	Prospective cross-sectional survey of residents in July 2020 about training during the COVID-19 pandemic compared to before the pandemic	Elective operative volume decreased by 82% during the pandemic. Emergency operative exposure was preserved, with 61% of residents reporting similar or increased emergency operating. Elective office-based procedures were significantly reduced ($p < 0.001$)	Good

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
Effect of SARS and COVID-19 outbreaks on urology practice and training, 2021, China (Hong Kong), Urology (302)	Comparative study of data collected from a prospective cross-sectional survey of all residents from all the urology centres (n=11) in Hong Kong (48.5% response rate) and a review of the operative logs	The mean number of operating sessions decreased significantly from 85 pre-pandemic to 51 during the COVID-19 period ($p = 0.005$). The total number of operating sessions was reduced by 40.5% across all reviewed centres	Fair
Impact of the COVID-19 pandemic on core surgical training, 2020, UK, General surgery (303)	Prospective cross-sectional survey of core surgical trainees (64% response rate, 28/44)	71.4% reported fewer operative opportunities. None of the trainees had performed any form of endoscopy during the pandemic	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Impact of COVID-19 on Neurosurgical training in Southeast Asia, 2020, Indonesia, Malaysia, Philippines, Singapore, and Thailand, Neurosurgery (281)	Descriptive cross-sectional survey of residents from 33 training programmes in South-East Asia (298 responses, 63% response rate)	Reduction in elective procedures ranged from 50% in Thailand to 100% in Indonesia and the Philippines, 92% in Malaysia and 70% in Singapore (statistically significant)	Good
Has 2020 been a lost year in orthopaedic surgery and trauma training? Residents' perceptions, 2021, Spain, Orthopaedics (304)	Prospective cross-sectional survey of 307 orthopaedic residents in February 2021	70% of surgeries were suspended in 2020, with no operating for an average of 8 weeks, affecting 67% of the residents. 52% considered the impact of the pandemic as bad or very bad on their surgical training	Good

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
The impact of COVID-19 on surgical training at a tertiary hospital in Greece: a 'hidden infectious enemy' for junior surgeons?, 2021, Greece, General surgery, (305)	Prospective cross-sectional survey of all core general surgical trainees from one hospital about their operative experience during and before the pandemic (September to November 2019 and 2020). 94% response rate (16/17)	All trainees performed almost 50% fewer cases during the pandemic. Senior trainees assisted in 37 cases during the pandemic compared to 90 before the pandemic	Good
The impact of the coronavirus pandemic on European Neurosurgery trainees, 2021, Europe, Neurosurgery (306)	Prospective cross-sectional survey of all European neurosurgical residents about their operative exposure before and during the pandemic. 16.4% response rate (134/810)	93% of residents reported a reduction of hands-on surgical exposure. One-third of the participants were spending >15 hours in the operating room pre-pandemic but 52 residents spent more than 10 hours in the operating room during the crisis, indicating a statistically significant decrease in operative exposure ($p < 0.05$)	Poor

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
How the COVID-19 pandemic changed Urology residency- a nationwide survey from the Portuguese resident's perspective, 2021, Portugal, Urology (307)	Prospective cross-sectional survey of urology residents regarding their operative experience before and during the pandemic in May 2020. 54.4% response rate (43/79)	49% reported up to 100% reduction in minor operative procedures. 40% reported a >50% reduction in major operative procedures. 54% of residents reported a reduction of robotic and laparoscopic procedures due to concerns about contamination during the COVID-19 pandemic	Good
The reduction in clinical and surgical exposure of trainees during COVID-19 and its impact on their training, 2021, Pakistan, General surgery (308)	Comparative study of results from a prospective cross-sectional survey of General surgical trainees from one unit (18/24, 75% response rate) to the operative log from August 2019 to May 2020	The number of elective cases performed went down to 1,465 from 2,364 ($p<0.005$) during COVID compared to pre-COVID, corroborated by the logbook data. Major cases performed by trainees, pre-COVID was 332, during COVID reduced to 105. Minor cases pre-COVID was 113, during COVID was 55. Reduction in operative volume was similar across all training years, showing a significant impact on operative exposure	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Canadian Ophthalmology resident experience during the COVID-19 pandemic, 2020, Canada, Ophthalmology, (309)	Prospective cross-sectional survey of all residency programmes in May and June 2020. 47% response rate (102/217)	51% of residents were working at reduced volumes. 65% of residents on surgical rotations had not operated in the previous 2 weeks	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
COVID-19 and Cardiothoracic surgery: Effects on training and workforce utilisation in a global pandemic, 2021, conference abstract, USA, Canada, Columbia, Finland, Australia, South Korea, Nigeria, Cardiothoracic surgery (261)	Prospective cross-sectional survey of cardiothoracic surgery trainees in June-August 2020 regarding their operative exposure during and before the pandemic. 22.2% response rate (126/748)	86% of the trainees reported a reduction in the operative volume of which 54% reported a >50% reduction and 23% did not operate at all. 98% of the USA trainees and 80% of international trainees reported reduction of operative volume (statistically significant)	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Impact of the COVID-19 pandemic on Ophthalmology residency training in Portugal, 2020, Portugal, Ophthalmology (310)	Prospective cross-sectional survey conducted between March and April 2020 of all ophthalmology trainees in Portugal. 94% response rate (75/80)	No department performed elective ophthalmology surgeries during the pandemic. Nearly half the residents participated in emergency surgery. 99% did not perform cataract operations during the pandemic compared to 8% before the pandemic	Fair
The continuing impact of Coronavirus disease 2019 on Neurosurgical training at the 1-Year Mark: Results of a nationwide survey of Neurosurgery residents in Turkey, 2021, Turkey, Neurosurgery (284)	Prospective cross-sectional survey of neurosurgical residents from Turkey conducted in January and February 2021 about surgical training during and before the pandemic. 54% response rate (356/435)	50% reported a significant decrease of elective operating, 9% felt it was unchanged 4% felt it increased. Only 6% felt emergency operating considerably decreased	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Factors associated with General surgery residents' operative experience during the COVID-19 pandemic, 2021, USA, General surgery (311)	Comparative study of retrospective review of 1358 operative logs from 3 consecutive academic years (4 months in 2017-2018, 2018-2019, and 2019-2020) from 16 general surgery programmes and cross-sectional survey of programme directors from 16 general surgical programmes	771 resident case logs (56.8%) were from 8 university-based programs, 407 (30.0%) from 5 university affiliated programs, and 180 (13.2%) from 3 independent programs. Residents performed a mean of 68 major cases pre-pandemic compared with 45 cases during the pandemic ($p< 0.001$), with 34% reduction in operative volume during the pandemic	Good
A survey of the impact of the COVID-19 crisis on skill decay among surgery and Anaesthesia residents, 2021, USA, (312)	Cross-sectional survey of surgical and anaesthetic residents and faculty from 2 large tertiary centres regarding training in 2019, 2020 and 2021. 53% response rate (91/173)	Three chief residents did not meet defined minimum case log for general surgery in 2020.All surveyed residents felt that their training was significantly impacted due to COVID-19 pandemic. 82% reported a reduction in case volumes ($p< 0.05$)	Good

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
The impact of COVID-19 related lockdown on Ophthalmology training programs in India, 2020, India, Ophthalmology (313)	Cross-sectional survey of ophthalmology residents via social media in April 2020. 716 responses received	80.7% reported a negative impact on their surgical training due to COVID lockdowns. 62.4% trainees reported a >/=50% reduction in operating	Fair
Impact of the COVID-19 pandemic on orthopaedic and trauma surgery training in Europe, 2020, Europe, Orthopaedics (314)	Cross-sectional survey in May 2020 of 327 orthopaedic trainees in 23 European countries about training during the COVID pandemic compared to before	During the pandemic, 57% of institutes allowed only emergency surgical procedures	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Impact of elective case postponement secondary to COVID-19 on General surgery residents' experience: Operative cases logged at three academic teaching hospitals, 2021, USA, General surgery (315)	Retrospective cohort study of operative logs of general surgical trainees from three academic hospitals, 81 residents pre-COVID and 77 residents during COVID	Year 4 residents had a significant decrease in total cases, 759 procedures during the pandemic compared to 1010 total cases before (p= 0.005). There was no difference for year 5 residents	Good
Impact of the COVID 19 pandemic on surgical skills training in Paediatric surgery residents, 2021, Argentina, Paediatric surgery (316)	Descriptive retrospective study of surgical training in the paediatric surgery department of one tertiary centre from March to May 2020. Results were compared to the same trimester in 2018 and 2019 to quantify the impact of the pandemic, 100% response rate	The average number of surgeries in 2015 to 2019 was 530 compared to 368 surgeries during the pandemic, a reduction of 31.02%. No changes in case complexity was noted. A statistically significant reduction in procedures performed by the residents as leading surgeons in 2020	Good

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
Access and feasibility of Orthopaedic training in the independent sector- A Deanery's experience, 2021, UK, Orthopaedics (317)	Cross-sectional survey of trainees who attended operative theatre sessions at independent hospitals between November and December 2020 to supplement their surgical training. 89% response rate (57/64)	44% of trainees had accessed the 12 independent sector hospitals, attending an average of 4 sessions, and were first surgeons on 4 of the 7 cases in each operating list	Good
The impact of COVID-19 on Urology resident surgical experience: An analysis of national case logs, 2021, conference abstract, Canada, Urology (318)	Comparative analysis of the theatre log from 11 urology residency programmes for 20 common urologic procedures, comparing data from September 2019-March 2020 with March 2020 to September 2020	12,831 procedures were recorded over 12-months by 122 residents in 11 training programs. 7211 procedures were logged before the pandemic compared to 5620 procedures after. 82% of programs reported a reduction in surgical volume	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Effects of the COVID-19 pandemic on operative volume and residency training at two academic Neurosurgery centres in New Orleans, 2021, USA, Neurosurgery, (319)	Retrospective review of operative log from two tertiary centres comparing March to June 2020 with March to June 2019	Pre-pandemic operative average was 58 procedures/week. 77% reduction in operative procedures in 2020	Good
The effect of COVID-19 on trainee operative experience at a multihospital academic neurosurgical practice: A first look at case numbers, 2021, USA and Egypt, (320)	Retrospective review of operative log for 54 days pre-lockdown to 54 days post lockdown to evaluate the impact of the pandemic on operating exposure of trainees (March-May 2020 compared to January -March 2020)	Mean total cases per day in the pre-lockdown group were 12.26, compared to 7.78 in the post lockdown group ($p= 0.01$)	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Impact of COVID-19 on academic activities of Ophthalmology postgraduates: A cross-sectional survey, 2021, India, Ophthalmology, (321)	Cross-sectional online survey of Indian ophthalmology trainees in January 2021 to evaluate the impact of the pandemic on surgical training compared to before the pandemic. 84 trainees responded	A marked reduction in operative procedures performed independently per week. 32% noted an increase in intraoperative surgical time post the pandemic	Fair
Impact of COVID 19 pandemic on Plastic surgery activities and residency programs in a tertiary referral centre in Iran, 2021, Iran, Plastic surgery, (322)	Retrospective case study of logbooks in a six-month time frame comparing two consecutive years (during and before the pandemic)	There was a 70% reduction in case volume in plastic surgery. The total number of surgeries decreased by an average of 23.5% in all the specialities after the COVID-19 outbreak ($p< 0.05$)	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Impact of COVID-19 on operative experience of junior surgical trainees, 2020, UK, General surgery, (323)	Comparative study of operative logbooks in a five-month time frame of March-July 2019 with 2020	16,729 operative procedures were recorded during the control period compared with 6223 procedures during the COVID period, demonstrating a 63% decrease, across all levels of complexity	Good
Decrease in operative volume in General surgery residents in Chile: effects of the COVID-19 pandemic, 2021, Chile, General surgery,(324)	Comparative study of the operative logbooks of eight postgraduate year 3 trainees in 2019 to 2020	Significant decrease in the total number of surgical procedures of 61.7% ($p<0.001$), though some trainees had more thoracic surgery exposure than usual due to the changes in the rota	Fair
Impact of COVID-19 on Ophthalmic specialist training in the United Kingdom- the trainees' perspective, 2020, UK, Ophthalmology, (325)	Cross-sectional survey of UK ophthalmology trainees in March 2020. 111 trainees completed the survey	87% were concerned COVID-19 will impact their training. Acquiring competencies like cataract surgery and completing the logbook worried up to 81% of the trainees	Poor

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
The impact of COVID 19 on surgical training: a systematic review, 2021, Global, General surgery,(326)	Systematic review and qualitative synthesis of surgical training before and during the pandemic from January 2020 to August 2020. 29 included studies	All of the studies reported a decrease in the number of operative cases or operative experience available to trainees, particularly medium complexity operations where trainees would usually be the first operator	Good
Riding the waves: the ongoing impact of COVID 19 on a national surgical training cohort, 2021, UK, General surgery (327)	Two online surveys of surgical trainees in May 2020 and October 2020 comparing surgical training during the first wave of the pandemic to the second wave of the pandemic. 29% response rate (98/340), with 44% core surgical trainees and 46% higher surgical trainees	All trainees experienced a statistically significant reduction in day case operating and endoscopic sessions. Core surgical trainees also experienced a statistically significant decrease in emergency sessions. Major elective and emergency session numbers returned to pre-COVID levels in the second survey	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Military Otolaryngology residency training and practice impact assessment during COVID-19, 2021, conference abstract, USA, ENT, (328)	Cross-sectional survey to assess the impact of the pandemic on ENT surgical training in the Defence Health Agency sites	Time in the operating room ($p < .001$) decreased significantly for both residents and faculty.	Poor
Impact of Coronavirus disease on the Ophthalmology residency training in Brazil, 2020, Brazil, Ophthalmology (329)	Cross-sectional survey conducted in May-June 2020 the programme directors of ophthalmology training programmes in Brazil to evaluate the impact of the pandemic on training. 83% (79/95) response rate	54% reported that elective surgery was completely suspended and for 20%, it was drastically reduced. For emergency operating, 76% said it was reduced, drastically reduced, or suspended.	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
Advanced head and neck surgery training during the COVID-19 pandemic, 2020, USA, OMFS, (330)	Comparative study of operative logs (2020 to 2019 and 2018) and a cross-sectional survey of programme directors , trainees, and fellows. 97% (37/38) of programme directors and 39% (12/31) of trainees responded	70% reported a 50% to 90% reduction in the number of elective cases and 76% reduction in emergency operating at their institutions. 81% stated that their fellows were still participating in oncology cases and remained active in a variety of procedures	Fair
Perceived impact of Urologic surgery training program modifications due to COVID-19 in the United States, 2020, USA, Urology, (331)	Survey of programme directors and residents at urology centres in March to April 2020. 43% (55/127) of programme directors and 18% (23/127) trainees responded	83% to 100% reported decreased surgical volume. Least affected were emergency surgery and oncology	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Reshaping Ophthalmology training after COVID-19 pandemic, 2020, Global (32 countries), Ophthalmology, (263) .	Cross-sectional survey of ophthalmology trainees from 32 countries in May 2020	Surgical activity massively decreased with 74.6% of trainees reported a reduction of >75% of their surgical practice	Fair
Decrease in Neurosurgical program volume during COVID-19: Residency programs must adapt, 2020, USA, Neurosurgery, (332)	Operative log review of case volume from March to May 2019 and 2020	Elective surgery volume (53%) and total surgical procedures (42%) decreased during COVID. Thrombectomies had increased by 21%. Operative cranial traumas had decreased by 18%	Poor

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Impact of the COVID-19 Pandemic on Surgical Training and Learner Well-Being: Report of a Survey of General surgery and other surgical specialty educators, 2020, USA, General surgery, (3)	Cross-sectional survey of programme directors. 21% (472/ 2196) response rate	The volume of surgical procedures was severely reduced by the pandemic with 87% reduction of elective operating. Emergency operative volume reduced by 20%	Fair
COVID-19 pandemic effect on otolaryngology resident surgical case numbers, conference abstract, 2021 ENT, USA, (333)	Retrospective analysis of surgical operative logs of all residents from a large residency programme comparing February to March 2019 and 2020	The total decrease in surgical case numbers was 46%. Junior residents had a 28% decrease, while senior residents had a 54% decrease	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Impact of COVID-19 on surgical training, 2021, UK, General surgery (334)	Retrospective comparative analysis of operative theatre records in a large teaching hospital comparing April to June 2019 to 2020	An overall reduction in operative volume by 66% during the pandemic, with a 71% decrease in the registrars as first operators	Good
Neurosurgery training in India during the COVID-19 pandemic: straight from the horse's mouth, 2020, India, Neurosurgery, (335)	Cross-sectional survey via social media of neurosurgical trainees in India in May 2020	68% reduction in surgeries performed by trainees since the onset of the COVID-19 pandemic- 39.86 surgeries per month decreased to 12.31 per month($p < 0.0001$)	Fair
Impact of COVID-19 on a Urology residency program, 2021, Brazil, Urology (336)	Retrospective analysis of operative logs from 18 urology residents training at a single institution between February and May 2017 to 2020	Overall surgical volume significantly decreased in 2020, by 51%, compared to the previous three years ($p < 0.001$), affecting the third, fourth and fifth year of the residency program	Good

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
COVID-19 impact on surgical training and recovery planning (COVID-STAR)-A cross-sectional observational study, 2021, UK, Multiple surgical specialities, (57)	National, collaborative, cross-sectional study involving 13 surgical trainee associations using a pan-surgical specialty questionnaire on the impact of COVID-19 on surgical training over 4 weeks in May 2020	The reported impact of COVID-19 on surgical training experience was very significant (average on Likert scale was 8.66), with no difference between training grades or specialities. 84% to 87% reported complete suspension of elective non-cancer surgery and elective endoscopy operating. 76% reported at least a >50% loss of operating	Good
COVID-19 pandemic and the lived experience of surgical residents, fellows, and early-career surgeons in the American College of Surgeons, 2020, USA, General surgery, (337)	Cross-sectional online survey of members of the Resident Associate Society and the Young Fellows Association. 5.4% (1160/21385) response rate of which 40% were residents and 60% were fellows and early career surgeons	96% reported a negative impact of the COVID-19 pandemic. 84% of residents reported a >50% reduction in operative volume and inability to meet minimum case requirements. 84% reported a reduction of 50% of elective operating and 19% reported a decrease in emergency operating	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
What is the impact of the COVID-19 pandemic on residency training: a systematic review and analysis, 2021, Global, General surgery, (259)	Systematic review of surgical training until November 2020	51(96.23%) of the included studies reported a reduced operative case volume	Fair
The impact of COVID-19 pandemic on Orthopaedic resident education: a nationwide survey study in South Korea, 2020, South Korea, Orthopaedics, (338)	Online survey of orthopaedic residents from 43 hospitals in South Korea. 229 residents completed the survey	Working time in the operating theatre was significantly decreased ($p < 0.001$). 68% of residents participated in surgeries for more than 10 hours/week before the COVID-19 pandemic but 48% participated in surgeries for more than 10 hours/week during the COVID-19 pandemic ($p < 0.001$)	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Early changes to Neurosurgery resident training during the COVID-19 pandemic at a large U.S. academic medical centre, 2019, USA, Neurosurgery, (339)	Retrospective analysis of 24 trainee operative logbooks in a single residency programme from January 2019 to June 2020 comparing pre-COVID to the effect of the pandemic	An average of 15 fewer cases had been logged in April 2020 ($p < 0.01$), and 5 fewer cases (20%) had been logged in May 2020 ($p= 0.01$). A comparison of the institutional case numbers showed a significant reduction in the overall case numbers for April and May 2020 compared with the same months in 2019 (mean difference 21, $p= 0.01$)	Fair
The influence of the COVID-19 outbreak on European trainees in obstetrics and gynaecology: A survey of the impact on training and trainee, 2021, Europe, O&G, (340)	Online survey of the European Obstetrics and Gynaecology trainees via social media regarding the impact of the pandemic on their training. 110 trainees from 25 countries responded	95 % of trainees reported a negative effect on their training due to COVID-19. Training was interrupted for 21 % and 65% were worried about their training. Surgical skills training decreased for 67% of trainees due to cancellation of surgeries. 5% met the goals for their surgical competencies. Gynaecological oncology was least affected	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Effect of COVID-19 on surgical training across the United States: A national survey of General surgery Residents, 2020, USA, General surgery, (341)	Cross-sectional survey of general surgical residents in all general surgical residency programmes (260) across the USA. 1102 residents completed the survey	41% reported that they were not allowed in the operating room for cases considered high-risk for COVID-19 transmission. Case volume reduction was statistically significant ($p<0.01$)	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Urology residency training at the time of COVID-19 in Italy: 1 Year After the Beginning, 2021, Italy, Urology (342)	Cross-sectional survey of surgical training from 27 urology training programmes comparing the long-term impact of the pandemic with the training received pre-pandemic. 53.3% (312/585) response rate	The proportions of those experiencing a significant decrease of training exposure were 26.7%, 46.9%, 37.6%, and 33.3% (as compared with 82.3%, 69.7%, 59.7%, and 50.2% in the previous survey) for diagnostic procedures, endoscopic surgery, open surgery, and minimally invasive surgery, respectively. The most impactful reductions in training activities were reached by final-year residents	Good

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
Impact of the COVID-19 pandemic on Urology residency training in Italy, 2020, Italy, Urology (343)	Cross-sectional survey of Italian urology residents one month after the start of the pandemic. 60.8% (351/577) response rate	Before the COVID-19 pandemic, the proportion of residents routinely involved in "surgical" activities ranged from 49% to 74%. In the COVID-19 period, the proportion of residents experiencing a severe reduction (>40%) or complete suppression (>80%) of training exposure ranged between 44% and 62% for surgical activities. This reduction was even more pronounced for residents attending the final year of training. Statistically significant reduction in diagnostic and endoscopic procedures ($p < 0.001$) for residents in year 2,3, 4 and 5. For open surgery, year 5 had a statistically significant decline in involvement	Fair
Impact of COVID-19 pandemic on urology residency training, 2020, Saudi Arabia, Urology (344)	Cross-sectional survey of all urology residents about the impact of the pandemic on surgical training. 38% (77/202) response rate	Statistically significant decline in diagnostic procedures ($p < 0.001$), endoscopic surgeries ($p < 0.001$), minimally-invasive surgeries ($p < 0.001$), and major open surgeries ($p < 0.001$) in comparison to before the COVID-19 pandemic	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Early effects of COVID-19 pandemic on Neurosurgical training in the United States: A case volume analysis of 8 Programs, 2020, USA, Neurosurgery (345)	Comparative review of the operative log from eight residency programmes from 2019 to January to April 2020	Compared with 2019, mean operative volume declined 15% (p= 0.003) in March 2020 and 49% (p= 0.002) in April 2020, respectively, which was statistically significant, affecting all the training programmes included in this study	Good
Impact of the COVID-19 pandemic on surgical residency training: Perspective from a low-middle income countries, 2020, Nigeria, General surgery (346)	Cross-sectional online survey of surgical residents from July to August 2020. 82.9% (207/250) response rate	59% reported a decrease and 36% reported no change in emergency operating. 91% reported a decrease in elective surgery. 82% believed the pandemic had a negative impact on their training and professional growth. 59% felt the pandemic had elongated the duration of training and time of completion of residency training	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
Challenges for a new robotic surgery program in gynaecological oncology at a cancer center in the United Kingdom during COVID-19 pandemic, 2022, conference abstract, UK, O&G, (347)	Retrospective observational study and descriptive service evaluation from December 2020 to April 2022	41 Robotic surgery cases in first 8 months; 102 robotic surgery cases in subsequent 8 months; training improved as restrictions eased	Fair
Effects of the SARS-CoV-2 pandemic on residency training in orthopaedics and traumatology in Germany: A nationwide survey, 2022, Germany, Orthopaedics, (348)	Cross-sectional, online survey of orthopaedic residents in October and November 2021, 95 trainees responded	Residents reported a mean 25% reduction in operating theatre time, with 84 of 95 trainees (88.4%) stating that their surgical training was delayed, and 76 residents (80%) reporting that the pandemic set them back in overall training progression	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Effectiveness of the world's first 1-Day online hands-on laparoscopic suturing training during COVID-19 pandemic, 2022, Turkey, O&G, (349)	Single-arm prospective pre-test/post-test interventional study evaluating the effect of a 1-day online hands-on laparoscopic suturing course. Participants completed standardised intracorporeal suturing tasks before and after the intervention. Technical performance was assessed using direct objective measures, including timed task components (needle loading, suture passing, knot-tying, and total intracorporeal suturing time) and Objective Structured Assessment of Technical Skills (OSATS) scoring	17 participants performed standardised intracorporeal suturing tasks on box trainers at baseline and following completion of the online course. Total intracorporeal suturing time decreased significantly from 273.8 ± 103.7 seconds at baseline to 90.0 ± 37.7 seconds post-intervention ($p < 0.001$). Significant reductions were also observed across individual task components: needle loading time decreased from 77.3 ± 27.7 seconds to 25.0 ± 13.0 seconds; suture passing time from 62.0 ± 31.0 seconds to 31.0 ± 9.8 seconds; and knot-tying time from 140.3 ± 106.6 seconds to 34.6 ± 28.5 seconds. OSATS scores improved from a mean of 16.8 ± 4.7 at baseline to 25.4 ± 2.8 post-course ($p < 0.001$)	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Impact of the COVID-19 pandemic on urology residency training programs in Germany, 2022, Germany, Urology, (350)	Nationwide cross-sectional online questionnaire survey evaluating the impact of the COVID-19 pandemic on clinical activity and residency training in urology. The survey was distributed via social media platforms (Facebook, Twitter, Instagram), the German Society of Residents in Urology newsletter, and professional working group distribution lists. Data were collected over a one-month period between 20 May and 20 June 2020	A substantial reduction in operative exposure was reported by respondents. 66% of residents indicated that their operative experience decreased due to a reduction in surgical procedures during the pandemic. 38% reported managing only urological emergencies, leading to marked reductions in routine operative case volume	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
Deterioration experienced by French otolaryngology residents in their training during the COVID-19 pandemic: A STROBE analysis, 2022, France, ENT, (351)	Retrospective cross-sectional observational study using a 55-item structured online questionnaire assessing academic education and surgical training during the first three waves of the COVID-19 pandemic. The survey was distributed to otolaryngology residents across five major French regions between August and October 2021. The study was reported in accordance with STROBE guidelines, with 89 responses.	Residents reported substantial reductions in operative exposure across all three COVID-19 waves. During the first wave, 42% of residents (37/89) reported a 50 to 75% decrease in surgical activity, with trainees in heavily affected regions (Île-de-France, Rhône-Alpes Auvergne, and Grand Est) frequently reporting reductions of 75 to 100% in operative practice. Although partial recovery was reported in subsequent waves, operative exposure remained reduced, with 45% (40/89) reporting a 25 to 50% decrease during wave 2 and 38% (34/89) reporting a 0 to 25% decrease during Wave 3. Subspecialties most affected included functional exploration (58.1%; 36/89), otology (17.7%; 11/89), and rhinology (12.9%; 8/89), while paediatric and oncological surgical activities were relatively preserved.	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
The effect of the COVID-19 crisis on vascular surgery training in France, 2023, France , Vascular surgery, (352)	Observational cross-sectional study using an anonymous 12-item structured online questionnaire. The survey was sent to all vascular surgery trainees (residents and fellows) registered with the French College of Vascular and Endovascular Surgery. Data were collected in June 2021 via an online questionnaire (Google Forms. A total of 52 trainees responded, the total number of trainees surveyed, and response rate were not reported	Respondents reported a substantial reduction in operative exposure during the COVID-19 pandemic. Elective surgical activity was affected for 96% of trainees (50/52), while 77% (40/52) reported reduced exposure to emergency vascular surgery. Nearly one-third of respondents (31%; 16/52) reported complete cessation of surgical activity for a mean duration of 1.5 months. Reduced vascular patient flow further contributed to decreased caseload and missed operative opportunities across all levels of training	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
The impact of the COVID-19 pandemic on surgeons' and surgical residents' caseload, surgical skills, and mental health in Kuwait, 2022, Kuwait, General surgery, (353)	Cross-sectional questionnaire-based study using the Depression Anxiety Stress Scale alongside training and workload-related items. An electronic self-administered survey (Google Forms) was distributed via the Kuwait Association of Surgeons and the SurgQ8 platform. Data were collected between October and November 2020. The reported response rate was 52%; the total number of respondents were not specified in the published report	Nationwide cancellation or postponement of non-urgent surgeries led to reduced caseloads across surgical specialties. Among residents, 65.8% reported postponement or shortening of surgical rotations. Formal skills training opportunities were also disrupted, with 86.8% reporting cancellation of wet and dry laboratory sessions. Clinical exposure was further reduced by redeployment to COVID-19-related duties, reported by 71.1% of respondents	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
Impact of the COVID-19 pandemic on Orthopaedic surgery residency training, 2023, USA, Orthopaedics, (354)	Cross-sectional online survey study of orthopaedic surgery residents. A 26-item electronic questionnaire was distributed to all accredited orthopaedic surgery residency programs nationally. A total of 142 residents responded, the total number of residents surveyed, and the overall response rate were not reported. The study used a single-timepoint observational design to assess perceived impact of the COVID-19 pandemic on training	66.2% of respondents indicated a significant decrease in operative experience. More than half of residents rated the overall impact of the pandemic on their surgical training as severe, with 54.2% scoring the impact between 8 and 10 on a 10-point scale	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Examining the impact of COVID-19 restrictions on the operative volumes of US general surgery residents, 2022, USA, General surgery, (272)	Retrospective cohort study using a before and after comparison of national operative case volume data obtained from Accreditation Council for Graduate Medical Education (ACGME) aggregate resident case logs, comparing graduating cohorts from 2018 to 2019 (pre-COVID-19) and 2019 to 2020 (COVID-19–affected). Additional institutional-level operative case log data were analysed for residents at a single academic centre, comparing March to May 2019 with March to May 2020. The study used complete administrative case log datasets rather than survey-based sampling	At a national level, general surgery residents experienced a statistically significant reduction in operative volume during the COVID-19 pandemic. Mean total major operative cases decreased by 1.5% (1055 ± 155 vs 1071 ± 150; $p = 0.011$), while surgeon-chief cases decreased by 8.4% (264 ± 67 vs 289 ± 69; $p < 0.001$). At the institutional level, operative case volume declined by 42.5% (12 ± 11 vs 20 ± 14 cases; $p < 0.001$). Junior residents experienced a 50.8% reduction in operative volume, while senior residents experienced a 43.5% reduction	Good

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
Impact of COVID-19 to Neurosurgical Education: A Systematic Review, 2022, Global, Neurosurgery, (265)	Systematic review conducted in accordance with PRISMA guidelines, synthesising published studies examining the impact of the COVID-19 pandemic on neurosurgical education. The review included 13 papers, observational studies reporting changes in operative exposure, training structure, and educational delivery. Literature searches were performed across PubMed, Med Rxiv, and bio Rxiv, covering studies published up to early 2022	Across the included studies, residents consistently reported negative impacts of the COVID-19 pandemic on training, driven primarily by reduced operative exposure. Reductions in surgical case volume were reported in nearly all studies, with some surveys indicating up to 99 to 100% of respondents reporting decreased elective surgical activity and 60 to 75%reporting reductions in emergency procedures. Concerns regarding training quality were common, with 33 to 87% of residents across studies reporting that COVID-19 negatively affected overall education, surgical skill acquisition, or progression toward operative milestones	Good

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
The impact of the first wave of the COVID-19 pandemic on the exposure of general surgery trainees to operative procedures, 2022, Canada, General surgery, (355)	Retrospective comparative cohort study using institutional operating room database and chart review. Operative case volumes were compared between a pre-pandemic period (March to June 2019) and the first COVID-19 wave (March to June 2020) at a single academic centre (McGill University Health Centre, Montreal). All general surgery procedures performed during the study periods were included	Operative case volume decreased by approximately 30%, from 1,328 cases in the pre-pandemic period to 914 cases during the pandemic period. Reductions in operative exposure were observed across all trainee levels, with junior residents exposed to 68% of baseline case volume, senior residents to 72.5%, and fellows to 69.9%. Minimally invasive surgery fellows were most affected, experiencing operative exposure reduced to 14% of baseline levels. In contrast, oncological and emergency surgical cases were relatively preserved	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Trauma surgery via distance mentoring: A model inspired by the 2020 pandemic, 2022, Trinidad and Tobago, General surgery, (279)	Prospective single-centre observational case series of all consecutive trauma laparotomies performed during the COVID-19 pandemic. Operative data were prospectively collected for trauma laparotomies performed between 1 September and 30 December 2020 at Port of Spain General Hospital. Procedures were performed by general surgery residents with real-time remote consultant supervision via distance mentoring	During the study period, residents completed 96% of trauma laparotomies**,** indicating preservation of operative exposure despite pandemic-related restrictions. Residents acted as primary operating surgeons under remote consultant supervision, maintaining direct hands-on operative experience	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Learning-by-teaching coming into play as a reliable trick for lower GI procedures: a learning curve analysis in 13,210 operative logs including the COVID-19 era, 2022, Turkey, General surgery, (356)	Single centre retrospective cohort study using interrupted time series analysis and logistic regression. Electronic operative logbook data were analysed for 13,210 lower gastrointestinal procedures performed between September 2014 and September 2020, spanning the early COVID-19 period. The dataset included all cases with resident participation and captured resident role in theatre (primary operator, assistant, or teaching resident). Learning curves were assessed using the 0 to 1st index to characterise learning by teaching dynamics before and during the COVID-19 era	Between September 2014 and 2020, 7,684 lower gastrointestinal surgical procedures involved general surgery resident participation. In 69% of cases residents participated in (5,276 cases)**,** the resident acted as the primary operator. Both overall resident participation and learning-by-teaching cases demonstrated a decline during the first three months of COVID-19 impact**,** followed by a subsequent rebound. The overall 0 to 1st index decreased from 1.06 before COVID-19 to 0.86 after, indicating a shift toward earlier resident operative responsibility, although cumulative learning curve trends were not significantly correlated ($p = 0.134$). Monthly average learning by teaching procedures increased after COVID-19 from a median of 13.0 (IQR 9.0–17.0) to 24.0 (IQR 10.0–29.0) ($p = 0.081$).Multivariable analysis identified the COVID-19 period as an independent predictor of learning-by-teaching activity (OR 1.93, 95% CI 1.54–2.42; $p < 0.001$).	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Laparoscopic pyeloplasty proficiency during a residency program after adoption of a standardized simulation training program, 2023, Brazil, Urology, (357)	Retrospective cohort study using chart review of operative records at a tertiary referral centre in Brazil. A total of 151 laparoscopic pyeloplasty procedures performed by postgraduate year 5 residents between 2006 and 2021 were analysed. Procedures were grouped into three periods: before simulation training (2006 to February 2017), after simulation training (March 2017 to February 2020), and during the COVID-19 pandemic (March 2020 to February 2022)	A total of 151 laparoscopic pyeloplasty procedures were included, of which 90 occurred before simulation training, 47after implementation of simulation training, and 14 during the COVID-19 pandemic. Annual surgical volume decreased during the pandemic period, with a 55.4% reduction in pyeloplasty case volume compared with the post-simulation, pre-pandemic period. Mean annual surgical volume was 15.7 procedures/year after simulation training compared with 7.0 procedures/year during COVID-19**.** Despite the reduction in operative volume during the pandemic, residents continued to perform laparoscopic pyeloplasty as primary surgeons under supervision	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
Laparoscopic cholecystectomy as a training case in the post-Covid world, conference abstract, 2023, UK, General surgery, (294)	Prospective observational cohort study using operative database extraction. All laparoscopic cholecystectomies performed between January and April 2023 were identified prospectively from an institutional operative database. The study examined case mix and trainee involvement in the post-COVID period	During the study period, 150 laparoscopic cholecystectomies were performed, including 79 acute cases (53%) and 71 elective cases (47%). Surgical trainees (registrars) acted as the primary operator in 78 procedures (approximately 52%), performing 36 elective cases (51%) and 42 acute cases (53%). No procedures were performed by more junior (SHO-level) trainees. Despite post-COVID operational pressures, including outsourcing of elective cases and increased case complexity, senior trainees continued to perform just over half of all laparoscopic cholecystectomies. Mean operative times were comparable between registrars (72 minutes) and consultants (78 minutes), suggesting maintenance of operative efficiency among senior trainees.	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
The lasting impact of COVID-19 on Otolaryngology key indicator cases, 2023, USA, Otolaryngology, (358)	Retrospective case log analysis comparing operative volume of 2018-2019 to 2020-2021	Reduction in case volume from 2386 (2018-2019) to 2148 (2020-2021), 9.9% decline; Key indicator cases reduced from 1715 to 1496 in the same period, 13.4% decline.	Fair
Effect of COVID-19 on Orthopaedic trauma theatre efficiency in North and East of Scotland, Conference abstract, 2023, UK, Orthopaedics, (359)	Retrospective observational study using trauma database analysis to assess operative efficiency and theatre throughout before and during the COVID-19 pandemic (2019 to 2021)	Trainee involvement as primary operating surgeon decreased following the onset of the COVID-19 pandemic, with junior trainees most severely affected**,** particularly in the North of Scotland trauma centre. Reduced theatre efficiency-manifested by prolonged anaesthetic and surgical preparation times, increased turnover times, and extended downtime between cases-was associated with fewer opportunities for trainees to act as main surgeons. No quantitative primary-surgeon case counts were reported	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
A survey of COVID-19 impact on skill decay among surgery/anaesthesia residents, 2021, USA, General surgery, (360)	Cross-sectional survey	82% residents & 94% faculty reported decreased operative volume	Fair
Impact of COVID-19 on neurosurgical resident training program, 2022, Germany, Neurosurgery, (361)	Mixed methods study with interviews and retrospective hospital data.	Number of surgeries dropped from 41.26 to 25.66 per month (reduction of 37.8%).	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
The Use of a Low-Fidelity Simulator to Improve Vascular Anastomosis Skills of Residents during the COVID-19 Pandemic, 2022, Brazil, Vascular Surgery, (295)	A prospective, case control, single-center study comparing COVID-year residents (PGY-3, case) with prior-year residents (PGY-4, control). Simulator performance scores (OSATS, Final Product Analysis), procedure timing, operative log review (number of anastomoses performed) and subjective questionnaire on confidence were used. Also, direct observation by senior surgeons.	COVID-year residents performed significantly fewer anastomoses than controls: 22.6 ± 7.76 vs 35.2 ± 3.9 anastomoses/resident ($p = 0.01$). During first semester 2020: Bypasses reduced by 25%, Arteriovenous fistulas reduced by 87.5%. Each COVID-year resident performed 4.6 anastomoses vs 16.2 in the prior year.	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative exposure and case volume**	**Appraisal of quality using NIH assessment tool**
Latin American Residents' Surgical Education after the Pandemic, 2022, Latin America (Chile, Colombia, Brazil, Argentina, Peru, Mexico), mainly general surgery (271)	A narrative review of literature	Severe reduction in surgical exposure across Latin America: Residents performed 56- 90% fewer surgeries (depending on country) during the pandemic. Elective procedures were largely suspended. Chile and Colombia reported greater than 70% reduction in operative training volume. Emergency cases continued but were insufficient to maintain operative skills.	Poor

Title, year, location, speciality, reference	Study design, methodology	Results: Operative exposure and case volume	Appraisal of quality using NIH assessment tool
Challenges imposed by the COVID-19 pandemic on the Obstetrics and Gynaecology residency program: a mixed-methods Swedish survey in the COPE Staff cohort study, 2022, Sweden, Obstetrics and Gynaecology, (290)	A mixed-methods cross-sectional cohort study with a nationwide online survey with 28-item questionnaire and qualitative content analysis	During the pandemic, operative exposure dropped markedly, with 70% (113/162) of residents performing fewer surgeries than before COVID-19. Senior residents were disproportionately affected, with 80% reporting reduced surgical cases compared with 64% of junior residents. Surgical rotations were frequently cancelled, and elective procedures were significantly reduced, severely limiting operative case volume.	Good

Table 14 Primary outcome: Operative exposure and case volume. Studies reporting the impact of the COVID-19 pandemic on operative case volume and operative exposure for trainees across surgical specialties. Study quality was appraised using the National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies(216). Conference abstracts are indicated in column 1. Abbreviations: ACGME- Accreditation Council for Graduate Medical Education, ANOVA- Analysis of variance, COPE-Pregnancy and early childhood, ENT- Ear, Nose & Throat (Otolaryngology), IQR- Interquartile range, NIH- National Institutes of Health, O&G- Obstetrics & Gynaecology, OMFS- Oral & Maxillofacial Surgery, OSATS- Objective Structured Assessment of Technical Skills, PGY- postgraduate year, PRISMA- Preferred Reporting Items for Systematic Reviews and Meta-Analyses, SD- Standard deviation

Primary outcome: Operative autonomy and role in theatre

Studies reporting operative autonomy and trainee role in theatre demonstrated a predominantly negative impact of the COVID-19 pandemic on progression towards independent operating, although the extent of this effect varied by institution, specialty, trainee seniority, and local mitigation strategies (Table 15).

Several studies, using operative log data or comparative institutional analyses, reported measurable reductions in trainee autonomy: In a two-centre neurosurgical comparison, residents at the UK centre performed fewer procedures as primary surgeon during the pandemic compared with pre-COVID levels (82 to 72 cases per month), whereas resident primary-surgeon case numbers increased at the German centre over the same period (68 to 89 cases per month), highlighting marked inter-institutional variation in operative autonomy during the pandemic(276). National case-log analysis from the United States demonstrated an 8.4% reduction in chief resident cases during the COVID-19 period (264 ± 67 vs 289 ± 69; $p < 0.001$), with increased double-scrubbing (i.e.. scrubbing with the consultant) further limiting opportunities for senior trainees to act as primary operators(272).

Survey-based studies across multiple specialties consistently reported reduced operative autonomy, often attributed to consultant-delivered operating, prioritisation of efficiency (i.e.. reduced time taken by a consultant to perform the operation when compared to a trainee), and reduced theatre access(272, 348, 361).Programme directors across surgical specialties in USA similarly reported a severe negative impact on expected progression of operative autonomy in 14 to 18% of trainees across training stages(362).In Kuwait, redeployment away from surgical services and shortened rotations were associated with reduced hands-on operating and trainee concerns regarding operative competency, particularly among junior residents (353).

Operative autonomy was not directly quantified but was inferred from reductions in operative exposure, key indicator cases, or qualitative accounts of trainee exclusion from theatre. French ENT residents reported substantial reductions in surgical activity during the first pandemic wave, occurring in the context of pre-existing concerns regarding achievement of operative autonomy by the end of training (351).Similar patterns were observed in vascular surgery in France, where complete cessation of operative activity was reported by 31% of trainees for a mean of 1.5 months, and a majority reported being behind in achieving operative training goals across all grades (352). In Sweden, O&G trainees described exclusion from theatre lists and restrictions on trainee operating, raising concerns about meeting procedural competency requirements necessary for progression(290).

A small number of studies reported preservation or recovery of operative autonomy under specific conditions. In Trinidad and Tobago, trauma laparotomies performed with virtual mentoring allowed residents to function as primary surgeons in 96% of cases, demonstrating maintained operative autonomy despite restrictions on in-person supervision(279).Post-COVID observational data from the UK demonstrated that senior trainees continued to act as primary operators in approximately half of laparoscopic cholecystectomies, although junior trainee participation was absent(294).

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
A tale of two cities: Residents' operative experience in the United Kingdom and Germany during the Coronavirus disease 2019 Pandemic, 2021, Germany and UK, Neurosurgery, (298)	Comparative analysis of operative volume between 2 centres and between 2019 and 2020 (3-month period in each year)	At the UK centre, the average number of procedures performed by residents as primary surgeon decreased from 82 cases per month pre-COVID to 72 cases per month during the pandemic. In contrast, at the German centre, resident primary surgeon case numbers increased from 68 to 89 cases per month when comparing pre-COVID and COVID periods, indicating differing impacts on resident operative autonomy between institutions	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
Access and feasibility of orthopaedic training in the independent sector- A Deanery's experience, 2021, UK, Orthopaedics, (317)	Cross-sectional survey of orthopaedic trainees who attended operative theatre sessions at independent sector hospitals between November and December 2020 to supplement disrupted training. Response rate was 89% (57/64)	Perceived operative autonomy and access to meaningful operative roles varied among trainees. While 80% of respondents reported an enjoyable operative experience and 52% reported achieving their training objectives, 20**%** reported reluctance or obstruction to trainee participation from theatre staff. Only 29% of trainees felt that operating in the independent sector would adequately compensate for loss of operative autonomy and training opportunities experienced during the pandemic	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
Impact of the COVID-19 pandemic on surgical training and learner well-being: Report of a survey of General surgery and other surgical specialty educators, 2020, USA, General surgery, (3)	A cross-sectional survey of programme directors. The response rate was 21% (472/2196)	Programme directors reported a negative impact of the COVID-19 pandemic on the expected progression of operative autonomy among trainees. Across training stages, 14 to 18% of respondents indicated a severe negative impact on residents' progression toward independent operative roles during the pandemic	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
Challenges for a new robotic surgery program in Gynaecological oncology at a cancer center in the United Kingdom during COVID-19 pandemic, Conference abstract, 2022, UK, O&G, (347)	Mixed (Quantitative + Qualitative), Retrospective observational study + descriptive service evaluation, Review of centre operations / descriptive assessment, Retrospective observational design	Early robotic surgical activity was undertaken under close supervision, with a gradual increase in independent operating as surgical services resumed. The number of robotic procedures increased from 41 cases in the first 8 months to 102 cases in the subsequent 8 months as COVID-19 restrictions eased. While the abstract reports improvement in training opportunities over time, specific measures of resident operative autonomy or independent operating roles were not reported.	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
Effects of the SARS-CoV-2 pandemic on residency training in orthopaedics and traumatology in Germany: A nationwide survey, 2022, Germany, Orthopaedics, (348)	Nationwide cross-sectional, online-based voluntary anonymous survey of orthopaedic and trauma surgery residents, conducted in October–November 2021. The survey was distributed via email lists of junior physician organisations (n = 95 respondents)	Residents reported a mean 25% reduction in operating-room time during the COVID-19 pandemic. Operative autonomy decreased, as prioritisation of efficiency resulted in senior surgeons assuming operative responsibility more frequently. Reduced access to operative cases and time in theatre was associated with a shift toward observational or assisting roles**,** indicating diminished resident participation as primary operators.	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
Deterioration experienced by French otolaryngology residents in their training during the COVID-19 pandemic: A STROBE analysis, 2022, France, ENT, (351)	Retrospective cross-sectional questionnaire-based study using a 55-item structured survey assessing academic education and surgical training across the first three COVID-19 waves. The survey was distributed to ENT residents in five French regions between August and October 2021 (n = 89). Reporting followed STROBE guidelines	Operative autonomy was not directly quantified. However, substantial reductions in operative case availability were reported, particularly during the first pandemic wave, with 75 to 100% reductions in surgical activity in some regions. Prior to the pandemic, 62.9% of residents (56/89) reported that their training was already insufficient to achieve operative autonomy by the end of residency. These findings indicate that reduced operative exposure during COVID-19 occurred in the context of pre-existing limitations in progression toward independent operating	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
The effect of the COVID-19 crisis on Vascular surgery training in France, 2023, France, Vascular surgery, (352)	Nationwide cross-sectional study using an anonymous 12-item online questionnaire distributed to all vascular surgery trainees (residents and fellows) registered with the French College of Vascular and Endovascular Surgery. Data were collected in June 2021 (n = 52 respondents)	Operative autonomy was not directly quantified**.** However, substantial reductions in operative exposure were reported, with 96% of trainees reporting reduced elective activity and 77% reporting reduced emergency operative activity. 31%(16/52) reported complete cessation of operative practice for a mean duration of 1.5 months, and 21% were redeployed to non-surgical clinical areas, further limiting theatre access. Across training grades, a large proportion of trainees reported being behind in achieving operative training goals (92% of junior residents, 65% of senior residents, and 55% of fellows), indicating impaired progression toward independent operative practice.	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
The impact of the COVID-19 pandemic on surgeons' and surgical residents' caseload, surgical skills, and mental health in Kuwait, 2022, Kuwait, General surgery, (353)	Cross-sectional questionnaire-based study conducted between October and November 2020 using the Depression Anxiety Stress Scale (DASS-21) and training-related items. The electronic survey was distributed via the Kuwait Association of Surgeons and SurgQ8 (52% response rate)	Residents reported reduced hands-on operative opportunities**,** with 71.1% redeployed away from surgical services, limiting access to the operating theatre. 66%reported postponed or shortened surgical rotations. Reduced operative exposure was associated with self-reported concerns regarding operative competency and "surgical skill decay," particularly among junior residents, indicating impaired progression toward independent operative practice	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
Examining the impact of COVID-19 restrictions on the operative volumes of US general surgery residents, 2022, USA, General surgery, (272)	Retrospective cohort study using a before and after comparison of national Accreditation Council for Graduate Medical Education (ACGME) aggregate case logs and institutional operative logs, comparing pre-COVID and COVID training periods (2018 to 2019 vs 2019 to 2020 nationally; March to May 2019 vs March to May 2020 locally)	Operative autonomy was not directly measured**.** However, senior-level autonomy was indirectly affected, with a national 8.4% reduction in chief resident surgical cases during the COVID-19 period (264 ± 67 vs 289 ± 69; $p < 0.001$). The authors also reported increased double-scrubbing (residents scrubbing in with faculty), further limiting opportunities for senior residents to act as primary operators, indicating reduced progression toward independent operative roles	Good
Trauma surgery via distance mentoring: A model inspired by the 2020 pandemic, 2022, Trinidad and Tobago, General surgery, (279)	Prospective single-centre observational case series of all consecutive trauma laparotomies performed under distance mentoring between 1 September and 30 December 2020, with prospectively collected operative and clinical data	Residents functioned as primary operating surgeons for trauma laparotomies, with real-time remote consultant supervision via distance mentoring. 96% of trauma laparotomies were completed by residents during the study period, demonstrating preservation of senior trainee operative autonomy despite pandemic-related restrictions on in-person supervision	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
Learning-by-teaching coming into play as a reliable trick for lower GI procedures: a learning curve analysis in 13,210 operative logs including the COVID-19 era, 2022, Turkey, General surgery, (356)	Single-centre retrospective cohort study with interrupted time-series analysis and logistic regression. Electronic operative logbook data from 13,210 lower gastrointestinal procedures performed between September 2014 and September 2020 were analysed, capturing resident roles in theatre (operator, assistant, teaching resident) and case characteristics	Resident operative autonomy was explicitly assessed using role-based participation (operator, assistant, teaching resident) and the 0-to-1st index, reflecting progression toward autonomous and teaching roles. During the early COVID-19 period, both overall resident participation and learning-by-teaching activity initially declined, followed by a subsequent rebound. COVID-19 was identified as an independent predictor of learning-by-teaching behaviour, indicating an adaptive shift in operative role allocation toward preserving resident autonomy despite reduced case volume. Absolute autonomy counts were not reported.	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
Laparoscopic cholecystectomy as a training case in the post-Covid world, conference abstract, 2023, UK, General surgery, (294)	Prospective observational cohort study using operative database extraction. All laparoscopic cholecystectomies performed between January and April 2023 were identified from a single institutional operative database.	Registrars served as primary operating surgeons in approximately 52% of cases**,** performing 36 elective (51%) and 42 acute (53%) laparoscopic cholecystectomies. No procedures were performed by SHO-level trainees**,** indicating reduced junior-level operative participation. Operating times were comparable between registrars (72 minutes) and consultants (78 minutes), suggesting similar operative efficiency among senior trainees.	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
The lasting impact of COVID-19 on Otolaryngology key indicator cases, 2023, USA, ENT, (358)	Retrospective cohort study using Accreditation Council for Graduate Medical Education (ACGME) ENT resident case logs, analysing operative volume and key indicator case completion between 2018 and 2021	Operative autonomy was not directly measured**.** However, exposure to key indicator cases was used as a training benchmark for readiness for independent practice, which was found to be reduced during the COVID-19 period. Total operative volume decreased from 2,386 pre-pandemic to 2,048 during COVID-19**,** with partial recovery to 2,148 post-pandemic**.** Key indicator cases declined by 13.4% overall**,** with reductions of up to 41.9% in some domains, indicating reduced opportunities for residents to achieve operative experiences required for progression toward independent practice	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
Impact of COVID-19 on neurosurgical resident training program: An early experience, 2022, Germany, Neurosurgery, (361)	Mixed-methods cohort study combining qualitative interviews with neurosurgical residents and retrospective hospital operative data, examining training impact between October 2019 and July 2020	Operative autonomy was reduced across major neurosurgical case groups**,** based on combined interview and operative data. Monthly surgical volume decreased from 41.26 to 25.66 cases (reduced by 37.8%) during the COVID-19 period, with residents reporting reduced operative responsibility and participation in key procedures. Autonomy was assessed qualitatively; specific primary-surgeon or independence metrics were not reported.	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Operative autonomy and role in theatre**	**Appraisal of quality using NIH assessment tool**
The use of a low fidelity simulator to improve vascular anastomosis skills of residents during the COVID-19 pandemic, 2022, Brazil, Vascular surgery, (295)	Prospective, controlled, single-centre study comparing COVID-year vascular surgery residents (PGY-3) with a prior-year cohort (PGY-4). Outcomes included operative log review (number of anastomoses performed), direct observation of independent anastomosis performance, simulator-based assessments (OSATS, Final Product Analysis), and trainee self-reported confidence	Operative autonomy was assessed as the ability to perform vascular anastomoses independently**.** At baseline, 80% of COVID-year residents were unable to complete an independent anastomosis**,** reflecting reduced operative exposure during the pandemic. COVID-year residents performed significantly fewer anastomoses than the prior-year cohort (22.6 ± 7.76 vs 35.2 ± 3.9 per resident; $p = 0.01$). Following a structured simulation workshop and partial resumption of operative cases, independent anastomosis performance improved to levels comparable with prior-year PGY-4 residents**,** indicating recovery of task-specific operative autonomy	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Operative autonomy and role in theatre	Appraisal of quality using NIH assessment tool
Challenges imposed by the COVID-19 pandemic on the Obstetrics and Gynaecology residency program: A mixed-methods Swedish survey in the COPE Staff cohort study, 2022, Sweden, O&G, (290)	Mixed-methods cross-sectional cohort study using a nationwide online survey of O&G residents, comprising a 28-item questionnaire and qualitative free-text content analysis (COPE Staff cohort)	Operative autonomy was not directly quantified. However, qualitative findings indicated a marked reduction in operative responsibility**.** Residents reported being excluded from theatre lists because trainee participation increased operating time, and some institutions restricted residents from performing surgical procedures entirely. This loss of operative role led many residents to express concern that they were not meeting procedural competency requirements necessary for progression to specialist practice**.**	Good

Table 15 Primary outcome: Operative autonomy and role in theatre. Studies reporting the impact of the COVID-19 pandemic on postgraduate surgical trainee operative autonomy and role in theatre, including changes in primary operator status, independent operating, participation as assistant or observer, and progression towards independent operative practice across surgical specialties. Study quality was appraised using the National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (216). Conference abstracts are indicated in column 1. Abbreviations: ACGME- Accreditation Council for Graduate Medical Education; DASS-21- Depression Anxiety Stress Scale-21; ENT- Ear, Nose & Throat (Otolaryngology); NIH- National Institutes of Health; O&G- Obstetrics & Gynaecology; OMFS- Oral & Maxillofacial Surgery; OSATS- Objective Structured Assessment of Technical Skills; PGY- Postgraduate year; UK- United Kingdom; USA- United States of America

Primary outcome: Engagement with simulation or alternative technical training modalities

Studies reporting engagement with simulation or alternative technical training modalities demonstrated substantial variability in access and uptake during the COVID-19 pandemic (Table 16). Across specialties and regions, simulation was frequently described as a potential mitigation strategy for reduced operative exposure; however, its availability and integration into training programmes was inconsistent.

Several survey-based studies reported limited or absent access to simulation resources at institutional level. Among UK core surgical trainees, only half reported access to a personal laparoscopic box trainer, while a substantial proportion reported either no access or inadequate access to simulation facilities(303). Similarly, in a national survey of Canadian ophthalmology residents, over half reported no access to any modality to maintain surgical skills during the pandemic, with minority uptake of simulators or wet-lab practice(309). Neurosurgical trainees in Turkey reported particularly limited access, with 78.7% indicating no access to training tools and very low availability of cadaveric, model-based, or VR/AR simulation(284). Educator surveys from USA reported widespread suspension or inaccessibility of simulation centres, with nearly 70% indicating that no additional technical skills development measures were implemented beyond reduced clinical exposure(362).

Where simulation was available, engagement was variable and often self-directed. In surveys of surgical trainees in USA, the majority did not utilise simulation to maintain skills, although a minority reported use of suture kits, laparoscopic trainers, or robotic consoles(312).Orthopaedic and vascular surgery surveys similarly demonstrated low institutional provision of simulation, contrasted with strong trainee belief that increased access could help compensate for lost operative exposure(352, 363).

A subset of studies evaluated structured simulation-based interventions and reported measurable improvements in technical performance. Interventional studies of online or tele-simulation courses demonstrated significant pre–post improvements in timed task performance and OSATS scores following short, intensive training interventions(295, 364, 365).Other single-centre educational innovations, including flipped-classroom workshops, take-home trainer programmes, and low-fidelity simulation courses in resource-limited settings, reported high engagement, improved technical performance, and positive trainee feedback(351, 353, 366).In vascular surgery, a structured low-fidelity simulation intervention supported recovery of task-specific autonomy and technical performance following pandemic-related reductions in operative exposure(295).

Despite these positive findings, several studies emphasised that simulation-based training did not fully compensate for the loss of live operative experience. In Canadian general surgery, restricted access to simulation during the first pandemic wave meant that simulation was unable to offset a substantial reduction in operative case volume(355).In ENT and ophthalmology, engagement shifted predominantly toward online academic substitutes, with relatively low participation in hands-on simulation workshops, and many trainees reporting a need for additional self-directed learning to address perceived skills gaps(351). Live-streamed surgery and virtual cadaveric dissection were described as valuable educational adjuncts but functioned primarily as observational rather than psychomotor training modalities(367, 368)

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Impact of the COVID-19 pandemic on core surgical training, 2020, UK, General surgery (303)	Prospective cross-sectional survey of core surgical trainees (CT1/ST1 and CT2/ST2) in the West of Scotland. An anonymous 51-item online questionnaire was distributed in April 2020, six weeks after the declaration of the COVID-19 pandemic. Response rate was 63.6% (28/44)	Access to simulation was variable. 14 trainees (50.0%) reported access to their own laparoscopic box trainer, while 8 (28.6%) reported no access and 9 (32.1%) felt access was inadequate. 14 trainees (50.0%) believed that access to a laparoscopic box trainer would help maintain laparoscopic skills during the pandemic, indicating partial but inconsistent engagement with simulation-based training	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Access and feasibility of orthopaedic training in the independent sector- A deanery's experience, 2021, UK, Orthopaedics, (317)	Cross-sectional survey of orthopaedic trainees who attended operative theatre sessions at independent sector hospitals between November and December 2020 to supplement disrupted training. Response rate was 89% (57/64)	This study evaluated independent sector operating as an alternative clinical training environment. While 44% of trainees accessed independent sector lists, operative engagement was limited: trainees attended a mean of 4 sessions and were first surgeon in a mean of 4 cases, with 28% only assisting. Only 29% of trainees felt that independent sector operating could compensate for training loss during the pandemic, indicating limited effectiveness as a substitute for structured technical skills training	Good

Title, year, location, speciality, reference	Study design, methodology	Results: Engagement with simulation or alternative technical training modalities	Appraisal of quality using NIH assessment tool
Canadian Ophthalmology resident experience during the COVID-19 pandemic, 2020, Canada, Ophthalmology, (309)	National prospective cross-sectional survey of all Canadian ophthalmology residents conducted May to June 2020. Anonymous online questionnaire assessing training experiences during the COVID-19 pandemic. Response rate 47% (102/217 residents)	Over half of residents (51%) reported no access to any modality to maintain surgical skills during the pandemic. Engagement with alternative technical training was limited: 20% reported use of a surgical simulator (Eyesi), 19% accessed wet lab practice, and 21% maintained skills through participation in live operative cases	Good
The continuing impact of Coronavirus disease 2019 on Neurosurgical training at the 1-year mark: Results of a nationwide survey of Neurosurgery residents in Turkey, 2021, Turkey, Neurosurgery(284)	National cross-sectional web-based survey administered January to February 2021. Response rate 54% (235/435).	Most residents reported no access to training tools (78.7%). Availability was low: cadaveric facilities 12.8%, simulation training models 8.1%, simulation animal models 6.0%, and surgical simulators (VR/AR) 0%. Despite limited availability, many residents rated these modalities as helpful: 47.3% felt cadaver practice would "considerably" compensate for lost operative exposure, 29.9% for training models, and 28.9% for VR/AR simulators	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
A Survey of the impact of the COVID-19 crisis on skill decay among surgery and Anaesthesia Residents, 2021, USA, General surgery, (312)	A cross-sectional survey of surgical and anaesthetic residents and faculty from 2 large tertiary centres regarding training in 2019, 2020 and 2021. 53% response rate (91/173)	58% of residents did not utilise simulation to maintain their technical skills. 39% used suture kits, laparoscopic trainers (9%), robotic consoles (3%), mannequins (1%) and other specialty-specific trainers (3%) to maintain their operative skills	Good
Impact of the COVID 19 pandemic on surgical skills training in paediatric surgery residents, 2021, Argentina, (316)	A descriptive retrospective study of surgical training in the paediatric surgery department of one tertiary centre from March to May 2020. Results were compared to the same trimester in 2018 and 2019 to quantify the impact of the pandemic, 100% response rate	All trainees spent <10 hours a month on simulation before the pandemic but 70% of trainees reported >10 hours a month during the pandemic	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Impact of the COVID-19 pandemic on surgical training and learner well-being: Report of a survey of General surgery and other surgical specialty educators, 2020, USA, (3)	Cross-sectional electronic survey of surgical chairs, program directors and Academy members across surgical specialties (distributed April to June 2020). Analytic sample n=472 (response rate 21% of estimated 2,196 programs)	Nearly 70% of respondents (266/388) reported no extra steps were taken to develop technical competencies beyond clinical opportunities. Simulation centres were frequently unavailable: 44% (180/405) reported centres were inaccessible, and 53% (217/407) reported suspension of simulation training. In qualitative responses some programs reported innovations (take-home kits, remote wet-lab supervision, livestreamed simulation), but overall institutional use of simulation to mitigate lost operative exposure was limited	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Challenges for a new robotic surgery program in Gynaecological Oncology at a cancer center in the United Kingdom during COVID-19 pandemic, conference abstract, 2022, UK, O&G, (347)	Retrospective observational study and descriptive service evaluation reviewing centre operations and training delivery from December 2020 to April 2022	Simulation-based training was maintained without interruption. Training incorporated simulator use, dry-lab exercises (docking/undocking and instrument handling), wet-lab training, proctor-supported cases, and use of an online video library. Wet-lab training was delayed due to temporary centre closure. Reduced operative exposure during early pandemic phases contributed to a slower initial learning curve, with improvement observed as restrictions eased	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Effectiveness of the world's first 1-day online hands-on laparoscopic suturing training during COVID-19 pandemic, 2022, Turkey, O&G, (349)	Prospective single-arm pre-test/post-test interventional study evaluating a 1-day online hands-on laparoscopic suturing course. Technical performance assessed before and after training using timed task metrics and OSATS scoring. 17 participants completed standardised intracorporeal suturing tasks on box trainers under remote supervision	All participants engaged in remote simulation-based technical training via an online platform using box trainers. Significant improvements in performance were demonstrated post-training: total intracorporeal suturing time reduced from 273.8 s to 90.0 s, with marked reductions in needle loading, suture-passing, and knot-tying times. OSATS scores improved from 16.8 to 25.4 ($p < 0.001$), indicating substantial short-term gains in simulated technical performance following online simulation-based training	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Deterioration experienced by French Otolaryngology residents in their training during the COVID-19 pandemic: A STROBE analysis, 2022, France, ENT, (351)	Retrospective cross-sectional observational study using a 55-item structured questionnaire assessing academic education and surgical training across the first three COVID-19 waves. Online survey distributed to ENT residents in five French regions (August to October 2021). Study reported in accordance with STROBE guidelines	Engagement shifted predominantly toward online academic substitutes. Alternative teaching methods were implemented for 86.5% of residents, with high uptake of e-learning platforms (94.4%) and moderate participation in in-department classes (51%). However, engagement with hands-on technical alternatives was limited: only 15.7% of residents reported participation in simulation workshops. While approximately half considered these adaptations appropriate, many required additional self-directed learning, indicating that simulation-based or practical alternatives were insufficient to compensate for reduced operative exposure	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
The effect of the COVID-19 crisis on Vascular surgery training in France, 2023, France , Vascular surgery, (352)	Nationwide cross-sectional observational study using an anonymous 12-item structured online questionnaire (Google Forms). Survey distributed to all residents and fellows registered with the French College of Vascular and Endovascular Surgery via website (June 2021)	Engagement with simulation-based technical training was limited. Only 23% of trainees reported that simulation laboratories were available at their institution. Despite this, 73% believed that simulation could help compensate for lost operative exposure, and trainees strongly favoured increased access to simulation as an alternative technical training modality. Overall, simulation was perceived as valuable but remained under-utilised during the pandemic.	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
The impact of the COVID-19 pandemic on surgeons' and surgical residents' caseload, surgical skills, and mental health in Kuwait, 2022, Kuwait, General surgery, (353)	Cross-sectional observational questionnaire study using an electronic self-administered survey (Google Forms). Distributed via the Kuwait Association of Surgeons and SurgQ8 between October and November 2020. Response rate approximately 52%	Engagement with formal simulation-based training was limited, with 86.8% reporting cancellation of wet- and dry-lab sessions. Residents identified potential compensatory alternatives rather than reporting widespread access or uptake: 81.6% considered small surgical workshops helpful, 52.6% surgical webinars, 47.4% virtual surgical skills workshops, and 60.5% virtual research sessions. Virtual mentor–mentee pairing was also suggested. Overall, alternative technical training modalities were largely aspirational rather than implemented during the pandemic period	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
The impact of the first wave of the COVID-19 pandemic on the exposure of General surgery trainees to operative procedures, 2022, Canada, General surgery, (355)	Retrospective comparative cohort study using institutional operating room database and chart review of all general surgery procedures. Operative exposure during March to June 2020 was compared with the same period in 2019 at a single tertiary academic centre (McGill University Health Centre, Montreal)	Access to simulation-based training was reduced due to hospital restrictions during the first pandemic wave. Simulation was unable to compensate for the substantial reduction in operative exposure (overall 30% reduction in cases compared with pre-pandemic levels), and no alternative technical training modalities were reported to replace lost hands-on operative experience	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Procedural simulation training in orthopaedics and traumatology: nationwide survey among surgeon educators and residents in France, 2022, France, Orthopaedics, (363)	Nationwide cross-sectional questionnaire survey of orthopaedic educators and residents in France. Two tailored online questionnaires were distributed by email between December 2020 and February 2021, referring to the 2018 to 2019 academic year (pre–COVID-19). Response rates: 57% for educators (67/117) and 24% for residents (87/369)	Engagement with simulation-based training was variable and incomplete nationwide. Among residents, 32% accessed simulation through formal teaching modules, while 29% reported never receiving any simulation training. Reported access routes included university degrees (26%), hospital departments (18%), and industry-supported training (17%). Educators reported achieving a mean of 33% ± 23% of curriculum-mandated simulation objectives. Simulation modalities included cadavers (85%), saw bones (77%), and commercial simulators (74%), particularly for knee and shoulder procedures. Despite limited access, perceived effectiveness of simulation was high (mean score 8.6 ± 2.1 among residents), while perceived regional integration was poor.	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Engagement with simulation or alternative technical training modalities	Appraisal of quality using NIH assessment tool
Combing workshop, web-based learning and hands-on workshop as a flipped classroom clinical skill training model during the COVID-19 pandemic, 2022, Taiwan, O&G, (365)	Prospective educational intervention using a flipped-classroom model combining pre-workshop web-based mini-lectures with a single in-person hands-on simulation workshop. All first to fourth year O&G residents at a single tertiary teaching centre were invited. Skills competency was assessed using pre- and post-tests (0-100 scale) at each station, with assessor feedback and a structured Likert-scale survey administered one-month post-workshop. Nineteen residents completed all components	High engagement with hands-on simulation-based technical training was demonstrated. Residents completed mandatory pre-workshop content followed by a 180-minute hands-on workshop delivered within a single afternoon, rotating through five simulation stations: vaginal breech delivery (mannequin), semen analysis (porcine semen), cervical conisation (hot-dog cervix model), obstetric anal sphincter injury repair (porcine anorectal model), and laparoscopic suturing (box trainers). Mean post-test skills scores across stations (95/100) were significantly higher than pre-test scores (60/100; $p < 0.001$), with improvements observed in both junior and senior residents. The model reduced in-person contact time while maintaining structured technical skills training during COVID-19 restrictions	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Evaluating the use of a take-home minimally invasive surgery box training, 2023, Netherlands, General surgery, (369)	Cross-sectional questionnaire study evaluating use of a take-home minimally invasive surgery (MIS) box trainer. Online survey using Likert-scale items assessing frequency of use, perceived relevance, and perceived impact on skills. 39 users responded	High engagement with take-home simulation-based technical training was reported. Trainees most frequently practiced needle trail and ring transfer tasks, which were rated highly relevant (mean scores 4.1–4.3/5). Participants reported that use of the trainer improved their technical skills (4.1/5) and added value compared with clinical training (4.2/5). Notably, 25% of trainees increased their use of the take-home trainer during the COVID-19 pandemic in response to reduced clinical exposure, indicating adaptive uptake of alternative technical training during periods of operative disruption	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Engagement with simulation or alternative technical training modalities	Appraisal of quality using NIH assessment tool
Incorporating simulation into the neurosurgical residency curriculum: a program director survey, 2023, USA, Neurosurgery, (370)	Nationwide cross-sectional survey of neurosurgery program directors using a REDCap electronic questionnaire (Feb–Jun 2022). Survey explored simulation availability, modalities, assessment practices, and changes during the COVID-19 pandemic. Response rate 42% (48/113 program directors), with representation from all US regions and a range of program sizes	Engagement with simulation was widespread but variably implemented. During the COVID-19 period, 70.8% of programs reported unchanged simulation use, 14.6% increased use, and 14.6% decreased use. Simulation modalities included cadaveric and perfused cadaver models, virtual reality simulators, task trainers, and crisis-management simulations. Simulation was commonly integrated alongside regional boot camps or industry-supported training. Feedback during simulation was frequently provided (always 54.2%; sometimes 41.7%) but was predominantly unstructured verbal feedback, with formal recorded or numeric assessment used in only a minority of programs. Simulation was rarely used as a formal gatekeeper for operative autonomy	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Developing a novel laparoscopic training model in resource-limited setting, 2023, South Africa, General surgery, (366)	Descriptive observational educational intervention describing the development and implementation of Grey's laparoscopic suturing course. Course evaluations, questionnaires, and pre-/post-course skills assessments were reviewed over a one-year period (2020 to 2021). 47 participants enrolled	High engagement with simulation-based technical training was demonstrated. The GLSC was a simulation-only laparoscopic suturing course delivered in a resource-constrained setting, with no live operative exposure, during the pandemic. Participants, predominantly registrars with limited prior minimal access surgery experience, completed structured skills laboratory training focused on intracorporeal suturing. Mean skills test scores improved from 50% pre-course to 88% post-course, and all participants were able to competently perform intracorporeal suturing during the skills laboratory session. All participants (100%) recommended the course and expressed interest in further advanced laparoscopic training	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Impact of COVID-19 on Neurosurgical resident training program: An early experience, 2022, Germany, Neurosurgery, (361)	Mixed-methods cohort study combining retrospective analysis of hospital operative data with semi-structured interviews of neurosurgical residents. Data covered the period October 2019 to July 2020 at a single neurosurgical training centre	Engagement with alternative technical training modalities was limited. A minority of residents reported use of skills laboratories (15%) during the pandemic. Educational adaptations were more commonly non-technical, with 20% engaging in webinars and a marked increase in telemedicine exposure (approximately five-fold). No structured or widespread simulation programme was described, and skills-lab use did not compensate for the substantial reduction in operative exposure	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Educational status of minimally invasive spine surgery, 2023, Global, Neurosurgery, (371)	International cross-sectional online survey assessing education and training in minimally invasive spine surgery and the impact of COVID-19. Survey distributed via multiple online platforms between April to June 2021. A total of 303 spine surgeons responded	Engagement with simulation-based technical training was primarily reflected through cadaveric laboratory practice. The majority of respondents considered cadaver training essential (61.4%) or important but not essential (31.3%) for skill acquisition, while only a small minority felt comfortable performing procedures without cadaver exposure (5.2%) or regarded cadaver training as unnecessary (2.0%). These findings indicate strong reliance on cadaver-based simulation for technical training. During the COVID-19 pandemic, access to MISS education was substantially restricted, with 79.8% reporting complete or significant limitations in learning activities	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Virtual fundamentals of laparoscopic surgery (FLS) boot-camp using tele simulation: an educational solution during the COVID-19 pandemic, 2023, Canada, General surgery, (364)	Prospective single-arm educational intervention evaluating a virtual tele simulation boot camp. Delivered via Zoom with three 1-hour tele simulation sessions, supplemented by independent home practice using laparoscopic box trainers, followed by an in-person laparoscopic manual skills examination. Engagement and outcomes assessed using pre- and post-course Likert surveys and FLS exam results. Fourteen PGY-1 residents participated; 11 completed post-course surveys	High engagement with tele simulation technical training was demonstrated. Participants valued access to a take-home FLS box (rating 5.0 ± 0.0), and 90% reported practicing more at home than if required to attend a simulation centre. Engagement with the virtual platform was rated highly (ease of FLS box use 4.7 ± 0.5; Zoom accessibility 4.7 ± 0.5; audio/video clarity 4.6–4.7 ± 0.5). Independent practice time varied from minimal to approximately 10 hours. Self-reported technical proficiency improved significantly across efficiency (1.5 → 3.6), precision (1.4 → 3.8), and confidence (1.4 → 4.0). Thirteen of fourteen participants passed the official FLS manual skills examination following the programme, indicating successful technical skill acquisition via tele simulation during COVID-19 restrictions	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
The use of a low fidelity simulator to improve vascular anastomosis skills of residents during the COVID-19 pandemic, 2022, Brazil, Vascular Surgery, (295)	Prospective, controlled, single-centre study conducted during the first COVID-19 pandemic year (March 2020 to March 2021). COVID-year PGY-3 vascular surgery residents were compared with a prior-year PGY-4 cohort. The intervention consisted of a structured low-fidelity simulation workshop. Outcomes included objective simulator performance metrics (OSATS, Final Product Analysis), procedure time, operative log review, and resident confidence questionnaires. Participant numbers not explicitly stated	High engagement with simulation technical training was demonstrated. Residents participated in a supervised low-fidelity vascular anastomosis workshop using a silicone tube connected to a pulsatile pump, delivered over three weeks (1 hour/week). Objective technical performance improved progressively, with OSATS scores increasing from 16.5 at baseline to 30 post-training, and Final Product Analysis scores improving from 14.5 to 27. Resident confidence increased from 2 to 4 on a Likert scale. The simulation intervention was implemented in response to marked COVID-related reductions in operative exposure and supported recovery of technical performance to levels comparable with the prior-year cohort	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Engagement with simulation or alternative technical training modalities**	**Appraisal of quality using NIH assessment tool**
Interactive live-stream surgery contributes to surgical education in the context of contact restrictions, 2022, Germany, ENT, (367)	Prospective cross-sectional educational evaluation of interactive live-streamed surgery delivered during COVID-19 contact restrictions. Surgery was transmitted in real time from the operating theatre using a fully digital surgical microscope, endoscope, or environmental camera. Participants joined remotely via personal computers and completed an online post-session evaluation. Sixty-five students participated	Interactive live-streamed observation of surgery, representing a non-hands-on alternative to in-person technical exposure. Following participation, 61.5% of students reported a subjective increase in knowledge, and 53.9% felt that live-streamed surgery should be offered as a permanent adjunct to traditional teaching. A majority (63.1%) expressed a desire for broader availability of live-streamed surgical sessions. Live streaming functioned as an observational substitute for theatre attendance during periods of restricted physical access, rather than a replacement for psychomotor skills training	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Engagement with simulation or alternative technical training modalities	Appraisal of quality using NIH assessment tool
Innovation in delivering a live, virtual cadaver dissection course, 2022, USA, Plastic surgery, (368)	Qualitative descriptive educational innovation report describing the design, planning, and execution of a live, virtual cadaveric dissection course during the COVID-19 pandemic. The course followed a structured three-phase framework (preplanning, planning, execution) and used advanced audiovisual technology (4K cameras, loupe-mounted camera, Zoom platform, picture-in-picture display) to enable real-time remote participation. The target audience was plastic surgery trainees from three residency programmes	Engagement with cadaver-based simulation delivered virtually was described. 13 upper-extremity peripheral nerve dissections were demonstrated using four cadaveric specimens, streamed live with real-time interaction through chat, polling, and integrated clinical scenarios. Content was tailored to trainee seniority, with foundational anatomy emphasised for junior trainees and advanced dissection planes and surgical approaches for senior trainees. Virtual cadaveric dissection functioned as a remote simulation-based alternative to in-person cadaver courses during COVID-19 contact restrictions, supporting continued exposure to surgical anatomy and operative concepts, but without hands-on psychomotor skill practice	Poor

Table 16 Primary outcome: Engagement with simulation or alternative technical training modalities. Studies reporting the impact of the COVID-19 pandemic on trainee engagement with simulation, take-home trainers, tele-simulation, cadaveric practice, wet/dry labs, virtual/online alternatives and other non-operative technical training modalities across surgical specialties. Study quality was appraised using the National Institutes of Health (NIH) Quality Assessment Tool for Observational, Cohort and Cross-Sectional Studies(216). Conference abstracts are indicated in column 1. Abbreviations: FLS-Fundamentals of Laparoscopic Surgery, MIS- Minimally Invasive Surgery, MISS- Minimally Invasive Spine Surgery, NIH- National Institutes of Health, O&G- Obstetrics & Gynaecology, OSATS- Objective Structured Assessment of Technical Skills, GLSC- Global Laparoscopic Suturing Curriculum, PGY- Postgraduate year, VR/AR- Virtual Reality/Augmented Reality, ENT- Ear, Nose & Throat (Otolaryngology), UK- United Kingdom, USA- United States of America

Secondary outcome: Perceived decline in technical skills and confidence

Studies reporting postgraduate surgical trainees' perceptions of technical skills and confidence consistently described a perceived negative impact of the COVID-19 pandemic across multiple specialties and training levels (Table 17).These findings were predominantly derived from self-reported survey data which reflect trainees' subjective assessments of confidence, skill decay, and preparedness for progression toward independent practice.

Across general surgery and core surgical training cohorts, a majority of trainees reported reduced confidence in performing surgical procedures during the pandemic. In the UK, 71.4% of core surgical trainees reported that their confidence in open, laparoscopic, and endoscopic skills had been negatively impacted, coinciding with reduced opportunities to operate as primary surgeon and limited access to simulation resources(303).Similarly, in Greece, 62.5% of junior general surgical trainees reported reduced confidence in the operating theatre, occurring alongside an almost 50% reduction in operative exposure compared with pre-pandemic periods(293).

Comparable perceptions were reported across other specialties. In Canadian ophthalmology training programmes, over half of residents (55%) agreed or strongly agreed that their surgical skills would deteriorate owing to pandemic-related shutdowns, with concerns regarding technical skills outweighing concerns about clinical knowledge (309). In India, neurosurgical trainees perceived that the pandemic would negatively affect both operative and clinical skills, corresponding with a reported reduction of approximately 67.5% in surgeries performed or assisted per month(372).

Several studies highlighted the influence of redeployment, training interruption, and prolonged service disruption on perceived skill decline. In a USA survey of surgical residents, 64% of residents reported perceived technical skill decay during the pandemic, while 75% of faculty respondents perceived a decline in residents' technical skills. Residents who were redeployed were significantly more likely to report skill decay than those who were not redeployed ($p < 0.05$), although faculty

expressed optimism regarding eventual attainment of level-appropriate proficiency by completion of training(360).

In some studies, perceived decline in technical skills was inferred rather than directly self-reported. In Saudi Arabia, more than half of programme directors anticipated that residents' surgical skills would be adversely affected if pandemic-related disruption persisted for six months or longer, reflecting concern about prolonged interruption to operative training rather than measured loss of competence (292).

Perceived skill decline was also reported in the context of pre-existing concerns regarding operative training. Among French ENT residents, substantial perceived deterioration in technical skill development was reported across all three COVID-19 waves, with surgical training consistently perceived as more affected than academic education(351). Similarly, in vascular surgery in France, 77% of trainees perceived that their surgical skills were negatively affected by the pandemic, with junior residents reporting the highest rates of unmet training goals (92%), indicating particular vulnerability among early-stage trainees(352).

In O&G training in Sweden, 69% of residents expressed concern that the pandemic negatively affected the quality of their specialist training, with reduced operative exposure perceived to contribute to diminished procedural competency and confidence. Over one-quarter feared prolongation of training, and a minority reported confirmed residency extensions, reinforcing concerns regarding delayed technical progression(290).

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Perceived decline in technical skills and confidence**	**Appraisal of quality using NIH assessment tool**
Impact of COVID-19 on Saudi Neurosurgery residency: Trainers' and trainees' perspectives, 2021, Saudi Arabia, Neurosurgery, (292)	National cross-sectional, online questionnaire-based survey of neurosurgery residents and programme directors conducted between May 16 and May 27, 2020, exploring the impact of COVID-19 on training, operative exposure, and educational activities. Response rates were 95% for residents and 100% for programme directors	More than half of programme directors (58.8%) agreed that residents' surgical skills would be adversely affected if the pandemic persisted for six months or longer. Although operative case volume significantly decreased during the pandemic, perceived decline in technical skills was inferred from anticipated impact rather than direct self-reported loss of competence. Over one-third of residents (35.8%) reported high anxiety levels during the pandemic, which may reflect reduced confidence related to training disruption	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Perceived decline in technical skills and confidence	Appraisal of quality using NIH assessment tool
Impact of the COVID-19 pandemic on core surgical training, 2020, UK, General surgery (303)	Cross-sectional, online voluntary anonymous survey of core surgical and improving surgical trainees in the West of Scotland region, conducted during the COVID-19 pandemic. Twenty-eight of 44 trainees responded (63.6% response rate)	The majority of trainees (71.4%) reported that their confidence in performing surgical skills had been negatively impacted by the pandemic, including open, laparoscopic, and endoscopic procedures. Reduced opportunities to operate as the primary surgeon (71.4%) and limited access to simulation resources were reported, contributing to perceived decline in technical skills and confidence.	Fair
The impact of COVID-19 on surgical training at a tertiary hospital in Greece: a 'hidden infectious enemy' for junior surgeons?, 2021, Greece, General surgery, (305)	Single-centre, cross-sectional survey of all core general surgical trainees at a tertiary university hospital in Greece, comparing operative experience and training before and during the COVID-19 pandemic. Data were collected using voluntary anonymous printed questionnaires, with a response rate of 94% (16/17 trainees)	Nearly two-thirds of trainees (62.5%) reported reduced confidence in the operating theatre as a result of the COVID-19 pandemic. This perceived decline in confidence coincided with a marked reduction in operative exposure, with trainees performing or assisting in almost 50% fewer surgical cases compared with the pre-pandemic period	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Perceived decline in technical skills and confidence**	**Appraisal of quality using NIH assessment tool**
Canadian ophthalmology resident experience during the COVID-19 pandemic, 2020, Canada, Ophthalmology, (309)	National cross-sectional, anonymous online survey of all Canadian ophthalmology residents conducted between May 6 and June 13, 2020. The survey explored the impact of the COVID-19 pandemic on surgical and clinical training, wellbeing, and attitudes. A total of 102 of 217 residents responded (47.0% response rate), representing all 15 residency programmes	Over half of residents (55%) agreed or strongly agreed that their surgical skills would deteriorate owing to pandemic-related shutdowns. Concerns regarding loss of surgical skills were more prominent than concerns about clinical skill deterioration. Clinical skill refers to review of patients in clinics, knowledge etc. Reduced operative exposure and limited access to simulation resources were reported, contributing to perceived decline in technical skills and confidence despite overall optimism regarding eventual competency at completion of training	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Perceived decline in technical skills and confidence**	**Appraisal of quality using NIH assessment tool**
A survey of the impact of the COVID-19 crisis on skill decay among Surgery and Anaesthesia Residents, 2021, USA, General surgery, (312)	Web-based cross-sectional survey of surgical and anaesthesia residents and faculty across two large academic tertiary medical centres in the USA. The survey assessed perceptions of training and technical skill changes across pre-pandemic and pandemic periods (2019–2021). Ninety-one of 173 respondents completed the survey (53.0% response rate)	Nearly two-thirds of residents (64%) reported a perceived reduction in technical operative skills during the COVID-19 pandemic, while 75.0% of faculty perceived a decline in residents' technical skills. Residents who were redeployed were significantly more likely to report technical skill decay compared with those who were not redeployed ($p < 0.05$). Despite concerns regarding technical skill deterioration, faculty expressed optimism that residents would achieve level-appropriate proficiency by completion of training	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Perceived decline in technical skills and confidence**	**Appraisal of quality using NIH assessment tool**
Impact of the COVID 19 pandemic on surgical skills training in paediatric surgery residents, 2021, Argentina, (316)	Single-centre retrospective study evaluating changes in paediatric surgical training during the COVID-19 pandemic (March to May 2020), with comparison to the same trimesters in 2018 and 2019. An anonymous self-perception survey assessing surgical skills development and confidence was administered to residents, achieving a 100% response rate	The majority of residents (70%) reported a perceived decrease in confidence during surgery during the pandemic period. Additionally, 70% reported no improvement in surgical performance and 50% reported taking longer to complete surgical procedures. These perceived declines in technical skills and confidence occurred alongside a substantial reduction in operative exposure, despite increased engagement in simulation-based training	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Perceived decline in technical skills and confidence**	**Appraisal of quality using NIH assessment tool**
Neurosurgery training in India during the COVID-19 pandemic: straight from the horse's mouth, 2020, India, Neurosurgery (335)	National cross-sectional, anonymous survey of neurosurgical residents across India, conducted between May 7 and May 16, 2020. A validated questionnaire was distributed via social media platforms to assess changes in surgical exposure, clinical training, academic activity, and perceptions regarding the impact of the COVID-19 pandemic on training	The majority of respondents perceived that the COVID-19 pandemic would negatively affect their operative and clinical skills. This perceived decline in technical skills occurred alongside a marked reduction in surgical exposure, with a reported decrease of approximately 67.5% in surgeries performed or assisted per month. Concerns regarding training progression and future competence were particularly pronounced among residents approaching licensing examinations	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Perceived decline in technical skills and confidence**	**Appraisal of quality using NIH assessment tool**
Deterioration experienced by French otolaryngology residents in their training during the COVID-19 pandemic: A STROBE analysis, 2022, France, ENT, (351)	National retrospective cross-sectional, questionnaire-based observational study conducted between August and October 2021. A structured 55-item online survey was distributed to otolaryngology residents across five French regions to assess academic education and surgical training during the first three COVID-19 waves	Residents reported a significant perceived deterioration in technical skill development during the COVID-19 pandemic. During the first wave, 79.7% (71/89) felt their training was negatively impacted, with surgical training consistently perceived as more affected than academic education across all three waves (61.8% in Wave 1, 59.6% in Wave 2, and 64.0% in Wave 3). The substantial reduction in surgical activity, particularly in core subspecialties such as otology and rhinology, contributed to concerns regarding reduced operative proficiency and delayed technical progression	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Perceived decline in technical skills and confidence**	**Appraisal of quality using NIH assessment tool**
The effect of the COVID-19 crisis on Vascular surgery training in France, 2023, France, Vascular surgery, (352)	National cross-sectional observational study using an anonymous 12-item online questionnaire distributed to all vascular surgery trainees (residents and fellows) registered with the French College of Vascular and Endovascular Surgery.	The majority of trainees (77.0%; 40/52) perceived that their surgical skills and training level were negatively affected by the COVID-19 pandemic. Over half of respondents (56.0%; 29/52) reported failing to meet their surgical training goals, with junior residents reporting the greatest perceived impact (92.0% reporting unmet goals). Perceived decline in technical skills and confidence was attributed to reduced elective and emergency surgical exposure, redeployment to non-surgical units, and temporary cessation of operative activity	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Perceived decline in technical skills and confidence	Appraisal of quality using NIH assessment tool
Challenges imposed by the COVID-19 pandemic on the Obstetrics and Gynaecology residency program: a mixed-methods Swedish survey in the COPE Staff cohort study, 2022, Sweden, O&G, (290)	Nationwide mixed-methods cross-sectional cohort study during the pandemic using an online 28-item questionnaire distributed to obstetrics and gynaecology residents in Sweden, supplemented by qualitative free-text content analysis.	A strong perception of declining technical skills and confidence was reported, with 69.0% (112/162) of residents expressing concern that the pandemic negatively affected the quality of their specialist training. Reduced operative exposure was perceived to contribute to inadequate procedural competency and diminished confidence. In addition, 28.0% of residents feared prolongation of training, and 7.0% reported confirmed residency extensions (mean 18.6 ± 11 weeks), reinforcing concerns regarding delayed technical progression.	Good

Table 17 Secondary outcome: Perceived decline in technical skills and confidence. Studies reporting postgraduate surgical trainees' self-reported perceptions of decline in technical skills, operative confidence, or preparedness for independent practice during the COVID-19 pandemic across surgical specialties. Outcomes include trainee-reported confidence, perceived skill decay, anticipated impact on competence, and concerns regarding technical progression. Study quality was appraised using the National Institutes of Health (NIH) Quality Assessment Tool for Observational, Cohort and Cross-Sectional Studies(216). Conference abstracts are indicated in column 1. Abbreviations: ENT- Ear, Nose & Throat (Otolaryngology), NIH- National Institutes of Health, O&G- Obstetrics & Gynaecology, PGY- Postgraduate year, STROBE: Strengthening the Reporting of Observational Studies in Epidemiology, UK- United Kingdom, USA- United States of America

Secondary outcome: Satisfaction with technical skills training and perceived impact on progression

Studies examining trainee satisfaction with technical skills training and perceived impact on progression consistently reported widespread concern regarding disruption to training pathways, delayed progression, and preparedness for independent practice during the COVID-19 pandemic (Table 18). These findings were predominantly derived from trainee- and educator-reported survey data and reflect subjective assessments of training adequacy, confidence in progression, and anticipated career impact.

Across multiple surgical specialties, trainees reported dissatisfaction with technical training opportunities and anxiety regarding delayed progression. In general surgery in the United States, all chief residents expressed concern regarding delays to board examinations and preparedness for certification, although a majority still intended to proceed with planned graduation and fellowship progression(373). Programme directors expressed greater concern than residents regarding loss of operative experience and recommended additional training or remediation during fellowship or early employment to address perceived gaps in preparedness (373).

Similar concerns were reported internationally. In Southeast Asia, 74% of neurosurgery trainees believed that the pandemic had negatively affected their training, citing uncertainty surrounding board examinations, reduced hands-on operative exposure, and growing operative backlogs as threats to timely progression(281). In Europe, 88.8% of neurosurgery trainees reported a negative impact on training, with some estimating that the disruption equated to the loss of approximately one year of operative experience, raising concerns about readiness for advancement(374).

Across orthopaedic training programmes, substantial dissatisfaction with training progression was reported. In Spain, two-thirds of residents felt their surgical training had been negatively affected, over half rated the impact as poor or very poor, and many anticipated the need for additional training time to compensate for lost operative exposure(375). Similarly, in pan-European

orthopaedic surveys, more than half of trainees expressed concern about achieving annual training goals, with a quarter anticipating the need for an additional year of training and others reporting anxiety regarding postponed examinations and delayed certification(314, 375). In Germany, 88.4% of orthopaedic trainees reported delayed surgical training and 80% described a general setback in residency progress, with more than half anticipating prolongation of training (348).

Urology trainees reported comparable concerns. In Portugal, approximately one-third of residents indicated plans to prolong their residency due to disrupted operative exposure and delayed skill acquisition(376). In Germany, residents described both major and minor delays in specialisation progress, with perceived deterioration in operative skill development and concerns that training quality during the pandemic was inferior to that of pre-pandemic cohorts(350). In USA, urology trainees similarly reported negative impacts on training adequacy, increased anxiety regarding competency at completion of residency, and concerns about preparedness for independent practice (331)

Concerns regarding delayed progression were also reported in other specialties. In cardiothoracic surgery, over one-third of trainees reported concern that they would not meet minimum operative case requirements for progression, with redeployment and reduced specialty-specific operating contributing to dissatisfaction with training adequacy(377). Ophthalmology programme directors in Brazil similarly reported the need for compensatory planning, including increased workload and, in some cases, extension of training duration, to mitigate pandemic-related training deficits (329).

Limited confidence in recovery strategies was evident. In a global orthopaedic survey, 78% of respondents perceived a moderate to high negative impact of the pandemic on training programmes, nearly half expressed pessimism regarding trainees' ability to catch up on lost experience, and the majority reported no action taken by national training bodies to mitigate disruption (264). In the UK, only 19% of trainees in a pan-surgical survey intended to progress to the next stage of training having gained all expected training opportunities, reflecting widespread concern regarding readiness for progression at formal review points(57).

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
General surgery chief residents' perspective on surgical education during the coronavirus disease 2019 (COVID-19) pandemic, 2020, USA, General Surgery, (378)	Prospective cross-sectional mixed-methods study using an anonymous web-based survey distributed to general surgery chief residents from six academic medical centres in Boston, Massachusetts, between March 31 and April 7, 2020. Semi-structured interviews were also conducted with attending surgeons to contextualise resident perspectives. The survey response rate was 61.5% (24/39)	All responding chief residents (100%) expressed concern regarding delays in board examinations, and many reported anxiety about preparedness for board certification and potential delays to graduation. Despite these concerns, 75% wished to proceed with planned graduation and transition to fellowship as scheduled, and 87.5% intended to pursue fellowship training. Attending surgeons expressed greater concern than residents regarding loss of operative experience, with 93.3% recommending tailored additional training during fellowship or early job onboarding to address perceived preparedness gaps.	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
Effect of SARS and COVID-19 outbreaks on Urology practice and training, 2021, China, Urology (379)	Comparative observational study combining institutional operative data review with a prospective cross-sectional anonymous online survey of urology residents across all public-sector urology centres in Hong Kong. Training impact during the COVID-19 period (February to March 2020) was compared with a pre-pandemic control period and with historical data from the SARS outbreak	Over half of residents (53.3%) reported cancellation of professional examinations, resulting in delays in progression through training. Substantial reductions in operative exposure during the COVID-19 period were reported and coincided with decreased resident participation in surgical cases, contributing to concerns regarding delayed training milestones and preparedness for advancement.	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
Impact of COVID-19 on Neurosurgical training in Southeast Asia, 2020, Indonesia, Malaysia, Philippines, Singapore, and Thailand, Neurosurgery,(281)	Cross-sectional online survey of neurosurgery residents from 33 training programmes across five Southeast Asian countries. A 33-item questionnaire was distributed via Google Forms between May 22 and May 31, 2020, assessing operative exposure, educational activities, and training concerns. A total of 298 of 470 residents responded (63% response rate)	Residents reported significant concern regarding uncertainty surrounding board examinations and potential delays in career advancement during the COVID-19 pandemic. Reduced hands-on surgical exposure and increasing backlog of operative cases were perceived to threaten timely progression through training. 74% of respondents believed that the pandemic would have a negative impact on their neurosurgical training, reinforcing widespread anxiety regarding preparedness and advancement	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
Has 2020 been a lost year in Orthopaedic surgery and trauma training? Residents' perceptions, 2021, Spain, Orthopaedics, (304)	National prospective cross-sectional observational study using a 17-item online survey distributed via web link and social media to orthopaedic surgery and traumatology residents across Spain between February 10 and February 28, 2021. The survey assessed the impact of the COVID-19 pandemic on clinical activity, surgical training, and educational provision	A substantial proportion of residents reported significant disruption to training progression, with 77.2% having rotations suspended and 69.7% of scheduled surgeries cancelled. Surgical activity was completely halted for a mean of eight weeks. Two-thirds of residents (66.8%) felt their surgical training had been negatively affected, with anticipated repercussions for future employment. Over half of respondents (52.1%) rated the overall impact on their training as poor or very poor, and the majority expressed a desire for additional training time to compensate for perceived loss of training during the pandemic	Good

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
The impact of the Coronavirus pandemic on European Neurosurgery trainees, 2021, Europe, Neurosurgery, (374)	Multi-national prospective cross-sectional observational study using a 44-item anonymous web-based survey distributed via email to European neurosurgical residents between November 2, 2020, and January 15, 2021. Responses were received from 134 of 810 residents across 22 European countries (16.4% response rate)	The majority of respondents (88.8%) reported that the COVID-19 pandemic negatively affected their neurosurgical education. A significant reduction in surgical exposure and clinical involvement was reported, and some trainees estimated that the disruption equated to the loss of approximately one full year of hands-on training. These perceptions reflected substantial concern regarding delayed progression and preparedness for advancement, with online webinars widely viewed as insufficient substitutes for operative experience	Poor

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
How the COVID-19 pandemic changed Urology residency- a nationwide survey from the Portuguese resident's perspective, 2021, Portugal, Urology, (376)	Nationwide prospective cross-sectional observational study using a 30-item online survey distributed to all urology residents in Portugal between April 25 and May 25, 2020. The survey assessed reductions in clinical and operative activity during the COVID-19 pandemic and residents' perceptions of its impact on training	Residents reported marked reductions in clinical and operative exposure across multiple domains during the pandemic. One-third of respondents (32.6%) indicated plans to prolong their residency as a consequence of disrupted training and reduced operative experience. These findings reflect concerns regarding delayed progression and adequacy of training attainment, despite increased engagement in research and continuing medical education during the pandemic period	Good

Title, year, location, speciality, reference	Study design, methodology	Results: Satisfaction with technical skills training and perceived impact on progression	Appraisal of quality using NIH assessment tool
COVID-19 and Cardiothoracic surgery: Effects on training and workforce utilisation in a global pandemic, 2021, USA, Canada, Columbia, Finland, Australia, South Korea, Nigeria, Cardiothoracic surgery, (261)	International prospective cross-sectional observational survey of cardiothoracic surgery trainees distributed via professional trainee organisations between June 25 and August 5, 2020. Trainees were asked to report changes in operative exposure, service allocation, and training experiences during the early phase of the COVID-19 pandemic. A total of 126 eligible responses were analysed from 748 surveys distributed (22.2% response rate)	Over one-third of trainees (38%) reported concern that they would not meet minimum operative case requirements required for progression due to pandemic-related reductions in surgical exposure. Half of respondents reported operative case volume reductions exceeding 50%, and redeployment to COVID-19-specific clinical settings further limited specialty training time, particularly among junior trainees. These factors contributed to perceived risk of delayed progression despite most trainees reporting preserved overall clinical acumen.	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
The continuing impact of Coronavirus disease 2019 on Neurosurgical training at the 1-year mark: Results of a nationwide survey of Neurosurgery residents in Turkey, 2021, Turkey, Neurosurgery, (284)	Nationwide cross-sectional observational study using a 38-item anonymous web-based survey distributed to neurosurgery residents in Turkey between January and February 2021. The survey assessed operative exposure, educational activities, and perceived impact of the COVID-19 pandemic on training. Responses were received from 235 of 356 residents (66% response rate), representing more than half of neurosurgical trainees nationally	Residents reported substantial concerns regarding training progression and preparedness one year into the pandemic. Over two-fifths of respondents (42.1%) indicated increased concern about the impact of COVID-19 on their surgical training and future career. A majority reported adverse effects on practical training, and 57.4% considered extending their residency to compensate for lost operative experience. Reduced elective operative exposure was identified as a key contributor to perceived delays in progression and readiness for advancement	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
Impact of the COVID-19 pandemic on Orthopaedic and Trauma surgery training in Europe, 2020, Europe, Orthopaedics, (314)	Cross-sectional study using a 24-item online survey distributed in May 2020 to orthopaedic surgery trainees affiliated with the Federation of Orthopaedic and Trauma Trainees in Europe. The survey examined changes in clinical roles, surgical exposure, educational activity, and personal training considerations during the COVID-19 pandemic	More than half of trainees (55%) believed their orthopaedic training would be negatively affected by the COVID-19 crisis. Concerns regarding achievement of annual training goals were reported by 58.2% of respondents, while 25% anticipated the need for an additional year of training to compensate for disruption. Although 61% expected to complete their current rotation as planned, 16% reported concern about postponement of final examinations, reflecting uncertainty regarding timely progression and certification	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
Impact of Coronavirus disease on the Ophthalmology residency training in Brazil, 2020, Brazil, Ophthalmology, (329)	National cross-sectional study using a validated electronic questionnaire distributed to programme directors/education coordinators of all ophthalmology residency programmes accredited by the Brazilian Council of Ophthalmology. The survey was administered via email and instant messaging platforms between May and June 2020. 79 of 95 coordinators responded (83% response rate)	Most education coordinators reported disruption to residency training requiring compensatory planning. Approximately 70% indicated that a recovery strategy was in place, including plans to increase residents' workload (26%) and, in a minority of programmes, to extend the duration of training (approximately 11%). These responses reflect anticipated impacts on progression timelines and the need for system-level mitigation to address training deficits arising from reduced clinical and surgical exposure during the pandemic	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
Perceived impact of Urologic surgery training program modifications due to COVID-19 in the United States, 2020, USA, Urology, (331)	National cross-sectional study using an anonymous online survey of programme directors and residents at accredited urology residency programmes in the United States. The survey was conducted between March and April 2020 to evaluate programme modifications and perceived effects on training. Responses were received from 55 of 127 programme directors (43%) and 23 of 127 residents (18%)	9% expressed a likelihood of fellowship training. The majority of respondents (approximately 80%) perceived that programme modifications during the COVID-19 pandemic negatively impacted urologic surgical training. Over half of residents (51%) reported increased anxiety regarding competency upon completion of residency, indicating concerns about preparedness for independent practice. Many residents reported adaptive responses, including increased engagement in self-directed learning (90%) and research activities (77%), reflecting attempts to mitigate reduced operative exposure while progression concerns persisted	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
COVID-19 impact on Surgical Training and Recovery Planning (COVID-STAR)- A cross-sectional observational study, 2021, UK, Multi-speciality (57)	A national, collaborative, cross-sectional study involving 13 surgical trainee associations using a pan-surgical specialty questionnaire on the impact of COVID-19 on surgical training over 4 weeks in May 2020	Only 19% of trainees intended to progress to the next stage of training at ARCP having gained all training opportunities	Good
Impact of Coronavirus 2019 (COVID-19) on training and well-being in subspecialty surgery: A national survey of Cardiothoracic trainees in the United Kingdom, 2020, UK, Cardiothoracic surgery, (56)	A cross-sectional online survey of cardiothoracic surgical trainees about the impact of the pandemic. 64% (76/118) responded	Trainees reported a significant deviation in their sessional activity in operating theatres ($p< 0.0001$). 63% of trainees report somewhat (25%, n= 19) or very (63%, n= 48) concerned about the impact of the pandemic on their learning and progression through structured training. There was no association between trainee seniority and declared concern	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
Orthopaedic training during COVID-19 pandemic: should action be taken?, 2022, Global, Orthopaedics, (264)	Cross-sectional survey study using a six-item questionnaire distributed via the International Society of Orthopaedics Surgery and Traumatology. Responses were collected from 230 orthopaedic surgeons across 76 countries and six continents between November and December 2021	The majority of respondents (78.0%) perceived that the COVID-19 pandemic had a moderate to high negative effect on current orthopaedic training programmes. Nearly half expressed pessimism regarding the development of competent future orthopaedic surgeons, with only 19.0% believing that trainees would be able to catch up on lost knowledge and experience. In addition, 59.0% reported no action taken by national training bodies to mitigate training disruption, reinforcing concerns about delayed progression and future preparedness at a systems level	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
Effects of the SARS-CoV-2 pandemic on residency training in Orthopaedics and Traumatology in Germany: A nationwide survey, 2022, Germany, Orthopaedics, (348)	Nationwide quantitative cross-sectional observational study using a voluntary anonymous online survey distributed via junior physician organisations. Structured questionnaires were used to assess the impact of the COVID-19 pandemic on operative exposure, educational activities, and residency progression among orthopaedic and trauma surgery residents. 95 responses received.	A substantial proportion of residents reported disruption to training progression, with 88.4% (84/95) stating that their surgical training was delayed and 80.0% (76/95) describing a general setback in residency progress. Reduced operative exposure and prioritisation of efficiency were perceived to decrease operative autonomy, with senior surgeons more frequently undertaking cases. Over half of respondents (55.8%) anticipated prolongation of their residency, reflecting concerns regarding preparedness for progression and delayed skill acquisition	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
Impact of the COVID-19 pandemic on Urology residency training programs in Germany, 2022, Germany, Urology, (350)	Nationwide quantitative cross-sectional observational study using an online questionnaire evaluating the impact of the COVID-19 pandemic on clinical activity and urology residency training. The survey was distributed between May 20 and June 20, 2020, via social media platforms, professional newsletters, and resident working group mailing lists	Residents reported substantial disruption to training progression, with 28.0% describing a very large delay (80–100%) in their specialisation and a further 28.0% reporting at least a minor delay. Approximately half of respondents reported significant restrictions in their training, driven by reduced surgical activity and clinical exposure. These disruptions contributed to a perceived deterioration in operative skill development and concerns that training quality during the pandemic was inferior to that of pre-pandemic cohorts	Fair

Title, year, location, speciality, reference	**Study design, methodology**	**Results: Satisfaction with technical skills training and perceived impact on progression**	**Appraisal of quality using NIH assessment tool**
The impact of the COVID-19 pandemic on surgeons' and surgical residents' caseload, surgical skills, and mental health in Kuwait, 2022, Kuwait, General surgery, (353)	National quantitative cross-sectional observational study using an electronic self-administered questionnaire. The survey was distributed via professional surgical networks between October and November 2020	Residents reported substantial disruption to training pathways, with reduced operative exposure, missed opportunities to work with mentors, and limited participation in theatre activities. These disruptions contributed to dissatisfaction with training and concerns regarding future career progression and specialty training applications. Redeployment away from surgical duties and cancellation of educational activities were perceived to disadvantage residents in terms of preparedness for progression and professional development	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Satisfaction with technical skills training and perceived impact on progression	Appraisal of quality using NIH assessment tool
Impact of the COVID-19 pandemic on Orthopaedic surgery residency training, 2023, USA, Orthopaedics, (354)	National quantitative cross-sectional observational study using a 26-item anonymous online survey distributed to orthopaedic surgery residency programs across the United States. The survey examined the perceived impact of the COVID-19 pandemic on operative experience, education, preparedness, and career progression	A majority of residents reported substantial disruption to training progression, with 66.2% indicating a significant reduction in operative experience. Over half of respondents rated the overall impact of the pandemic on their training as severe (54.2% rating impact 8–10/10). Only 15.5% believed their clinical ability in the following year would remain unaffected, indicating concerns regarding preparedness for progression. In addition, 88.7% believed the pandemic would negatively affect the 2021 residency match, reflecting broader career-related uncertainty	Fair

Title, year, location, speciality, reference	Study design, methodology	Results: Satisfaction with technical skills training and perceived impact on progression	Appraisal of quality using NIH assessment tool
Impact of COVID-19 on Neurosurgical resident training program, 2022, Germany, Neurosurgery, (361)	Single-centre mixed-methods cohort study combining retrospective hospital training data with semi-structured interviews of neurosurgical residents. The study examined the impact of the COVID-19 pandemic on operative exposure, training progression, and resident experiences between October 2019 and July 2020	Residents reported delays in training progression and increased stress during the pandemic period. Operative exposure decreased substantially, coinciding with reported logbook delays and reduced autonomy across major case groups. Despite these challenges, 35.0% of residents reported increased engagement in research activities, suggesting adaptive reallocation of time during periods of reduced clinical activity	Fair

Table 18 Secondary outcome: Satisfaction with technical skills training and perceived impact on progression. Studies reporting postgraduate surgical trainees' satisfaction with technical skills training during the COVID-19 pandemic and perceived impact on training progression, preparedness for independent practice, examination outcomes, and career advancement across surgical specialties. Outcomes include trainee- and educator-reported concerns regarding delayed progression, unmet training requirements, anticipated or confirmed training extensions, and perceived adequacy of training attainment. Study quality was appraised using the National Institutes of Health (NIH) Quality Assessment Tool for Observational, Cohort and Cross-Sectional Studies(216). Conference abstracts are indicated in column 1. Abbreviations: ACGME- Accreditation Council for Graduate Medical Education, ARCP- Annual Review of Competency Progression, ENT- Ear, Nose & Throat (Otolaryngology), NIH- National Institutes of Health, O&G- Obstetrics & Gynaecology, PGY- Postgraduate year, UK- United Kingdom, USA- United States of America

Discussion

Overview of findings

This systematic review synthesised evidence from 101 studies examining technical skills training in surgical subspecialties during the COVID-19 pandemic. The majority of included studies were conducted in high-income countries, with limited representation from low- and lower-middle-income settings. All surgical subspecialties were represented, although some were sparsely studied.

Most studies employed quantitative methodologies and relied predominantly on self-reported survey data, limiting methodological diversity and the availability of objective measures of technical skill acquisition. Due to heterogeneity in study design, outcomes, and reporting, meta-analysis was not appropriate. Instead, findings were synthesised according to predefined primary and secondary outcome measures, allowing clearer alignment between extracted data and reported results.

Across outcomes, the pandemic was associated with reduced operative exposure, diminished operative autonomy, inconsistent engagement with alternative training modalities, widespread trainee concern regarding technical skills and confidence, and dissatisfaction with training progression.

Impact on technical skills training

The development of surgical technical skills relies on the acquisition of knowledge (through formal educational activities and self-study) and the practise of hand-skills through deliberate practice (traditionally reliant on the experience gained through operating on patients on the job, and more recently through simulation) (380-382). Central to this process is sustained exposure to operative tasks of increasing complexity, allowing trainees to integrate motor skills, decision-making, and situational awareness in authentic clinical contexts (383, 384).

The COVID-19 pandemic disrupted this model by reducing hands-on operative exposure across most surgical subspecialties. The updated review demonstrates that reduced case volume, particularly elective and medium-complexity procedures, was a consistent finding across institutions and countries. The few centres that preserved operative exposure, emergency activity, or alternative operating environments experienced less disruption to opportunities for technical skills acquisition than those where operating was severely curtailed(334). This finding aligns with wider surgical education literature emphasising that continuity of practical exposure, in addition to than absolute case numbers, is critical for maintaining technical capability(385, 386).The impact of reduced operative exposure was compounded by the cancellation of examinations and face-to-face training courses, alongside inconsistent or underutilised adoption of simulation during the pandemic(2).

Operative autonomy and role in theatre

Beyond reduction in overall case volume, the review highlights a decrease in trainee operative autonomy during the COVID-19 pandemic. Across surgical specialties, trainees were less frequently positioned as primary operators, with a shift towards consultant-delivered operating. This appeared to be driven by multiple intersecting factors, including efficiency pressures in constrained theatre lists, workforce redeployment, and a possible prioritisation of service delivery during periods of system strain. Consequently, trainees were more commonly relegated to assisting or observational roles, even when present in theatre.

Operative autonomy is a critical component of surgical training, facilitating the transition from supervised skill acquisition to independent practice. Prior literature consistently demonstrates that graded responsibilities essential for consolidating technical skills; developing intraoperative decision-making, and fostering professional identity as an independent surgeon(387-390). Reduced autonomy therefore represents a qualitatively different educational loss from reduced case numbers, as it directly constrains opportunities for experiential learning at higher cognitive and technical levels(391).

The reduction in operative autonomy also raises important questions about the recalibration of risk tolerance in surgical education during crisis conditions. While increased consultant operating may enhance short-term efficiency, it may inadvertently undermine long-term workforce readiness by delaying trainees' progression towards independence. Pre-pandemic evidence suggests that appropriately supervised trainee-led operating does not compromise patient outcomes and may enhance educational value without increasing operative risk(392, 393). The pandemic response therefore appears to have prioritised immediate system resilience over sustained training needs, with limited empirical justification for the extent of autonomy restriction observed.

Engagement with simulation and alternative technical training modalities

Despite a substantial and well-established evidence base supporting simulation as an adjunct to surgical technical skills training (as presented in Chapter One of this thesis), engagement with simulation during the COVID-19 pandemic was inconsistent and highly variable across institutions. While some trainees reported increased independent use of low-cost modalities such as box trainers or participation in short-term, structured simulation interventions, access to institutional simulation facilities was frequently restricted or suspended due to infection control measures, staffing constraints, and competing organisational priorities. As a result, simulation uptake was often opportunistic rather than strategically planned.

The updated review demonstrates that structured simulation-based interventions were capable of producing short-term improvements in simulated technical performance during periods of reduced operative exposure. This finding is consistent with pre-pandemic literature demonstrating that simulation can effectively support skill acquisition, particularly for basic and procedural tasks, when aligned with principles of deliberate practice and feedback(394-396).

The pandemic exposed a persistent disconnect between the endorsement of simulation within surgical education and its practical integration into training systems. While simulation has been proposed as a partial mitigation strategy during periods of reduced clinical exposure, its effectiveness is contingent upon deliberate curricular alignment, protected time, trained faculty, and clear progression pathways linking simulated performance to clinical entrustment decisions(115, 397, 398). In the absence of these enabling conditions, simulation risks functioning as a compensatory activity rather than a meaningful substitute for experiential learning.

Perceived decline in technical skills and confidence

Across surgical specialties, trainees frequently reported perceived declines in both technical skills and operative confidence during the COVID-19 pandemic. These perceptions were closely associated with reduced operative exposure, redeployment away from surgical services, and disruption to established training structures. The loss of routine participation in operating theatres, combined with prolonged uncertainty regarding training continuity, appears to have contributed to a widespread sense of skills erosion and diminished readiness for operative responsibility.

The majority of evidence in this domain was derived from self-reported survey data and therefore reflects subjective experience rather than objectively measured technical performance. While these perceptions cannot be assumed to represent true technical skill decay, they remain educationally significant.

Confidence and perceived competence play a critical role in trainees' willingness to engage with operative opportunities, seek autonomy, and progress towards independent practice(399-401). Reduced confidence may therefore have downstream effects on learning behaviours and professional development, independent of actual technical ability(401, 402).The distinction between perceived skill decline and objectively measured skill decay is well recognised in the surgical education literature(89, 403).

Studies conducted prior to the pandemic suggest that while technical skills can deteriorate after prolonged periods of non-use, the magnitude and reversibility of this decline vary by task complexity, prior experience, and opportunities for skills maintenance(404, 405). During COVID-19, however, few studies incorporated objective assessments of technical performance in the operating theatre, limiting the ability to disentangle true skill loss from reduced confidence or anxiety about loss of operating opportunity affecting trainees' skills. This limitation underscores the need for caution in interpreting reported declines and is explored further in the limitations of this review.

Nevertheless, the persistence and consistency of reported confidence loss across contexts suggest a meaningful educational signal. Prolonged disengagement from operative activity, coupled with diminished autonomy and uncertainty regarding progression, may have undermined trainees' sense of professional efficacy.

Satisfaction with training and perceived impact on progression

Widespread dissatisfaction with technical skills training during the pandemic was reported by both trainees and educators, accompanied by significant concern regarding delayed progression, unmet training requirements, and preparedness for independent practice. The cancellation of examinations, postponement of mandatory courses, and rapid modification of assessment processes contributed to heightened uncertainty and anxiety regarding certification and career trajectories. These disruptions disproportionately affected trainees approaching key transition points, such as completion of training or eligibility for independent practice.

Concerns regarding progression were further amplified by the absence of clearly articulated recovery strategies in many training systems. Although some trainees anticipated the need for training

extensions or additional remediation, few jurisdictions had formalised, transparent mechanisms in place to address cumulative training deficits. Where recovery measures were reported, they were typically local, short-term, and inconsistently accessible, relying on individual trainers or institutions rather than coordinated national approaches. This variability risks exacerbating inequities in training outcomes and undermining the principle of standardised competency assurance.

The dissatisfaction reported during the pandemic aligns with pre-existing critiques of surgical training systems that are dependent on trainees providing service provision which compete with their training time and are vulnerable to external events that can negatively impact training (238, 406, 407). While competency-based frameworks aim to provide flexibility in progression, the pandemic led to tensions between technical skill requirements for each training year, procedural volume to demonstrate experience, and true readiness for independent practice.

From an educational systems perspective, dissatisfaction with training and perceived delays in progression may have lasting implications for workforce morale, retention, and confidence in training institutions. Evidence suggests that unresolved uncertainty and perceived lack of institutional support can contribute to burnout and disengagement (408-411). The findings of this review therefore highlight the importance of transparent communication, equitable recovery planning, and proactive support for technical skills development in mitigating the long-term consequences of training disruption.

Historical context

In their paper titled "Lessons from Epidemics, Pandemics, and Surgery", Nicholas Hakes et al describe the historical changes to surgery that occurred in the wake of epidemics and pandemics (412). The examples they quote include the formalisation of surgical guilds after the Plague, incorporating hygiene practices due to the Spanish flu and more recently the systemic flexibility that was required to deal with the Severe Acute Respiratory Syndrome (SARS) outbreak (412).

The COVID-19 pandemic similarly exposed vulnerabilities within contemporary surgical training, particularly in relation to technical skills development. Rather than representing an isolated or unprecedented disruption, the pandemic highlighted longstanding deficiencies for technical skills acquisition in surgical training programmes.

Proposal for recovery of technical skills training

A recovery measure discussed in this systematic review was the outsourcing of technical skill training to the independent sector (317). The independent healthcare section in the UK is not accessible for everyone (413, 414).

Though independent sector operating provided a potentially effective resource to consider post pandemic training recovery, other modalities for recovery such as simulation, training only operating lists, mentorship, extensions to training time and funding fellowships should also be considered. The recovery measures must be accessible, sustainable, and equitable (415-417).

Considering several avenues for recovery would provide educators globally the chance to understand their contexts, access to resources, their trainees' needs and apply the recovery measures that are likely to be the most effective.

As discussed in Chapter One of this thesis, use of simulation for technical skills training is evidence based. However, both with the evidence presented in this review and established in literature, simulation is often poorly implemented and therefore not completely beneficial. The poor implementation of simulation presented us with a large literature gap that required further exploration (115, 240, 418). The next step, explored in Chapter Six of this thesis, was identifying the barriers to implementing simulation into surgical training.

Strengths and limitations

This systematic review was conducted in accordance with the PRISMA statement and associated methodological guidance, with the aim of minimising identification and selection bias. All stages of the review process were explicitly documented, and any deviations from the registered protocol were transparently reported to maintain methodological rigour.

In contrast to previously published reviews examining the impact of COVID-19 on surgical training, this review adopted a specific focus on technical skills training and included a broader range of surgical subspecialties. This deliberate narrowing of educational focus, combined with wider specialty inclusion, enhanced the depth and richness of the findings and allowed for a more nuanced exploration of how technical skills development was affected across diverse surgical contexts.

Several limitations must nevertheless be acknowledged. A significant proportion of the included studies relied on self-reported data, particularly in relation to operative exposure, technical skills, and trainee confidence. While such data provide valuable insight into lived experience, they are inherently subjective and vulnerable to recall bias, response bias, and contextual influences associated with the pandemic. In addition, relatively few studies incorporated objective or standardised measures of technical skill, and those that did were often limited to short-term or simulation-based outcomes. This constrained the ability of the review to distinguish between perceived skill decline, delayed progression, and true technical skill decay.

The heterogeneity of study designs, outcome measures and the absence of randomised controlled trials did not allow for a meta-analysis of the results. Qualitative and narrative synthesis methods were applied to integrate the findings.

Studies were included based on relevance to the review question rather than methodological quality alone, and levels of bias therefore varied across the included literature. Opinion-based publications

were excluded; however, many studies were observational in nature and conducted rapidly in response to the pandemic. This variation should be considered when interpreting the findings.

During the conduct of the review, deviations from the registered protocol were necessary and were fully documented. These included narrowing the scope of the review to focus specifically on technical skills training and modifying the risk-of-bias assessment tool to better reflect the nature of the included studies. While such adaptations may introduce methodological complexity, they were undertaken to enhance the relevance and interpretability of the findings in response to the evolving evidence base.

Finally, the limited representation of low-and middle-income countries highlights a potential publication and sampling bias. Given the variability in surgical training structures, resource availability, and pandemic impact globally, this restricts the generalisability of the findings. The experiences and mitigation strategies reported in predominantly high-income settings may not be readily transferable to lower-resource contexts, and caution is therefore required when extrapolating conclusions beyond the populations represented in the included studies.

How does this chapter answer the research question?

In response to the research question, "What was the impact of the COVID-19 pandemic on postgraduate technical skills training in surgical subspecialties?", this systematic review demonstrates that the pandemic had a predominantly negative and widespread impact on postgraduate surgical technical skills training. Across specialties and regions, trainees experienced substantial reductions in operative exposure and case volume, diminished opportunities for operative autonomy, and inconsistent access to simulation or alternative technical training modalities. These disruptions were accompanied by pervasive trainee concerns regarding technical skill development, confidence, satisfaction with training, and delayed progression toward independent practice. While targeted local innovations and structured simulation interventions partially mitigated training loss in some

contexts, their implementation was variable and insufficient to fully compensate for reduced hands-on operating. The findings indicate that COVID-19 exposed and amplified pre-existing vulnerabilities in surgical technical skills training systems, underscoring the need for well-planned educational interventions such as simulation implemented into routine surgical training to support recovery and future preparedness.

Chapter Conclusion

The purpose of this systematic review was to understand the impact of the COVID-19 pandemic on technical skills training in surgical subspecialities. This chapter adds to the evidence regarding the issues with technical skills training in Chapters Three and Four.

This chapter has practical implications. The post-COVID recovery of surgical training is an opportunity for a paradigm shift in surgical training with technical skills simulation as an essential adjunct to learning in the operating theatre. The findings underscore the need for adaptable, equitable recovery measures to address training deficits.

The next chapter will identify the barriers to the use of simulation through a scoping literature review. This knowledge, of the gaps in literature for technical skills training in surgery combined with the knowledge of the barriers to using simulation, is necessary to develop strategies for the implementation of simulation into surgical training.

Chapter Six: Barriers to the implementation of simulation into surgical training: A scoping review of literature

Note on publication of Chapter Six

The study in Chapter Six has been published as a paper titled 'Mind the gap: A scoping literature Review and thematic analysis to understand the barriers to using technical skills simulation in surgical training' in the Indian Journal of Surgery on 31st October 2025. I have suitably modified the paper, complying with departmental and university regulations.

Contribution statement

I am the lead author for the work presented in this chapter. I conducted the research, collected, and analysed the data and authored the paper for publication. The co-authors of the paper (Debbie Aitken and Helen Higham) provided guidance, acted as second reviewers, and were the supervisors of my doctoral research.

Chapter Introduction

Chapter Three discussed the lack of descriptive detail in surgical curricula on the modalities to be used for technical skills training, particularly simulation. Chapters Four and Five, presented further evidence of deficiencies in surgical technical skills training both prior to and during the pandemic. One of the important themes identified in Chapter Four was the need for a multimodal approach to technical skills training, emphasising the inadequacies of relying only on access to an operating theatre to learn. In Chapter Five, the systematic review of technical skills training during the pandemic discussed trainees having some access to simulation but the resource being inadequately used. This chapter will explore the barriers to using simulation in surgical training.

Note

A regional survey was conducted using an adapted version of the Association for Simulated Practice in Healthcare (ASPiH) questionnaire in October 2021. The intention was to capture local perspectives on the barriers to using simulation. However, upon further reflection and in response to examiner feedback, the survey data were excluded from this chapter. The questionnaire, originally designed to collect institutional-level information, was distributed to multiple educators within the same centres to enrich qualitative insight; this approach, however, raised concerns regarding the appropriateness and validity of the tool for individual-level analysis. Following discussion with my supervisors, it was concluded that the survey did not contribute additional or distinct findings beyond those already identified through the literature review. Its exclusion does not therefore alter the themes or conclusions presented. The omission of the survey data also reflects a deliberate methodological refinement, acknowledging the limitations of the instrument's design, scope, and relevance to the study's aims.

Surgical simulation is equivalent in efficacy to traditional training

Surgical technical skills training refers to the acquiring of adequate manual dexterity and knowledge to perform surgical tasks of a range of complexities (419). Traditional training models relied solely on accomplishing technical skills training by "learning on the job" (420, 421). However, modern healthcare poses challenges- reduced working hours, increased number of residents and inadequate sessions in the operating theatre to learn(421).

Surgical educators, over the last few decades, have realised the crisis in surgical training that awaits us and have actively looked for alternative avenues to offer residents technical skills training opportunities (254). Numerous publications over the last three decades have investigated simulation as an important tool for surgical education, that can train residents with transferable skills to the operating theatre (100, 101, 422, 423).

Sutherland et al, in 2006, published a systematic review that collated the data on simulation and compared it to the traditional training modalities and reported equivalence in efficacy (76). A systematic review by McGaghie et al highlighted the superiority of simulation based education combined with deliberate practice over traditional training alone for building skills(112). This evidence was reassuring to educators who wanted to offer additional training alternatives to their resident doctors.

When discussing technical skills simulation for surgical trainees, there are a few factors to consider-

Firstly, simulation should not be used to replace the experience gained in an operating theatre but should be viewed as an adjunct to practise and hone technical skills in a psychologically safe environment with no risk of patient harm (424). The ultimate goal of incorporating technical skills simulation should be to reduce the learning curve in theatre, practise difficult skills that take time to learn and the "in the operating theatre" training time used as an opportunity for learning skills that cannot be learnt easily in simulation (420, 424).

Secondly, the use of simulation regularly over time has been described in literature as distributed practice (244), and has been shown to be superior to an approach that uses simulation in sudden bursts.

Thirdly, the number of medical school places in the UK has increased(425). Therefore, the number of surgical training posts would have to eventually increase to accommodate the increase in medical graduates coming through. The existing difficulties with providing adequate "in operating theatre" training opportunities will be compounded. Using technical skills simulation efficiently and purposely alongside traditional training may be the solution modern healthcare systems require to provide adequate opportunities for doctors to become technically competent (426, 427).

Fourthly, for complex skills like laparoscopic suturing, the most efficient way to learn would be to practise in simulation first, until a reasonable level of proficiency is achieved, before attempting it in an operating theatre on a real patient (428, 429).

The cost of surgical training: Simulation and "on-the-job" training

One of the biggest worries and criticism regarding simulation training is the cost involved with providing the equipment, trained faculty, technical staff etc. A publication in 2023 referred to the cost of setting up a simulation lab to range from USD 100,000 to several million USD (420). Earlier work estimated set-up costs of USD 876,485, annual fixed costs of USD 361,425, and variable costs of USD 311 per course hour (430). However, if the comparator was training on the job in an operating theatre, it is worth noting there are substantial costs involved with this option too.

In one paper published more than two decades ago, the cost of training a surgical resident was calculated to be nearly USD 47,970 per resident (54).This study was conducted between July 1993 and March 1997.The authors of this paper acknowledged the high costs involved with training residents in an operating theatre environment advocating for pre-operating theatre technical skills training opportunities to be developed and incorporated including simulation.

Similar publications indicated that it is more cost effective to train in simulation first before performing the procedure in real life (430-434).

Potential barriers and the literature gap

Despite the evidence that demonstrates the efficacy of technical skills simulation, the evidence from Chapters Three, Four and Five highlighted a large gap between the intention of implementing technical skills simulation and current surgical training.

It is vital to understand the barriers that have prevented the implementation of simulation thus far, because any intervention designed to improve implementation must address or work within the constraints that exist in the current training system.

Aim and Objectives

The aim of this study was to identify the barriers to using simulation in surgical training.

The Objectives were

1. To conduct a scoping review of the literature examining factors that are barriers to the use of simulation in surgical training.
2. To conduct a thematic analysis to generate overarching themes representing the identified barriers.

Methods

Levac, Colquhoun and O'Brien's five stages of conducting a scoping review was used to develop the methodology (435). The stages included identifying the research question, identifying relevant studies, study selection, charting data and collating, summarising and reporting the results.

Identifying the research question

The focus for this scoping review was surgical training and so the research question was 'what are the barriers to using simulation for surgical training?'. This research question was focussed enough to help identify relevant papers but broad enough to cover a range of surgical specialities to be able to conduct an effective scoping review.

Identifying relevant studies

The search strategy was determined with advice from a specialised librarian. The search terms are detailed in Box 4. Medline and EMBASE were searched in September 2024. Hand searches of reference lists of full text articles were also conducted to identify all relevant papers.

Search terms
1 exp Simulation Training/ (23894)
2 (Surg* or operat* or procedur*).tw. (9878566)
3 barrier*.ti,ab,kf. (1020365)
4 1 and 2 and 3 (263)
5 remove duplicates from 4 (208)

Box 4 Search terms used for the literature review

Study selection

To be included, articles were required to satisfy the following inclusion criteria:

1. Articles relating to surgical training
2. Articles including simulation-based education
3. Articles discussing barriers to implementing simulation

Non-English language articles and those that did not meet the inclusion criteria in terms of population, context and concept were excluded. The title and abstract search was conducted by AS and the full text reviews was completed by AS, with HH and DA acting as a second reviewer. Consensus was reached on all full text papers. EndNote was used to manage the search and selection process.

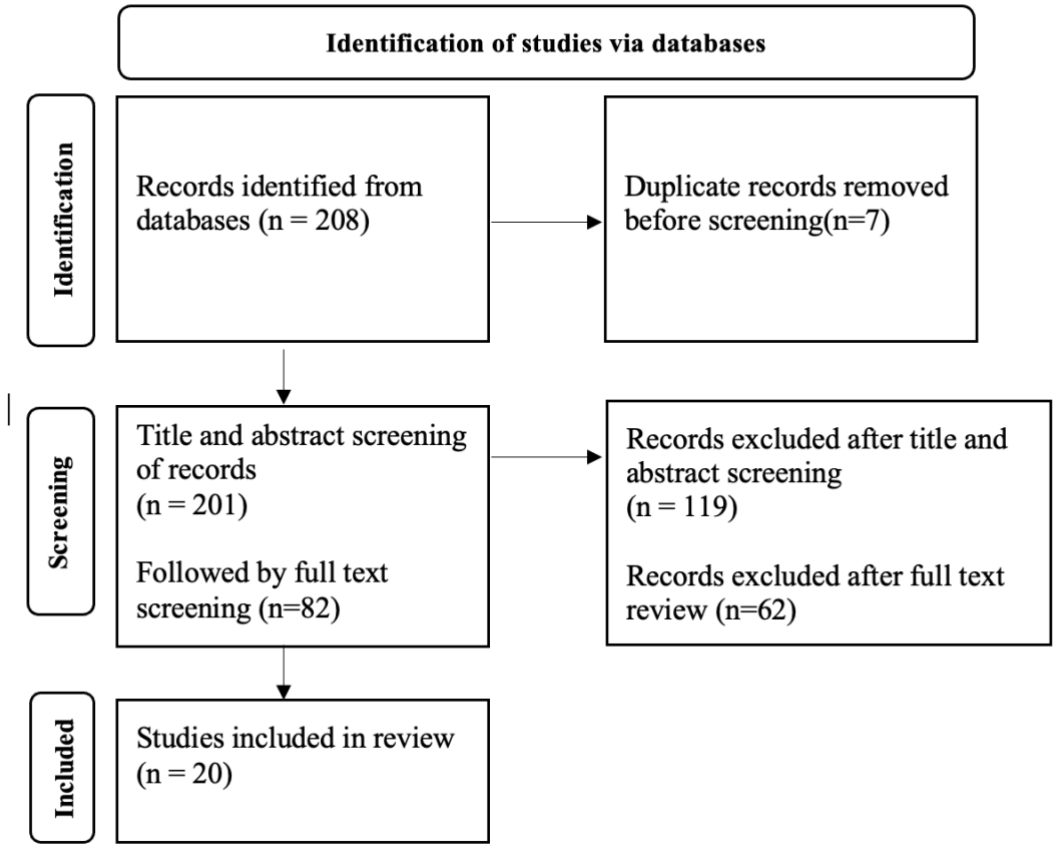


Figure 8 The search results of MEDLINE and EMBASE identified 201 papers that underwent title and abstract search. Data was extracted from 20 papers based on the inclusion and exclusion criteria

Charting the data

Once the papers to be included in the review had been finalised, data from the papers was extracted onto a Microsoft Excel spreadsheet. Relevant data from each study including study population, study methodology and outcome measures were documented.

The thematic analysis was conducted following the process detailed in the paper by Naeem et al (218), the data was first read through in its entirety and initial codes were developed using an inductive coding process. A second review of the data was performed with deductive coding. The codes were then sorted into potential themes. The themes were reviewed and compared to the source data to check if its representative and the themes were finalised with regards to the barriers to implementing technical skills simulation. The thematic analysis was an iterative process with regular discussions amongst AS, HH and DA (436).

Collating, summarising and reporting results

Once the themes had been developed, the results were presented and contextualised as discussed in the subsequent results and discussion section

Results

Two hundred and eight papers were identified with the search, after electronic de-duplication. A second de-duplication was carried out by hand (Figure 8). Two hundred and one papers underwent abstract, title and full text review. A further full text review identified 20 papers for inclusion and data extraction. Table 19 contains general demographic information regarding the papers, including country, speciality, aim, methodology and the population included in the studies.

The studies were representative of a large number of continents and countries, with two publications from Africa, four from the UK and Europe, eight from North America, four global (i.e., from multiple continents) and three from Australasia. The majority of the studies used quantitative methodology (13 of 20), four studies used qualitative methodology, and three studies were literature and systematic reviews.

Author, title, country, reference	**Speciality**	**Aim**	**Method**	**Participants, (the response rate is indicated in brackets where available)**
Experiences and Perceptions of Ophthalmic Simulation-Based Surgical Education in Sub-Saharan Africa Kenya, Uganda, Tanzania, Zimbabwe, and South Africa (437)	Ophthalmology	To investigate the subjective perspectives of ophthalmology trainees and experienced ophthalmic surgeon educators towards the delivery of conventional ophthalmic surgical training and simulation based surgical education in Western, Eastern, Central and Southern Africa	Semi structured interviews before and after an intense simulation training course in intraocular surgery. Thematic analysis of transcripts	27 trainee ophthalmologists and 12 ophthalmic educators
Barriers and facilitators to deliberate practice using take-home laparoscopic simulators UK and Ireland (Scotland, Ireland, Wessex, Bristol) (438)	Core surgical training	To uncover the barriers to engagement with take-home deliberate practice simulation programme for laparoscopic skills (incentivised laparoscopy practice study, simulator EcoSim, module EcoSim core)	Qualitative study using focus groups with key stakeholders including junior surgical trainees, consultants/attendings and simulation faculty. Thematic analysis was performed	63 participants in 12 focus groups (43 core surgical trainees, 20 trainers)

Author, title, country, reference	**Speciality**	**Aim**	**Method**	**Participants, (the response rate is indicated in brackets where available)**
Simulation Training in Vascular and Endovascular Surgery: A Nationwide Survey Among Surgeon Educators and Trainees in France France (439)	Vascular surgery	To investigate the utilisation of simulation training among vascular surgeons in France, amidst ongoing shifts in teaching approaches and educational reforms	National survey assessed the experiences and perceptions of vascular surgery professionals regarding simulation training	76 participants
The Role of Simulation in Teaching Sinus Surgery in Otolaryngology Residency: A Survey of Rhinologists USA, Canada, Puerto Rico (440)	ENT	To obtain an understanding of current ESS simulation use to aid the future development of an ESS training curriculum	Survey of training programmes	67 training programs

Author, title, country, reference	**Speciality**	**Aim**	**Method**	**Participants, (the response rate is indicated in brackets where available)**
Perceptions and barriers to robotic simulator training during surgical residency USA (441)	General surgery and integrated cardiothoracic surgery	To understand the effect of a self-directed robotic training curriculum on residents' skills, ability to function as adult learners and explored the correlation of trainees' long-term goals and their interest in obtaining training in the use of robots	Survey of residents	37 participants (74% response rate)
Use of simulation-based training of surgical technical skills among ENTs: an international YO-IFOS survey Global (51 countries) (442)	ENT	To investigate and compare the use of simulation-based technical skills training in the ENT curriculum in different countries, and to explore the needs and opinions about the use of simulation among young otolaryngologists	Survey conducted among Young otolaryngologists of the International federation of oto-rhino-laryngological societies members	162 participants (34% response rate)

Author, title, country, reference	**Speciality**	**Aim**	**Method**	**Participants, (the response rate is indicated in brackets where available)**
Systematic Review of Voluntary Participation in Simulation-Based Laparoscopic Skills Training: Motivators and Barriers for Surgical Trainee Attendance Global (443)	General surgery	To examine and report on evidence relating to surgical trainees' voluntary participation in simulation-based laparoscopic skills training	Systematic review	9 papers were included
Simulation Training Experience and Trends in Minimally Invasive Gynaecologic Surgery Fellowship: A Survey USA (444)	Gynaecology	To determine trainee and fellowship director experience, perceptions, and preferences with simulation and to assess the status of simulation training in Fellowship Minimally Invasive Gynaecological Surgery programs	A survey was distributed during the 2022 annual meeting regarding simulation training experience based on fellowship minimally invasive gynaecological surgery milestones	38 individuals responded: 12 (31.6% response rate) first-year fellows, 6 (15.8% response rate) second-year fellows, and 20 (52.6% response rate) program directors/assistant program directors

Author, title, country, reference	**Speciality**	**Aim**	**Method**	**Participants, (the response rate is indicated in brackets where available)**
Current status of resident simulation training curricula: pearls and pitfalls USA (445)	General surgery	To detail the current state of the most commonly used laparoscopic, endoscopic, and robotic surgery simulation programs in general surgery residency education, including resources required for successful implementation and benchmarks for evaluation	Literature review	Unclear how many papers were included
Barriers to the implementation and uptake of simulation-based training programs in general surgery: a multinational qualitative study UK, USA, France, Japan, and Canada (446)	General surgery	To identify barriers and facilitators to the implementation and uptake of surgical simulation training programs	Qualitative study with semi-structured interviews of general surgical trainees and experts	37 participants: 17 experts (program directors and surgical attendings with an interest in surgical education) and 20 residents

Author, title, country, reference	**Speciality**	**Aim**	**Method**	**Participants, (the response rate is indicated in brackets where available)**
Take home box trainer project-what barriers remain? Australia (447)	Obstetrics and Gynaecology	To identify trainee perspectives on the take home box trainer program	17 box trainers (EcoSim Pro-Trac) were provided for home use supported by a formal curriculum, questionnaire for feedback	12 trainees (71% response rate)
Simulation-based training in urology residency programmes in the USA: Results of a nationwide survey USA (448)	Urology	To evaluate the current usage of simulation in urological education in the USA and the barriers to incorporating a simulation-based educational curriculum	Survey of residency programme directors at urology training programmes	43 participants (35% response rate)

Author, title, country, reference	**Speciality**	**Aim**	**Method**	**Participants, (the response rate is indicated in brackets where available)**
Virtual Reality and Surgical Simulation Training for Orthopaedic Surgery Residents: A Qualitative Assessment of Trainee Perspectives USA (449)	Orthopaedics	To better understand orthopaedic surgery trainee's current perceptions about VR and how it can best be implemented within their own training	Semi structured interviews until thematic saturation	6 participants were residents from year 2 to year 5
Facilitators and Barriers to Implementation of Simulation Based Education in Vascular Surgery in Europe Europe (119)	Vascular surgery	To explore the status and availability of simulation-based education in vascular surgery for learning vascular surgical procedures and to identify facilitators and barriers to implementation	Survey distributed via the European Society for Vascular Surgery and the Union Européenne des Médecins Spécialistes	147 key opinion leaders (target population 338) accepted invitation to round 1, representing 30 European countries. The dropout rates for rounds 2 and 3 were 29% and 40%, respectively. Most respondents (88%) were senior, consultant level or higher

Author, title, country, reference	**Speciality**	**Aim**	**Method**	**Participants, (the response rate is indicated in brackets where available)**
Gamification of robotic simulation to train general surgery residents USA (450)	General surgery	To determine whether gamification of robotic simulation training could increase robotic simulator utilization among general surgery residents	Weekly progress on simulator performance including leader boards for 4 weeks during the intervention period and compared to two control groups. Usage time and mean scores were compared between the control periods and intervention periods. A post study qualitative assessment interview using semi-structured interviews determined barriers and motivational components of simulator usage	15 general surgical residents

Author, title, country, reference	**Speciality**	**Aim**	**Method**	**Participants, (the response rate is indicated in brackets where available)**
Simulation Training in Obstetrics and Gynaecology Residency Programs in Canada Canada (451)	Obstetrics and Gynaecology	To evaluate the current use of simulation in obstetrics and gynaecology residency programs in Canada	Survey of 16 active and accredited obstetrics and gynaecology residency programs in Canada to programme directors, faculty members and senior residents	12 responses
Surgical Simulation in East, Central, and Southern Africa: A Multinational Survey Countries in East, Central, and Southern Africa (452)	General surgery	To characterise the current state of surgical skills simulation in East, Central, and Southern Africa and determine residents' perception and future interest in such activities	Survey	43 trainees (57%)

Author, title, country, reference	**Speciality**	**Aim**	**Method**	**Participants, (the response rate is indicated in brackets where available)**
Motivators and Barriers to Access, and Engage in Laparoscopic Simulation Training in O& G -A Study to Understand Trainees' and Trainers' Perspectives in Australia and New Zealand Australia and New Zealand (453)	Obstetrics and Gynaecology	To explore the key motivators or barriers towards engaging in laparoscopic simulation training	Survey of O&G trainees and trainers	200 trainees and trainers responded to the survey
Barriers to Engagement in Surgical Simulation Education Global (454)	General surgery	To identify barriers to surgical simulation engagement and strategies to mitigate these	Literature review	29 papers included. The majority (86%) were in high income countries and four in low middle income countries. Most were surveys (22/29), and five involved semi-structured interviews/focus groups

Author, title, country, reference	**Speciality**	**Aim**	**Method**	**Participants, (the response rate is indicated in brackets where available)**
Simulation training in obstetrics and gynaecology: What's happening on the frontline? Australia and New Zealand (455)	Obstetrics and Gynaecology	To investigate the current availability and utilisation of simulation training, and the attitudes, perceived barriers, and enablers towards simulation in Australia and New Zealand	Survey	624 participants (158 trainees and 466 fellows)

Table 19 Demographic information from the 20 papers included in this literature review. Abbreviations: ESS- Endoscopic Sinus Surgery, ENT- Otolaryngology, O&G- Obstetrics and Gynaecology, UK- United Kingdom, USA- United States of America, VR- Virtual Reality, YO-IFOS: Young Otolaryngologists of the International Federation of Otorhinolaryngological Societies

Thematic analysis of barriers to the use of simulation for surgical training

There were six themes that were developed during the thematic analysis(Figure 9):

1. Availability of faculty and faculty support
2. Lack of dedicated simulation space
3. Lack of technical support staff
4. Limited funding for space, faculty, and equipment
5. Insufficient allocated time and motivation for trainees
6. Long term sustainability planning

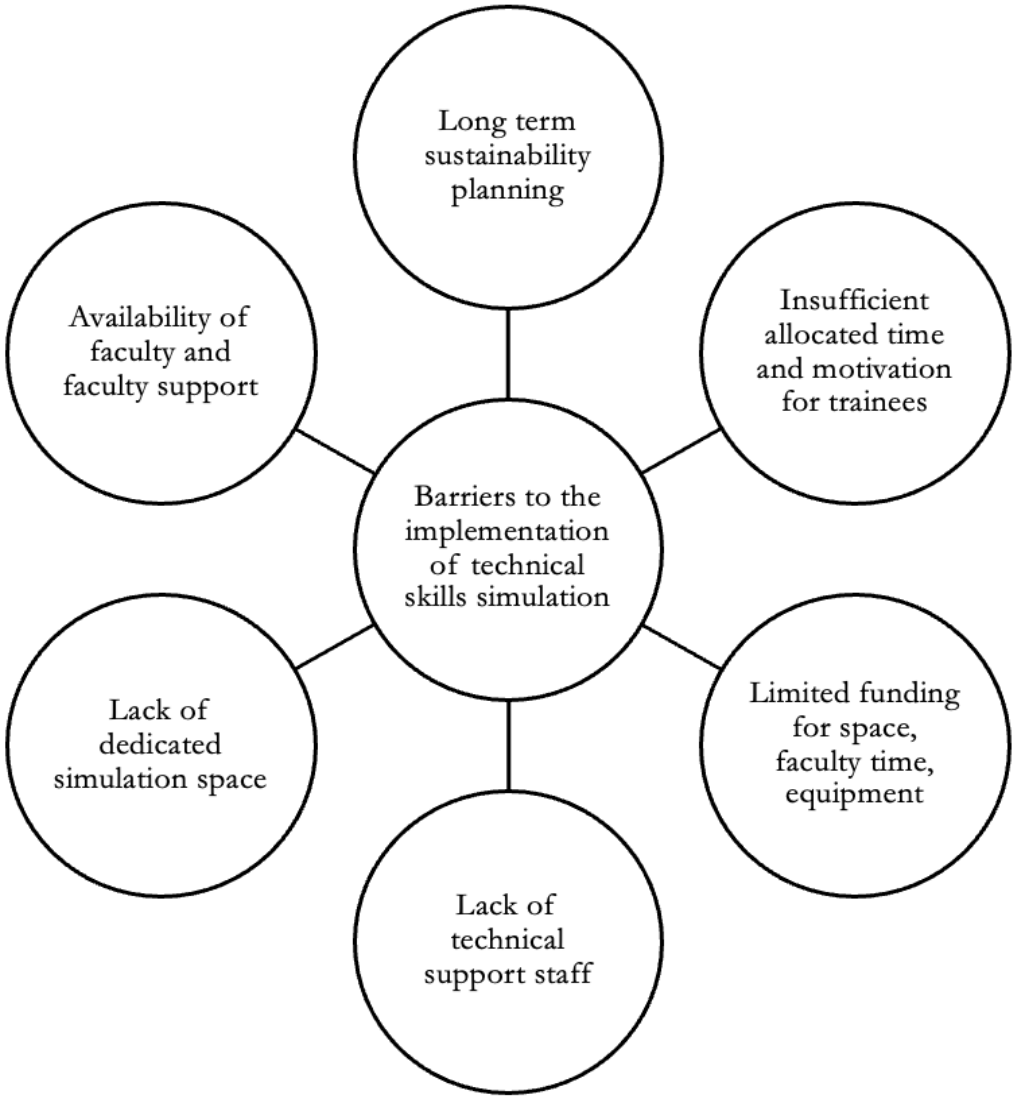


Figure 9 Thematic analysis of the data from the scoping review identified six themes relating to the barriers to implementing simulation for surgical training

Availability of faculty and faculty support

Fourteen of the included 20 papers reported faculty related issues as a barriers for implementing simulation. The issues were with lack of dedicated time, no provisions of a financial incentive for faculty to teach in simulations, no formal training for surgical educators to provide simulation, an overall lack of awareness of simulation programmes, lack of interest in teaching and considering simulation to be inferior to clinical training (119, 437, 438, 440, 442, 444-446, 448, 451-455).

Lack of dedicated simulation space

Eleven of the 20 papers reported issues with access to appropriate simulation space. Simulation facilities were poorly maintained or were difficult to access. Some studies reported no access to simulation facilities for one third to half of the participants in the studies (437, 439, 440, 442-444, 446, 451, 452, 454, 455). A further three studies reported issues with the simulation equipment- need for constant upgrade of the equipment, lack of Wi-Fi at the facilities and difficulty setting up the equipment (447-449).

Lack of technical support staff

Four of 20 studies reported lack of technical support staff to be a barrier for providing simulation training, including difficulty with maintaining and updating the equipment, promoting the training that was run by the simulation centre and supporting faculty for delivering the training (437, 439, 449, 452).

Limited funding for space, faculty, and equipment

Thirteen of the 20 studies quoted the high cost of simulators (e.g., one study quoted the example of a VR simulator costing USD 50,000), cost for setting up a simulation lab and underfunded simulation programmes due to a focus on service provision as a substantial barrier to the implementation of simulation (119, 437, 440, 442, 444-446, 448, 449, 451, 452, 454, 455).

Insufficient allocated time and motivation for trainees

Trainees were not allocated adequate time in their work schedules for simulation related education, and the evidence from the literature review was overwhelming with 18 of the 20 studies contributing to this theme.

An additional code for this theme related to the lack of motivation of trainees to engage with simulation. The reasons for lack of motivation and poor engagement with simulation were due to trainees undervaluing simulation training, simulation not directly impacting their career progression, having access to the wrong type of simulation when the skill is not being used in day-to-day clinical activities, a general lack of interest, no provision for protected time to engage with simulation and inadequate access to training sessions (119, 437, 438, 440-444, 446-455).

The literature review also revealed two important findings- ignorance about the existing published literature about the efficacy of technical skills simulation which meant trainees were often unconvinced about the benefits of engaging with simulation combined with a lack of simulation culture in the environment they trained in (119, 438, 442, 446, 448).

Long term sustainability planning

This theme was developed from 11 of the 20 studies. According to the studies, sustainability planning that is required for the continued use of simulation training included explicitly building simulation into the larger surgical training system, incorporating it into normal working hours with scheduled simulation sessions, a standardised curriculum incorporated into existing training and standardisation of the simulation training offered (119, 437, 438, 443-446, 448, 452, 453, 455). Also, the need for protected time in the trainees' education schedules to enable them to complete simulation modules and demonstrate progress against pre-set criteria within the curriculum (443, 444).

Discussion

The thematic analysis of the literature review identified six distinct barriers to the implementation of simulation training- availability of faculty and faculty support, lack of dedicated simulation space, lack of technical support staff, less funding for space, faculty, and equipment, insufficient allocated time and motivation for trainees and long-term sustainability planning. Though these themes are discussed as distinct concepts in the results section, they are in fact interrelated and are likely to stem from a wider systemic and infrastructural undervaluing of simulation's role in surgical education (179).

Availability of faculty and faculty support

No educational programme, simulation or otherwise, can be sustained without faculty who are capable of planning, delivering, and supporting the trainees on a long-term regular basis (456, 457).

The findings indicated that simulation faculty often participate on a voluntary basis, with no specific time allocated in their job plans for delivering simulation training. There is a lack of faculty training for simulation which potentially could result in the delivering of unstandardised training that may not use the entire gamut of simulation strategies that exist because of a lack of awareness. This lack of institutional incentive (financial or career progression) results in clinical work being prioritised over simulation training (458).

Evidence shows that faculty buy-in is vital for the survival of simulation training programmes and therefore, training and workforce policy changes must occur to formalise the role of engaging with simulation-based education in the job plans of faculty (459). Providing a formal pathway for faculty to upskill- with a fellowship or a certificate course, would provide formal recognition of the role of simulation faculty, which is important for providing long-term sustainable simulation training (460).

Long term development of faculty should include training senior residents in providing simulation training as a career pathway to pursue, so they could continue with faculty development and providing simulation training even after their completion of training (460).

Infrastructure and resource constraints: Lack of dedicated simulation space, lack of technical support staff and limited funding for space, faculty, and equipment

The thematic analysis revealed multiple interrelated infrastructural barriers to implementing simulation training.

For simulation training to be delivered, the essential components are space, equipment, staff, and a plan (179). Arguably, all of these components require funding. However, the health economics calculations have supported the regular use of simulation (461).

Though there is a potentially substantial upfront cost associated with simulation for equipment and facilities, long term costs of surgical training using a combination of simulation and traditional training is likely to be cost effective, as training doctors in an operating theatre is also expensive, time consuming, potentially reducing the efficacy of an operating list and potentially placing patients at harm (430, 462). There is also the indirect benefit of improving patient outcomes, reducing surgical complications, and thereby potentially reducing litigation and malpractice pay-outs (463-466).

However, solely dedicating all efforts and funding to the set-up of simulation facilities is not adequate for seeing long term training and financial benefits. Three types of staff support are required(467):

Firstly, technical staff, who can see to the day to day running of simulation centres and manage the equipment.

Secondly, trained simulation faculty, to provide simulation teaching whether at the simulation and training centres or in situ simulation.

Thirdly, leadership, who can plan for long term survival of simulation training, innovate, promote, and build a strategy to sustain and develop simulation training (467).

The shortage of technical support staff highlighted by this study impacts both the maintenance of the equipment and the overall quality of simulation training delivery. Technical support staff should be considered valuable and integral members of simulation teams, with a positive impact across all stages of the simulation process. Their specialised expertise contributes to the design, facilitation, setup, operation, and maintenance of simulation equipment, thereby supporting effective and efficient delivery of simulation activities, as evidenced by the literature review published by Tellefson et al (468). Technical support staff possess a high level of technical knowledge and troubleshooting skills essential for managing complex simulation systems. Publications describing the establishment of simulation centres have identified the recruitment of dedicated technical staff as a critical component of successful implementation (469, 470). However, literature to date has not demonstrated a clear correlation between the volume of simulation work and the employment of technical support staff. The decision to hire such personnel should instead be informed by the size and scope of the simulation centre, the diversity of its users, its educational objectives, institutional priorities, and available funding (471). For centres with a high volume of simulation activity, dedicated technical staff are likely to be cost-effective due to efficiency gains and reduced

operational downtime, whereas smaller centres may benefit from shared or part-time technical support arrangements aligned with their workload and resources(472, 473).

Space planning requires the development of a physical space to provide simulation which has the required technological infrastructure (Wi-Fi access), which can be an expensive endeavour (474).

Practical possibilities can include planning a centralised simulation centre that has capacity to provide training for larger group. Alternatively, simulation can be delivered in situ in the workplace, at home with equipment trainees can take home with them, or using the existing educational centres (475).

The surgical trainee as a stakeholder for simulation training: Insufficient allocated time and motivation

The beneficiary of simulation training is the surgical trainee, who is currently in the midst of a training crisis with difficulties faced with scheduling sessions in the operating theatre (476).

The biggest motivators for trainees to engage with training related activities are improvement in technical skills and career progression (422, 477). This study highlights both the issues of inadequate scheduled time in a trainee's workload for simulation as well as a lack of motivation to engage with simulation.

For these barriers to be addressed, two separate approaches may be required. Simulation should be viewed as an important component of technical skills training and trainees need to be scheduled for simulation sessions in a similar manner to being scheduled to attend the operating theatre for training. This requires commitment from the hospitals and the training bodies to provide protected training time to be able to achieve this objective (478).

Also, once simulation training becomes a training requirement, the annual review process should incorporate this requirement and be able to work with trainees to devise individualised technical skills training plans that discusses short term targets to be achieved in an operating theatre environment as well as in simulation. ARCP incorporation of simulation has previously been attempted successfully with on a limited number of cardiology trainees (479).

These steps act as motivators for trainees who will see technical skills improve but also can easily view the link between their efforts with engaging with simulation and career progression.

Ultimately, surgical trainees are important stakeholders for simulation planning and should play an important role in the co-design and implementation of simulation training into surgical education.

Long-term sustainability planning: Strategy for the successful implementation of technical skills simulation training into surgical education

Long term development of a simulation strategy is an essential component of setting up simulation training to make the efforts sustainable and a normal routine aspect of surgical training.

The thematic analysis presented in this study revealed short term barriers like faculty and funding but also highlighted long term barriers like the lack of an embedded simulation curriculum, faculty training and inadequate embedding of technical skills simulation into a trainee's schedule. Further work is simultaneously required to educate trainees about the evidence behind incorporating simulation into surgical training.

Furthermore, a cultural shift is required by working with surgical educators and trainees to encourage a simulation culture in surgical departments. Very little research is available that explore strategies into sustaining surgical simulation long term.

Policy makers including the Royal Colleges and NHS workforce planning need to critically analyse the existing curricula and policies with a view to explicitly embed simulation training into competency-based curricula, with specific descriptions that make the implementation of simulation easy into local training (480, 481).

Although this scoping review was completed after the empirical studies described in Chapters Seven and Eight, its findings provide broader context for interpreting those studies. The barriers identified here, relating to faculty capacity, infrastructure, resources, and culture, mirror many of the challenges observed in the empirical work and help situate those experiences within the wider international literature. Together, these insights reinforce the need for system-level strategies to implement simulation sustainably into postgraduate surgical training.

Limitations

This scoping review has several limitations that should be acknowledged. Only English-language publications were included, which may have excluded relevant studies published in other languages. The heterogeneity of study designs and outcome measures limited the ability to compare findings quantitatively, and the quality of evidence varied across the included papers. The review was restricted to literature available in MEDLINE and EMBASE and therefore may not have captured studies indexed elsewhere. In addition, a regional survey conducted early in this research programme using an adapted ASPiH questionnaire was excluded from this chapter after methodological review, as explained previously. Finally, few studies originated from low- and middle-income countries, restricting the generalisability of the findings to those settings where simulation resources and infrastructure may differ substantially.

Future directions for education and research

The implementation of technical skills simulation for surgical training is a nascent field. A large literature gap exists between the evidence that supports the use of simulation for technical skills

training and having a training system where there is seamless implementation of technical skills simulation into routine training. Seamless implementation would mean trainees view learning technical skills in both simulation and the operating theatre as one continual process- learning skills in simulation that they then use in the operating theatre, continue to use simulation between operating theatre sessions to improve their technical skills, and use simulation to break down the components of difficult technical skills to practice.

Avenues research should explore:

a. Faculty development models: impact of financial and career incentives, development of formal simulation teaching qualifications, establishing simulation education as a legitimate career path
b. Trainee centric approaches: Studying the impact of evidence-based innovation to create simulation programmes that can be incorporated into existing training schedules, incorporating simulation training as a formal aspect for career progression, improving education about the efficacy of simulation training, using education theory to support simulation training
c. Cost effectiveness studies: Long term studies are required to explore the cost and benefit analysis of regular simulation training, its impact on patient outcomes, training goals and patient safety
d. Infrastructure innovation: Curriculum reform, developing simulation centres, the impact of sharing adaptable strategies across regions all require further research

Conclusion

The aim of this study was to identify the barriers to using simulation in surgical training. The thematic analysis of the literature revealed six interconnected barriers related to limited faculty availability and support, lack of dedicated simulation space, insufficient technical support staff, restricted funding, inadequate trainee time and motivation, and a lack of long-term sustainability

planning. These findings indicate that the barriers are multifactorial, encompassing human, infrastructural, financial, and cultural dimensions of surgical education. Understanding these barriers will help surgical educators to innovate and work with local resources to improve the simulation training offered to surgical trainees.

Part III: The Empirical Research

Overview

The studies I presented in Part II revealed a large gap in the research on surgical training. The research gap included poor curricular instruction, issues with technical skills training both before and during the COVID-19 pandemic and the need for a multimodal and structured approach to surgical technical skills training. The study on barriers to implementing simulation into surgical training revealed several factors including cost, difficulties with recruiting and training faculty, technical staff support, access to simulation facilities and lack of time to use simulation in a trainee's work schedule.

For the empirical studies, I considered several options for improving the implementation of technical skills surgical simulation, including surgical curriculum reform that embeds simulation into surgical curricula, building a low-cost sustainable simulation centre, ARCP based simulation reform, simulation faculty development programmes and trainee centric implementation strategies.

Fundamentally, I wanted the studies to be trainee centric; practical, easily implementable in the naturalistic setting of surgical training, that could give tangible short term and long-term results by improving trainee's experience of technical skills training.

Additionally, I wanted to explore implementation strategies for technical skills simulation that could work within the constraints of both the current healthcare system and surgical training, and potentially transferable across all the surgical subspecialities.

Theoretical positioning and analytic approach

At the design stage of this research, Kopta's theory of technical skills learning was used heuristically to support thinking around the structure, progression and timing of the simulation activities, particularly those described in Chapter Eight (482). The theory provided a useful conceptual lens for

considering stages of technical skills development when designing the simulation programme and anticipating potential learning patterns. However, following ongoing discussion with supervisors, educators and examiners, the explicit application of a single educational theory as an analytic framework was viewed as unnecessary to address the research objectives of this thesis. Consequently, the qualitative data presented in Chapters Seven and Eight were analysed in relation to the research questions and study aims, with emphasis placed on trainees' reported experiences, perceived facilitators and barriers to engagement, and the practical realities of integrating simulation into routine surgical training, rather than on mapping findings directly onto Kopta's theoretical constructs.

Chapter Seven: A longitudinal case study of understanding general surgical trainees' experiences when participating in a structured VR laparoscopic simulation training alongside conventional surgical training

Note on publication of Chapter Seven

The study I have presented in Chapter Seven was published as a paper titled "Exploring trainee experiences in a structured VR laparoscopic training programme for general surgeons: A longitudinal case study" in the journal Advances in Simulation (483).I have suitably modified the paper, complying with departmental and university regulations.

Contribution statement

I am the lead author for all the work presented in this chapter, as well as for the paper that was published from this research work. I conducted the studies, collected, and analysed the data and authored the paper. The co-authors of the paper (Sotiris Mastoridis, Michael Silva, Debbie Aitken, and Helen Higham) provided guidance on general surgical training, acted as advisors, were the supervisors of my doctoral research and oversaw and advised on my research work. I thank the VirtaMed team for providing the simulator used and technical support for the study in Chapter Seven. There were no conflicts of interest to declare for any members of the research team.

Introduction

Published evidence supports the use of simulation for learning technical skills combined with more traditional approaches such as learning in an operating theatre environment (76, 102, 484). There are numerous simulation models available to practise technical skills including laparoscopic box trainers, simple low fidelity simulation models and extended reality environments including VR, which were more or less comparable in efficacy for reducing the learning curve, improving efficiency of operating, reducing surgical complications, and probably improving patient safety (102, 485-488).

The studies that demonstrate the efficacy of technical skills surgical simulation often utilise a "boot camp" format, where trainees intensely practise using simulation and efficacy is demonstrated with a short study time using pre and post training scores (80, 94, 489, 490).

Though the studies were valuable in establishing the efficacy of technical skills simulation, they were largely conducted in controlled settings and therefore do not fully capture trainees' experiences of engaging with simulation within the realities of everyday surgical training. Real-world training practices include time constraints in the training work schedule and limited access to simulation faculty (118, 179, 491). Understanding how trainees experience simulation, and what influences their motivation and engagement in this context, is therefore essential to inform the design of future training programmes. Also, further research into the experience and motivating factors when participating in technical skills simulation is required to aid with the design of technical surgical skills training programmes (443, 492).

The research question for this study was "*What were the trainees' experiences when participating in structured VR laparoscopic simulation training alongside conventional surgical training?*"

The aim of the study was to explore trainees' experiences of participating in structured VR laparoscopic simulation training alongside conventional surgical training.

The objectives of the study were

Objective One: To explore trainees' perceptions of the factors that influence their engagement whilst participating in VR laparoscopic simulation, within the broader context of their general surgical training and the opportunities available to engage with simulation.

Objective Two: To examine trainees' views on the optimal timing, structure, and educational value of simulation within surgical training.

Objective Three: To generate recommendations for its effective and sustainable implementation.

This study adopts an interpretivist paradigm and uses an instrumental case study methodology to explore trainees' experiences within their authentic training environment. The focus is on understanding meaning and context rather than measuring simulator performance, aiming to provide a rich, in-depth account of how trainees perceive and engage with structured simulation alongside their routine surgical learning.

Methods

The context

The higher speciality surgical trainees (ST3 onwards) work at five different hospitals within the Thames Valley Deanery and rotate each year of training. Their progress is assessed annually against pre-determined parameters (based on national and regional training expectations) at the ARCP.

Technical skills learning happens in the workplace with supervision of consultants and senior trainees. The training programme director organises formal training for technical skills which include simulation training and lectures and trainees also have access to attend courses as recommended by the RCS, some of which are mandated by the curriculum.

This study, which was registered as a quality improvement project with the Oxford University Hospitals (OUH), received ethics exemption from the Clinical Trials and Research Governance (CTRG) unit, University of Oxford (Appendix Three).

Methodology

The qualitative approach of the case study methodology in this study is underpinned by the interpretivist paradigm.

The interpretivist paradigm acknowledges the subjective nature of reality which is constructed by individuals based on their interactions with the people and objects in their environment. Therefore, reality is perceived differently based on the individual context, history, culture, and experiences. The interpretivist paradigm aligns closely with the case study methodology used in this study (493).

In Sarah Crowe's paper on the case study methodology, a case study is described as "a research approach that is used to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context" (493). I used the case study methodology because I wanted to understand the complex subject of trainees' experiences of engaging with simulation in the real-life context of surgical training, and the case study methodology allowed for the rich, in-depth exploration of these experiences using qualitative methods.

There are three types of case studies described in the literature, namely intrinsic, instrumental, and collective(493, 494).This study is best described as an instrumental case study, which helps to gain a broad understanding of the phenomenon being studied (493, 494). In the context of this study, the instrumental case was the participation in structured simulation training using the VR laparoscopic simulator which was used in addition to the routine surgical training trainees were engaged in. The case study design facilitated the exploration of trainees' experiences and perceptions of simulation

within their authentic educational environment. The focus was on understanding how trainees made sense of their participation, rather than on measuring or comparing technical performance.

Recruitment process and the role of the TPD

Recruitment for this study was conducted through the established regional teaching network within the Thames Valley Deanery. All general surgical trainees in the deanery are expected to attend regular regional training days as part of their postgraduate curriculum. These sessions are coordinated centrally by the TPD for General Surgery, who oversees the delivery of the educational programme across the region.

As the first simulation training session with the VR simulator was incorporated into these existing regional teaching sessions, all eligible trainees were invited to participate through this framework. Attendance at regional teaching is protected within the trainees' work schedules; clinical duties, including daytime on-call responsibilities, are covered by their employing trusts to facilitate participation. Therefore, no additional recruitment or release from service duties was required beyond standard practice. Study leave could also be utilised by trainees to subsequently access the VR simulator, as this falls within the standard allocation of study leave used for participation in deanery-organised educational activities.

The role of the TPD in this study was primarily administrative and supervisory. The TPD coordinated access to training sessions and ensured that the programme was implemented in alignment with the deanery's existing educational policies. The TPD also facilitated communication with participating trainees, providing information about the teaching schedule, general surgical curriculum, and training requirements. Importantly, the TPD could not provide assessment or evaluation of trainees' individual performance on the simulator, thereby maintaining objectivity in both educational delivery and data collection.

The involvement of the TPD in simulation training is part of standard educational governance within the deanery and does not constitute a deviation from normal practice. The TPD routinely oversees regional teaching days, manages trainee educational activities, and ensures compliance with the national training curriculum. Their presence in this study was consistent with these responsibilities and did not influence the consent process, trainee participation decisions, or the outcomes measured.

The trainees who participated in the study

Higher speciality general surgical trainees from ST3 to ST8 in the Thames Valley Deanery who attended their mandatory regional training day in June 2022 were invited to participate in this study (convenience sampling).Although participants represented a range of training levels, the study design ensured that all trainees received a comparable introductory experience with the simulator. During the regional training day, each participant was set up on the VR simulator, provided with login details, briefed on the study parameters, and completed a baseline assessment under the same conditions. This standardised introduction was intended to minimise variability in initial exposure to the simulator and ensure a uniform starting point for engagement with the training intervention.

Trainees who did not attend the regional training day (due to nighttime on-call commitments or annual leave) were excluded from the study, although they retained access to the simulator for independent practice as part of routine training. Written consent to participate in the study was taken and trainees were provided a written participant information sheet (Appendix Three).

Trainees were invited for the follow-up semi-structured interviews using purposive sampling, selected from the cohort of participants who had consented to be interviewed. The sample was chosen to include representatives from each of the five hospitals within the Thames Valley Deanery. Interviews continued until thematic saturation was achieved.

The VR laparoscopic simulator

The VirtaMed™ VR simulator (Figure 10) is a high technology and high-fidelity simulator which aimed to mimic real-life laparoscopic surgery, with haptic feedback and realistic movement when using the instruments. A previous study has shown the simulator to be comparable to other laparoscopic simulators for improving basic laparoscopic skills (495). The simulator was loaned to the Thames Valley deanery for three months.

The VirtaMed™ VR laparoscopic simulator had three parts (Figure 10):

a. **The model of the abdomen:**

The abdomen made of plastic and covered with a skin toned silicone layer, mounted on a console with wheels, was modelled to appear like the abdomen inflated with carbon di oxide gas during a laparoscopic surgery. There were multiple port sites predrilled into the model.

b. **The instruments:**

The laparoscopic instruments could be introduced into the model abdomen through any of the port sites, depending on the exercise the trainee wanted to practise. The instruments themselves resembled real laparoscopic instruments but had blunt tips that were introduced into the abdomen model. The choice of instrument (scissors, grasper, diathermy etc.)was then made by the trainee from a list on the screen rather than physically taking the instruments out of the abdomen to change them. Diathermy pedals were also available to use. The instruments had the capacity to provide some haptic feedback.

c. **The screen and interface**

The screen projected the exercises and tracked the instrument's movements in real time, though there was no physical model present inside the abdomen that the trainees were operating on but rather a VR software platform.

The exercises were of two types: gamified and anatomically accurate (Figure 11). For this study, the simulator was set up for the general surgery software package, though the same simulator could also be set up for the gynaecology trainees with the relevant gynaecology package. At the end of an exercise, the simulator provided a score, including a breakdown of the individual skills the system tracked to calculate the overall score. The simulator also provided feedback on their performance.



Figure 10 The VirtaMedTM Virtual Reality (VR) simulator. Image provided by VirtaMed™. The simulator consists of an inflated abdomen for practising laparoscopic surgery, port sites to insert physical instruments, diathermy pedals, and a screen. The trainees receive haptic feedback through the handheld instruments for a more realistic laparoscopic operating experience

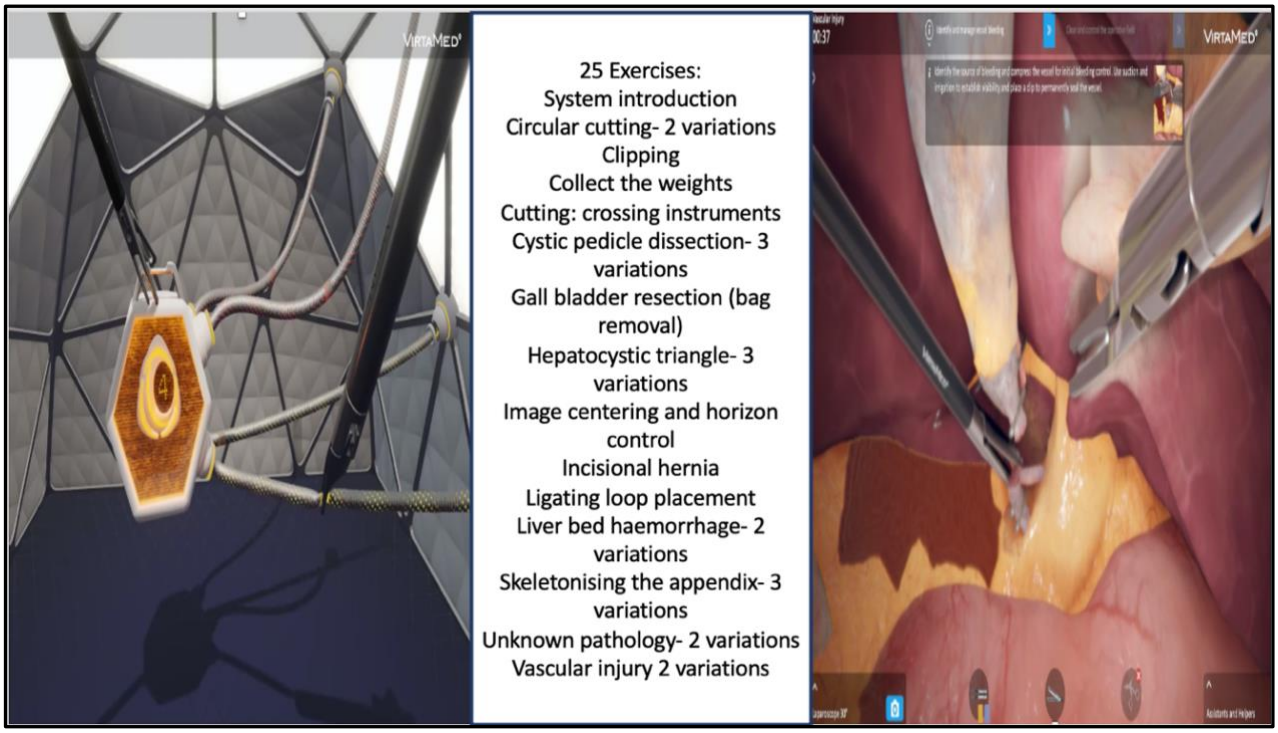


Figure 11 Trainees had access to 25 exercises on the VirtaMed™ VR simulator with two types of interfaces- eight gamified exercises and 17 anatomically accurate exercises. The anatomically accurate exercises displayed the anatomy of the liver, gall bladder and hepatocytic triangle

Additional simulation systems within the regional training programme

In addition to the VirtaMed™ VR laparoscopic simulator used for this study, trainees within the Thames Valley Deanery had ongoing exposure to three other technical skills simulation systems as part of their routine training. First, all trainees had previously been introduced to the Modified MISTELS laparoscopic box trainer programme, a hands-on curriculum using low-fidelity box trainers. This programme, introduced in January 2021, required trainees to complete standardised tasks (ball transfer, circular cutting, intracorporeal knot tying, and enterotomy closure with omental patch) under local trainer supervision, with progress and scores logged on an online platform. The MISTELS box trainers were located across all regional hospitals and remained accessible throughout the period of the VR study and engagement was discussed at previous ARCPs (Appendix Three). Second, the trainees had also previously used the robotic surgery simulator, which is located at the Churchill hospital, before they could participate in robotic surgery during their rotation at OUH.

Third, eight months after completion of the three-month VR programme and prior to the follow-up semi-structured interviews, the trainees attended a regional training day where they were introduced to an augmented-reality (AR) laparoscopic simulator (Inovus TOTUM). The AR system combines real laparoscopic instruments and haptic feedback with digital overlays of anatomical structures (Appendix Three). Trainees practised laparoscopic skills including laparoscopic suturing using this system for 20 minutes each on the regional training day. Although the MISTELS box trainer experience, the robotic simulator and the AR exposure was not part of the formal study, it formed part of the surgeon's routine regional teaching and is relevant to interpreting some of the interview reflections, as several participants compared this experience to box-trainer, robotic simulator, AR and VR modalities.

Location of the simulator during the study period

A room at the Churchill Hospital, part of the OUH NHS Foundation Trust in Oxford, was chosen to house the simulator. The room could be accessed 24/7 by the general surgical trainees during the study. The simulator was housed in a designated room at the Churchill Hospital, which remained accessible to general surgical trainees at all times during the study period via an access code. Trainees could use the simulator during protected teaching time, study leave, or self-directed sessions. The trainees were familiar with this set up as the robotic surgery simulator is similarly located at the Churchill Hospital.

Each trainee was set up with a log in to the simulator and had access to 25 exercises (Figure 11). Before beginning independent practice, trainees received face-to-face instruction on how to operate the simulator during the regional training day. This included a live demonstration from a VirtaMed employee on switching on the system, logging in, navigating the software, and selecting exercises. Each trainee was then supervised while completing the first exercise to ensure they were familiar with handling the instruments, understanding the interface, and interpreting the feedback scores. The trainees were advised to practise each exercise five times, reviewing the feedback before

reattempting the exercise, over a three-month period and were permitted to use their study leave and self-study sessions to use the simulator if needed. The recommendation for repeating each exercise five times was informed by guidance from the simulator manufacturer, VirtaMed™, based on their experience with trainee performance across their multiple simulation platforms. The manufacturer reported that, for most exercises, trainees typically reached a performance plateau after approximately five repetitions. Although this observation was not derived from a specific empirical study that the manufacturer could cite, it reflected consistent trends observed across their internal simulator usage data. According to the manufacturer, repetitions beyond this point were commonly associated with diminishing observable performance gains and reduced learner motivation.

The exercises on the simulator were available from a pre-selected list (25 exercises, listed in Figure 11) of varying complexity, and trainees could complete them in any order. Although the tasks were designed to progress from basic hand-eye coordination to full procedural simulations such as laparoscopic appendicectomy and cholecystectomy, trainees were permitted to self-select the sequence of exercises according to their individual learning needs and confidence levels. Progression was self-paced, and no minimum performance threshold was required to move between exercises.

The simulator provided automated feedback immediately after each exercise, including objective performance metrics such as time taken, economy of movement, and number of errors. Trainees were encouraged to review these results before reattempting the exercise to identify areas for improvement. Additional verbal feedback was available during the initial teaching session, but no individual performance coaching was provided during unsupervised practice.

The trainees were encouraged to concurrently continue with the other avenues of technical skills training they usually had access to, which included operating on real patients in the operating theatre and practising on other simulation models they had access to (laparoscopic box trainers located in the hospitals, home box trainers using the MISTELS programme the deanery had already introduced, the robotic surgery simulator and the AR laparoscopic simulator training they used to

practice on another regional training day). Details on the MISTELS programme can be found in the CTRG form (Appendix Three).

The trainees were aware that their engagement with simulation would form part of the discussions at the ARCP. Discussion regarding simulation engagement at ARCP was not a new concept as this had been an aspect of the MISTELs programme as well. The inclusion of simulation reflected the deanery's ongoing commitment to supporting skills development and was intended as an additional opportunity for reflection and feedback rather than formal assessment. At the end of the three months, the trainees continued to have access to simulators (e.g., box trainers, robotic surgery simulator) and regional simulation study days which included a session with an AR simulator. The trainees were followed up eight months later, at a mutually convenient time, to understand the long-term role simulation played on their technical skills training.

Data collection

The trainees were emailed a baseline qualitative questionnaire one week after they had their baseline assessment on the simulator. The baseline questionnaire documented previous simulation experience (e.g., which included their participation in the MISTELs laparoscopic training provided by the deanery, any simulation courses they had attended etc.), self-reported surgical technical skills confidence rating, their progress through surgical training including the impact of the pandemic and identifying personal objectives for the three months of this study. Trainees were asked to define their own personal learning objectives for the three-month VR simulation period using an open-ended question in the baseline questionnaire. These self-determined objectives were used to assess whether each trainee felt they had achieved their goals at the end of the programme.

The TPD reviewed trainee engagement with the simulation during the midpoint review, approximately six weeks into the study period. At this stage, all participants were contacted via email to encourage continued participation and provide individual feedback on their engagement. The

email reminded trainees of the importance of consistent simulator use, emphasising that "regular practice on a simulator will only help develop your technical skills further and consolidate what you have already learned in theatre." Trainees were also asked to record their sessions in their training logs and to reach out if they experienced any issues accessing the simulator or completing the exercises.

The email stated: "We're now at the midpoint of the VR simulation training, and I wanted to encourage you to continue engaging regularly with both the virtual reality simulator and the laparoscopic box trainer. Regular practice on a simulator will only help develop your technical skills further and consolidate what you have already learned in theatre. Please remember to get in touch if you have any difficulties accessing the simulator or completing the exercises. Your continued participation is greatly appreciated and will help us strengthen simulation-based training across the deanery."

The trainees completed a final assessment on the simulator at the end of the three-month study period as well as a follow-up qualitative questionnaire. The follow-up qualitative questionnaire included questions about the self-reported impact of the simulation experience on specific technical skills, the trainees' experience using the VR simulator, their views on the implementation of a structured simulation programme within their surgical training and if the personal goals they had set for themselves at the start of the study had been achieved.

The two qualitative questionnaires and the interview guide for the follow-up semi-structured interview were developed (using best practice advice by Boyton et al) to understand the trainee's simulation experience and explore their views on the best practices for the use of simulation within surgical training for technical skills development (496). The interviews were face to face and were recorded and transcribed before analysis. I maintained a research diary to record my observations through the interview process. The questionnaires and the interview guide are presented in Appendix Three.

Data analysis

I analysed the qualitative data following the steps for thematic analysis described by Naeem et al (218). I read and re-read the transcribed data to achieve familiarisation and initial understanding. I extracted data from the anonymised questionnaires into a Microsoft Excel spreadsheet and anonymised and transcribed the interview recordings. Next steps included identifying statements, keywords, development of initial codes, which I organised into subthemes based on shared meaning, viewing the data through the lens of the research question and aim of this study. These initial codes were not treated as mutually exclusive; where individual statements reflected multiple aspects of trainees' experiences, they were considered across more than one subtheme and theme during analysis. I subsequently synthesised the subthemes and overarching themes that addressed the research question. I conducted the analysis contemporaneously with data collection, using an inductive and iterative approach to allow themes to emerge naturally from the data. I discussed coding decisions and thematic development with the research team (my DPhil supervisors, the TPD and the general surgical trainee advising on this study) to enhance analytic rigour and ensure that the resulting themes accurately represented the trainees' experiences and the context of general surgical training.

All questionnaire and interview data were analysed in the thematic analysis. For transparency, summary tables and representative quotations are presented in the main text, and a redacted abridged transcript and tables are included in Appendix Three. Thematic analysis was conducted on the full dataset with a view to answer the research question; selected quotations are used to illustrate themes, consistent with qualitative reporting conventions(497).

Reflexivity and rigour

This study was an exploratory study looking at the experience of participating in structured simulation training implemented into regular general surgery training. As the lead researcher, I

remained conscious of my positionality and potential influence on the research process. My professional background as an O&G trainee, rather than a general surgery trainee, meant that I approached the data as both an insider to medical training and an outsider to the specific surgical context. I engaged in regular discussions with the research team, comprising the general surgical TPD and a general surgical trainee, to check interpretations and ensure the findings reflected the lived experiences of general surgery trainees rather than my own assumptions. The research team were senior clinicians and educators with extensive experience in organising and delivering simulation-based training. We collectively reflected on how our professional backgrounds might shape data interpretation and remained attentive to differing perspectives. These reflexive dialogues formed part of an iterative analytic process that strengthened the credibility and dependability of the study.

I also maintained a reflexive research diary throughout data collection and analysis to document observations, emerging interpretations, and reflections on my role as researcher. This process supported transparency and provided an audit trail of analytic decisions, contributing to the overall rigour and trustworthiness of the study.

Results

A total of 32 trainees accessed and used the virtual reality simulator during the study period. Of these, 22 trainees attended the regional training day in June 2022 and consented to participate in the study. The remaining trainees used the simulator as part of routine training but were not included in the study cohort. Of the 22 study participants, 14 consented to take part in follow-up interviews, and interviews were conducted with seven trainees, at which point thematic saturation was achieved.

The trainees were representative of all the five hospitals in the Thames Valley Deanery. The trainees' identities were anonymised, and each trainee was assigned a number in the data set so that their questionnaire responses could be compared (Table 20).

Trainees were invited individually for the semi structured interview until thematic saturation was achieved (namely trainee one to trainee seven from Table 20). The interviews were for 20 to 30 minutes each and all of the transcripts were utilised in the analysis, along with the qualitative questionnaires, the quantitative data from the simulator and research diary observations. The qualitative data was analysed contemporaneously as the study was conducted.

Once the thematic analysis was completed, the simulator's quantitative output was reviewed only as contextual information and was not used for inferential statistical testing in the main analysis. Quantitative data are provided in Appendix Three for transparency but are not used to draw conclusions in this chapter; the findings presented here therefore rely on the qualitative case study data to answer the research question. Where participants referred to performance thresholds or gated progression between simulation tasks, these accounts reflect their previous experiences with other simulation systems (e.g., robotic simulators) rather than the VirtaMed™ system used in this study, which allowed unrestricted, self-paced progression between exercises. None of the trainees had maintained a log of engagement with simulation.

Addressing the research question and objectives

The research question asked: *"What were trainees' experiences when participating in a structured VR laparoscopic simulation training programme alongside conventional surgical training?"*

This section presents findings that answer that question and the study objectives through two central themes: (1) varied motivators that encourage engagement with simulation, and (2) early introduction of simulation in surgical training. Together, these themes explore the factors that influenced engagement (Objective One), trainees' views on timing, structure, and educational value (Objective Two), and the implications for implementing simulation effectively within postgraduate training (Objective Three).

Trainee characteristics

Of the 22 trainees who participated in the VR study, there was an equitable distribution across training years from ST3 to ST7; no ST8 trainees participated (Table 20). Most participants (n=20) reported that they were progressing satisfactorily according to expected training milestones, while two trainees indicated that they required additional development to meet expected technical competencies. Eleven trainees described a negative impact from the COVID-19 pandemic on their operative experience due to reduced theatre exposure or redeployment.

The learning objectives were self-determined by trainees at the start of the programme and most related to improving fine motor skills, economy of movement, tissue handling, and procedural steps. These individualised goals were used as the reference point for self-assessment at the end of the three-month period (Table 20). Sixteen trainees reported that they had achieved or partially achieved their personal learning objectives. The trainees who did not meet their objectives wanted more time to practise on the simulator.

Trainee identification number	**Stage of training**	**Progress through training**	**Was there an impact of the COVID-19 pandemic on your training?**	**Learning objectives and expectations for this study (self-reported)**	**Perceived achievement of learning objectives (self-reported)**
Tr 1	ST5	Progressing satisfactorily according to expected training milestones	None, continued to operate	Not sure of my learning objectives	I could see the value of engaging with simulation
Tr 2	ST5	Progressing satisfactorily according to expected training milestones	Yes, less laparoscopy and emergency operating, more consultant led	Improve economy of movement and tissue handling	Yes, although I think a laparoscopic box trainer and experience in theatre is rewarding
Tr 3	ST5	Progressing satisfactorily according to expected training milestones	No	Improve laparoscopic skills, fine movements, bimanual handling, tissue handling and ergonomics	Yes
Tr 4	ST4	Progressing satisfactorily according to expected training milestones	Yes, less operating and time out of programme	Practise unfamiliar operations	Yes

Trainee identification number	Stage of training	Progress through training	Was there an impact of the COVID-19 pandemic on your training?	Learning objectives and expectations for this study (self-reported)	Perceived achievement of learning objectives (self-reported)
Tr 5	ST3	Progressing satisfactorily according to expected training milestones	No, was out of programme	Improve precision of handling instruments, practise independent operating, and see progress with repeated tasks	No, I didn't access it enough
Tr 6	ST4	Progressing satisfactorily according to expected training milestones	No	Improve technical skills and learn steps of the operation	No, I didn't access it enough
Tr 7	ST6	Progressing satisfactorily according to expected training milestones	No, was on maternity leave	Improve laparoscopy efficiency, reduce unnecessary movements, and improve tissue handling	Yes
Tr 8	ST3	Requires additional development to meet expected technical competencies	Yes, I require more development of my operative skills	Familiarity with laparoscopic procedures	No, I did not have enough time

Trainee identification number	Stage of training	Progress through training	Was there an impact of the COVID-19 pandemic on your training?	Learning objectives and expectations for this study (self-reported)	Perceived achievement of learning objectives (self-reported)
Tr 9	ST4	Progressing satisfactorily according to expected training milestones	Yes, it was difficult to access courses	Gain practical exposure to laparoscopy	Yes, I think the training did improve my confidence with laparoscopic skills as I was on a surgical subspecialty that doesn't perform much laparoscopic procedures
Tr 10	ST5	Returned from Out-of-Programme (OOP) period; reintegration into standard training pathway required	Yes, I was redeployed, and I operated less	Laparoscopic suturing	No
Tr 11	ST6	Progressing satisfactorily according to expected training milestones	Yes, both technical and non-technical skills were negatively impacted	Improve tissue handling, efficiency, economy of movement and timing to complete the task	Yes, The simulation training did improve my confidence with laparoscopic procedures in general

Trainee identification number	Stage of training	Progress through training	Was there an impact of the COVID-19 pandemic on your training?	Learning objectives and expectations for this study (self-reported)	Perceived achievement of learning objectives (self-reported)
Tr 12	ST7	Progressing satisfactorily according to expected training milestones	Yes, with impact on surgical skills related to benign conditions and proctology as these conditions were not prioritised. My laparoscopy training was not affected	Practise existing laparoscopic skills	Yes
Tr 13	ST4	Progressing satisfactorily according to expected training milestones	None	Walk through operations and learn key steps	I feel you can practise and gain confidence on the simulator. If there were more operations it would be good to actively learn the steps
Tr 14	ST6	Progressing satisfactorily according to expected training milestones	None	Improve surgical skills that I can transfer to clinical practice	It was quite motivational as it gives a rank and a score

Trainee identification number	**Stage of training**	**Progress through training**	**Was there an impact of the COVID-19 pandemic on your training?**	**Learning objectives and expectations for this study (self-reported)**	**Perceived achievement of learning objectives (self-reported)**
Tr 15	ST7	Progressing satisfactorily according to expected training milestones	None	Practise more advanced cases such as colectomies	I had little time to use the simulator, and I found the tasks quite simplistic
Tr 16	ST7	Progressing satisfactorily according to expected training milestones	Yes, with reduced operating	Improve technical skills	Yes
Tr 17	ST5	Progressing satisfactorily according to expected training milestones	No, was out of programme	Enhance techniques and learn methods to improve skills	Yes, it met my requirements

Trainee identification number	Stage of training	Progress through training	Was there an impact of the COVID-19 pandemic on your training?	Learning objectives and expectations for this study (self-reported)	Perceived achievement of learning objectives (self-reported)
Tr 18	ST6	Progressing satisfactorily according to expected training milestones	No, was out of programme and then on maternity leave	To improve my laparoscopic surgery skills and boost my confidence after a period of time away from regular operating, especially for laparoscopic cholecystectomies where I am less confident. Also, pass my ARCP	Yes
Tr 19	ST3	Progressing satisfactorily according to expected training milestones	Yes, there was less ST5 suitable cases to operate on	Refresh laparoscopic operating skills as I have been on non-laparoscopic specialties this year	Yes
Tr 20	ST5	Progressing satisfactorily according to expected training milestones	Yes, I was redeployed. Operative experience, endoscopy experience and clinic experience were affected.	To gain familiarity with colonic resections	No

Trainee identification number	Stage of training	Progress through training	Was there an impact of the COVID-19 pandemic on your training?	Learning objectives and expectations for this study (self-reported)	Perceived achievement of learning objectives (self-reported)
Tr 21	ST3	Progressing satisfactorily according to expected training milestones	No	Currently I'm in paediatric surgery where there is reduced laparoscopic surgery compared to general surgery, therefore hopefully the simulation will help me to maintain skills prior to re-joining general surgery	I felt I was able to be comfortable with the steps of the operation and develop my hand eye coordination and fluency of movement.
Tr 22	ST4	Progressing satisfactorily according to expected training milestones	Yes, reduced operating	To improve my technical skills since elective work is still reduced relative to pre-pandemic. Also, to maintain skills previously acquired that I may be using less in certain rotations.	No, I was only able to access it sporadically

Table 20 Trainee characteristics, including the stage of training, progress through training, learning objectives for using the VR simulator and if those objectives were achieved at the end of the three months of the study. The learning objectives were self-determined by trainees and recorded from their baseline questionnaire responses. The "perceived achievement of learning objectives (self-reported)" column summarises whether trainees perceived they had achieved their own stated objectives. Abbreviations: ARCP- Annual Review of Competency Progression, ST- Specialist Trainee Year

Exposure and experience with simulation

All of the trainees had exposure to technical skills simulation, with use of laparoscopic box trainers, the robotic simulator, and technical skills courses (basic surgical skills course, laparoscopic suturing course) being the most commonly accessed by all (Table 21). Table 21 summarises trainees' self-reported prior experience and frequency of simulation use as recorded in the baseline questionnaire.

Non-technical skills simulation was less common; most trainees reported attending mandatory courses such as the Advanced Trauma Life Support (ATLS), Advanced Life Support (ALS), Care of the Critically Ill Surgical Patient (cCRISP) or the wilderness and expedition medicine courses during earlier stages of training.

Barriers to simulation use included time and access constraints, with particular emphasis on the lack of protected practice time. Most trainees viewed simulation as an important training tool that should be introduced early in surgical education.

Trainees considered the VR simulator particularly valuable for early-stage learning, including hand-eye coordination, camera manipulation, and the steps of simple operations. Senior trainees found box trainers more helpful for advanced skills such as intracorporeal suturing. Most participants described simulation as beneficial overall, although five either gave no response or felt its effect was limited.

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 1	OUH	80	Used robotic simulator extensively and the box trainer ad hoc	Access to a simulator, useful for special skills only	Box trainer was helpful to learn intracorporeal suturing	Access earlier in training would have been more useful
Tr 2	OUH	28	Used the box trainer and some non-technical skills simulation during Core Training and registrar years, about once a month	Time, work commitments, more likely to engage with laparoscopic simulation if work has less laparoscopic operating and vice versa	Helped with confidence of tissue handling and hand eye coordination	More integration with teaching will give us time to use it in the daytime hours

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 3	OUH	167	Used the box trainer for suturing at least once a week	None, simulation is widely available in all units	Made excellent progress using simulation. E.g., there was a case of appendicitis when the base of the appendix wasn't secure after applying Endo loops. I applied my laparoscopic suturing skills to bury the base of the appendix. It prevented the case from being converted to open and enhanced postoperative recovery and reduced inpatient stay	The VR simulator is very useful for CT1-CT2 for manual skills, muscle memory, hand-eye coordination. ST3-ST4 would benefit as well as they still in early stages and don't have much experience

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 4	Wexham Park Hospital	69	Used box trainer. Very little, maybe twice a year	Time, space, access, interest	I haven't found much benefit to simulation	From FY2 onwards
Tr 5	Wexham Park Hospital	7	Infrequent use of box trainer for dexterity and laparoscopic suturing. Attended courses- non-technical skills, core surgical training surgical skills competition, cCRISP, ATLS, wilderness and expedition medicine course	Access and time	Helped with confidence with decision making, leadership and planning next steps in the case of role-playing team scenarios e.g., cCRISP. Dexterity with laparoscopic skills following practise on box trainer	CT1 onwards

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 6	Milton Keynes Hospital	23	Used various simulators including laparoscopy box trainers, robotic and endoscopy, intra-corporeal suturing. Only the ATLS & cCRISP courses for non-technical skills simulation. I have at times used simulation very frequently, practising for 25 minutes on all my non theatre days. I also did a master's in simulation and practised intracorporeal suturing every day	Work and rotating to different hospitals	Learning and mastering intra-corporeal suturing and applying it to patient care was probably the most visible benefit of simulation training for me	Simulation should be introduced early, from core surgical training onwards

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 7	Stoke Mandeville Hospital	11	Several courses in both technical and non-technical skills such as laparoscopic simulation courses (both box trainer and virtual simulators) and communication courses. I undertook the laparoscopic colectomy fellowship using the Symbionix simulator at the Royal Free Hospital, London as an SHO. I have a box trainer at home	Access, time, and tailoring modules to level of training	Yes, I believe my early exposure to simulation has greatly helped with established good safe basic principles which I could then build on and improve during my surgical training	For early-stage trainees for improving hand eye coordination and assisting at laparoscopy by holding the camera as well as simple operations like the appendix. For senior trainees, access in short bursts

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 8	Stoke Mandeville Hospital	13	Experience with box trainer once a month during core surgical training, non-technical skills previous emergency procedures/ teamwork in foundation training	Busy job, lots of pressure for personal development outside of work (ISCP, audits, research), Time outside of work to engage, geographical location of the trainer, minimal access to box trainer	No impact mentioned	Simulation should be used throughout, best from CT1 to ST4

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 9	OUH	81	Laparoscopic box simulators, one non-technical skills training day during ST3 which focussed on team working skills in acute situations. Frequency of use varied according to the rotation	The lack of allocated practice time on the simulators makes it difficult to implement the training into a daily routine. I think the main challenge will be maintaining use regularly	Simulation been useful to solidify certain laparoscopic skills such as suturing	Useful from the initial years of training

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 10	Stoke Mandeville Hospital	25	Attended a laparoscopic suturing course and used the pre-programmed exercises on the Di Vinci robot. Used the box simulator at home as core trainee. Use has been regular when on a course and as part of research projects	Simulators need to be user friendly, realistic, and easily accessible. Training needs to be provided, and they need to appeal to the competitive nature of surgical trainees	Yes I enjoyed using laparoscopic simulators on courses as they have given me the confidence to use laparoscopic suturing in my operating practice	Box trainers are better for practising surgery through all the years of training. The VR simulators may be helpful for those at the early part of their training who don't quite yet understand the steps of an operation

Tr 11	Stoke Mandeville Hospital	35	Laparoscopic box simulator for laparoscopic tasks such as stacking sugar cubes, polo mint etc. More recently practising laparoscopic suturing has been extremely useful and I find this skill very relevant and reproducible in live operating. Non-technical skills simulation of clinical event such as management of intra-operative bleeding during surgery and working in team approach with theatre staff, anaesthetist, and surgeons. Used the box trainers 5 times/ year for 30 minutes	Due to clinical commitment, on calls, rota gaps	The laparoscopic box trainer was extremely useful for practising laparoscopic suturing and I believe this task is transferrable to real live operating i.e., repairing serosal tear, enterotomy, perforated peptic ulcer disease	Useful from core surgical trainee
Tr 12	Stoke Mandeville Hospital	17	During Core Training, practised on an at home box trainer, attended	Mainly time and an additional expectation of a trainee (of	No impact mentioned	From core surgical training to develop laparoscopy skills

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
			courses for technical and non-technical skills. Now I use the box trainers via the Oxford Deanery LAPSIM program. I use the box trainer monthly for the last 18 months, before this only during courses	engaging with simulation alongside other clinical, academic, and administrative responsibilities were perceived as barriers to regular use)		including camera holding

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 13	Milton Keynes Hospital	45	Use of box sims to become more familiar with laparoscopic skills, and mannikins to act out critical medical issues. Monthly practice on box simulator and once or twice a year on mannikins	Free time, there is very little of this on a day-to-day basis	I think acting through certain operations has helped me learn the key steps, rather than being walked through cases in the operating room. Simulation lab work has been very useful in gaining confidence in acute medical settings and also improving teamwork	Most useful for core surgical training and early registrar training
Tr 14	Stoke Mandeville Hospital	3	Infrequent use of box trainers for laparoscopic suturing or when teaching junior trainees. Non-technical skills training as part of ATLS	Lack of protected time	Laparoscopic suturing	Not answered

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 15	Stoke Mandeville Hospital	7	Mainly box simulators and robotic simulation a few times a year	Pressures from other commitments and access when simulation is centralised	Laparoscopic suturing	Suited to start training from core surgical training
Tr 16	OUH	12	Occasional technical skills course using box trainers	Access to hardware	Not mentioned	Useful for all stages
Tr 17	OUH	13	Mainly box trainer at least twice a month	Lack of time	Helped tremendously with laparoscopic suturing, I am able to perform parts of an operation that requires this	Most stages of training, however more junior trainees will benefit more

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 18	Stoke Mandeville Hospital	37	As a junior trainee in non-technical skills simulation for acutely unwell patients and 'moulage' style simulated scenarios as part of ATLS/ALS courses. Limited experience with laparoscopic simulators	No dedicated time to spend using the simulator. Simulation cannot replace operative experience	I have attended courses as a junior trainee and practised suturing or moving sugar cubes using basic laparoscopic simulation light boxes	All stages of training to learn initially and then keep in touch
Tr 19	OUH	68	Box trainers, deteriorating patient, ATLS, trauma team leader, once every two years or so	Lack of time and no dedicated simulation time on the schedule	The impact often feels short-lived	Simulation should start from core surgical training

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 20	OUH	31	Have used laparoscopic box trainers to do tasks and laparoscopic suturing, robotic simulator, at least monthly this year	Lack of available equipment and lack of time. In the past, I have often had to stay late, come in on zero days, after night shifts etc, to do the mandated training	Has been useful in the case of laparoscopic suturing and getting a feel for robotic surgery	Benefits for junior trainees

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 21	OUH	84	Limited exposure, once a year, through the Royal College courses and box trainers as an ST3. I had a joint education/general surgery fellowship where I led simulated teaching sessions of non-technical skills with a mannequin however have not participated in any such myself since foundation training	Difficult to find time off of clinical work	Simulation in Foundation Training and medical school helped to prepare and learn about common medical emergencies. Not much impact on my surgical training apart from occasional courses such as ATLS or basic surgical skills course	Most effective for Core Training

Trainee	Hospital of employment during the VR study	Frequency of use of the VR simulator in the 3 months	Trainees' prior experience and frequency of engagement with simulation (baseline, self-reported)	Perceived barriers to simulation use	The impact of simulation on your training	The stage of training when simulation should be used
Tr 22	Milton Keynes Hospital	34	Used laparoscopic box trainers on a sporadic basis and in courses such as ATLS. Not much exposure to simulation for non-technical skills	simulation should become a routine part of our training; we need to have specific time set aside for it during our working week. This either needs to include travel time, or the simulators need to be present at our place of work	I think simulation has been of value in the past. For e.g., being able to practise laparoscopic suturing on a box trainer when I know I have a case coming up in which I will utilise this skill, particularly if it's something I haven't done for a while. However, I think there are probably a lot of opportunities for using simulation more	Most useful at Core Training level for an introduction to basic operations

Table 21 Previous experience, place of employment, frequency of use of the simulator in the 3 months of access, and engagement with simulation during surgical training, including trainees' views on barriers to using simulation, the impact simulation has had on their training and the stage of training they perceive simulation to be useful. Responses in the third column are taken directly from the baseline questionnaire, which asked trainees to describe their prior experience and frequency of engagement with simulation during surgical training. These reflect participants' self-reported experiences rather than prescriptive views on the role of simulation in general. Abbreviations: ALS- Advanced Life Support, ATLS- Advanced Trauma Life Support, cCRISP- Care of the Critically Ill Surgical Patient, CT- Core Training Year, FY2- Foundation Year 2, ISCP- Intercollegiate Surgical Curriculum Programme, OUH- Oxford University Hospitals, SHO- Senior House Officer, ST- Specialist Training year

Questionnaire-based findings

Analysis of the baseline and follow-up questionnaires provided additional contextual information that supported the qualitative themes. In the baseline questionnaire, all trainees (n=22) reported prior experience with simulation, mainly through box-trainers and occasional robotic or suturing courses. The most frequently cited barriers to regular use were lack of protected time, limited access outside normal working hours, and uncertainty about where simulation fitted within training priorities.

In the follow-up questionnaire, most respondents described the VR simulator as particularly valuable for developing hand–eye coordination and economy of movement, especially for early-stage trainees (Table 22), highlighting its potential to teach camera handling and orientation skills, noting that the 30-degree scope and improved awareness of operative steps. The trainee ratings are shown in Appendix Three.

When asked about stage of usefulness, trainees agreed the simulator was most relevant for early-stage registrars (ST3-ST4) and core trainees, while senior trainees suggested that additional modules covering more complex procedures would extend its benefit. Participants viewed the simulator as a helpful adjunct for confidence-building and skill maintenance, particularly during rotations with reduced laparoscopic exposure.

Skill / Domain	Median (IQR)	Mode	Range	Representative qualitative comments
Hand–eye coordination	7 (5-8)	8	2–10	Tr 1: "Very good for training juniors on 30° scope." Tr 1:"Excellent in familiarising students on different types of instruments."
Economy of movement	7 (6-8)	8	2–9	No corresponding qualitative data
Learning / practising steps of an operation	6 (4-8)	6	1–9	Tr 16: "Helped build awareness of operative steps." Tr 19: "Adopting a comfortable operative position."
Anticipating complications	5 (3-7)	7	1–9	No corresponding qualitative data
Managing complications	5 (4-7)	5	1–9	No corresponding qualitative data
Other skills	No score available	No score available	No score available	

Table 22 presents descriptive findings from the follow-up questionnaire completed by 22 trainees after three months of access to the VirtaMed™ VR simulator. Each skill domain was rated on a 1 to 10 scale (10= most useful). The median and inter-quartile range (IQR= range between the 25th and 75th percentiles) are shown. These descriptive data are provided to complement the qualitative themes

The thematic analysis

The interview data were analysed in relation to the four domains explored in the semi-structured interview guide (Appendix Three)- comparison of simulation platforms (VR vs AR), perceptions of structured versus self-directed practice, the perceived impact of simulation on real-life surgical work, and views on how simulation should be integrated into training. Findings from these domains were synthesised within the two overarching themes presented below. The anonymised abridged transcript can be found in Appendix Three.

The qualitative dataset comprised the two questionnaires and interview transcripts. Thematic analysis was used to construct themes that reflected how trainees experienced, interpreted, and made meaning of simulation within their everyday training.

Two overarching themes and eight subthemes emerged (Figures 12 and 13). The following sections describe these themes and subthemes, using participant quotations to illustrate how they relate to the study objectives and research question.

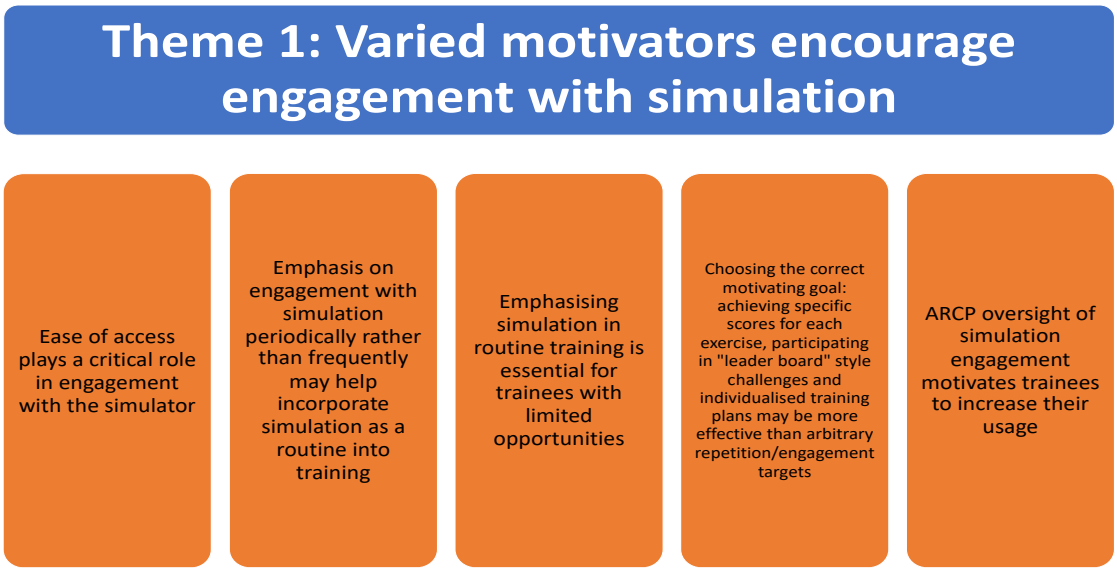


Figure 12 Theme one: Varied motivators encourage engagement with simulation. This theme discusses the use of multiple strategies to motivate trainees to engage with technical skills simulation including having easy access to a simulator, encouraging, and emphasising the periodic use of the simulator with other methods of technical skills training, individualised training plans with a choice of goals, and ARCP oversight. Abbreviations: ARCP- Annual Review of Competency Progression

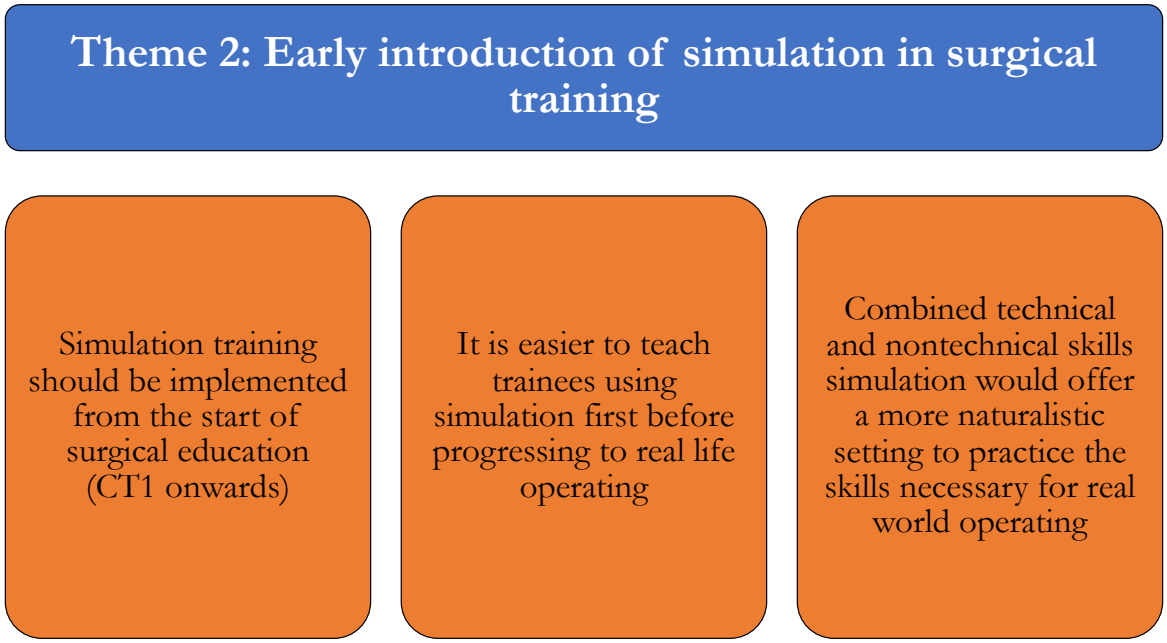


Figure 13 Theme two: Early introduction of simulation in surgical training. There were three subthemes identified- implementing simulation from the start of surgical training, it is easier to teach trainees surgical skills first in simulation before progressing to real life operating and combined technical and non-technical skills simulation would offer a naturistic setting to practise the skills necessary for real world operating. Abbreviation: CT- Core Training Year

Theme one: Varied motivators encourage engagement with simulation

Motivating factors differed between trainees according to stage of training, experience, personality, and current rotation. The theme captures how trainees described what encouraged or discouraged them from engaging with simulation.

Motivators included accessibility, structured periodic opportunities, individualised goals, gamification, and educational accountability through mechanisms such as the ARCP (Table 23).

Sub theme	**Example excerpts from questionnaires during the three months of using the VR simulator** **Tr- Trainee**	**Example excerpts from the semi-structured follow-up interviews** **Tr- Trainee**
Ease of access plays a critical role in engagement with the simulator	Tr 8: Ease of access- getting to Churchill Tr 12: Access due to distance would not have been a problem if I was working in Oxford Tr 14: The site being only in Oxford Tr 18: Access, it took me two hours round trip to get to and from the hospital Tr 22: Getting to the Churchill when working a long distance away, and the costs and time this entailed	Tr 1: "But I do think there are things I can gain from appropriate simulators. If I feel they are readily available, sure" Tr 3: "It's because I was local here. I just used it" Tr 5: "Improving access. People would be encouraged"

Sub theme	**Example excerpts from questionnaires during the three months of using the VR simulator** **Tr- Trainee**	**Example excerpts from the semi-structured follow-up interviews** **Tr- Trainee**
Emphasis on engagement with simulation periodically rather than frequently may help incorporate simulation as a routine into training	Tr 7: I think regular exposure, at least weekly, to the virtual simulator would greatly help to improve my surgical skills	Tr 3: "I think initially if you want to master it, the more you use it the better. Then maybe you can reduce the number of sessions once you are happy, to maintain skills" Tr 5: " I understand that's something that should be integrated into our teaching. I think probably you'll see benefits proportional to the amount you use" Tr 7: "The complication rate didn't necessarily change whether you did the case twice a week or twice a month. I think ideally I would want regular sessions to use the simulator within the timetable. As part of training. Like you would have clinical endoscopy, my next morning is my dedicated simulation session"

Sub theme	**Example excerpts from questionnaires during the three months of using the VR simulator** **Tr- Trainee**	**Example excerpts from the semi-structured follow-up interviews** **Tr- Trainee**
Emphasising simulation in routine training is essential for trainees with limited opportunities	Tr 9: Simulation use would vary depending on the clinical requirements of the rotation	Tr 1: "I think it's important for people coming onto jobs like upper gastrointestinal or any jobs that need intracorporeal suturing, to develop that (by practising on a simulator)" Tr 2: "As a middle to senior trainee, if I am doing a job where I'm getting a lot of laparoscopic exposure maybe I don't need to take an evening to come spend with the simulator. You actually miss it when you're doing a non-laparoscopic job and it's been a long time since I've done this, I should practise. 100% will benefit people who are not in laparoscopic jobs" Tr 3: "I was just doing it when I had time, going there, suturing, suturing, suturing (on a simulator). Next year, I went to upper gastrointestinal firm, and when they had suturing on their anti-reflux procedures, I noticed you know I was doing it without any problems. The consultants could see I can do it, fine do it" Tr 7: "If your firm is not doing anything then I think yes"

Choosing the correct motivating goal: achieving specific scores for each exercise, participating in "leader board" style challenges and individualised training plans may be more effective than arbitrary repetition/engagement targets	Tr 2: I did not like repetitive activities and rigid in the steps to complete the exercise in the virtual reality simulator Tr 3: It (the simulator) also gives feedback so they (the trainee) can act on feedback and try to improve by repeating exercise Tr 7: I enjoyed the gamified exercises. It was really fun Tr 15: Some of the tasks were interesting. It was useful to keep a score on performance	Tr 1: "It has to be structured. People won't use stuff if they aren't incentivised to use it. So, I think if you say you need to clock up x number of hours and you also need to get scores over a certain number then I think they'll just be able to do more work on it. And it'll be to their benefit, I'm sure" Tr 3: "It is nice to have some structure especially initially when you start, and you are a novice. But I think once again when u have done all the structured training, so then it's nice to have some variety and some self-direction" Tr 7: "I think, especially as surgeons, we tend to want to do well with the marks. With the actual tasks I would score really high. I think the simulation should be more tailored to what level you are at and what you have done in real life and then tailor it to the person and what you've done in real life. On the robotic simulator and I quite like that. There are lots of exercises you can do and the target there is you need to achieve 90% and above for each of the exercises and until you have done that you cannot go on to the next step, or you should really do that before u do any live surgery. It considers that everybody learns at different rates and some people can get 90% just after 5 goes and others might need 30, so in a way it doesn't matter how many times you do it as long as you achieve that 90% and over"

Sub theme	Example excerpts from questionnaires during the three months of using the VR simulator Tr- Trainee	Example excerpts from the semi-structured follow-up interviews Tr- Trainee
ARCP oversight of simulation engagement motivates trainees to increase their usage	Tr 7: ARCPs should have an element of simulation for assessment. Maybe review the video of the trainee doing the simulation or their engagement with the simulator or the scores they have got over time on the simulator Tr 18: I want to engage with simulation to pass the ARCP	Tr2: "I appreciate the reason for a structured programme and the reality is people are less likely to use it if it's always just there" Tr 4: "On a simulated model, I appreciate and accept that other people might find it incredibly useful to show it to a consultant or a senior for feedback would be really good. I'd like to see data for myself and for a collection of trainees over the entirety of training, progression through the years" Tr 7: "From the ARCP, you should have goals for this year from the simulation side." what you want to improve on. Let's see if by the end of the year you are able to achieve that. Then it's your personalised target and goals for simulation"

Table 23 Theme one- Varied motivators encourage engagement with simulation. Abbreviation: ARCP- Annual Review of Competency Progression, Tr- Trainee, VR- Virtual Reality

Ease of access plays a critical role in engagement with the simulator

Table 21 summarises how often each trainee used the simulator during the three-month period. Frequency of use is presented descriptively to illustrate engagement patterns rather than for statistical comparison.

Trainees who described easier access and more spontaneous use when they worked at Oxford University Hospitals, whereas those at other hospitals cited time, travel, and on-call commitments as barriers . These contextual differences were reflected in the frequency of use and aligned with participants' qualitative accounts of accessibility and motivation (Table 23).

Emphasis on engagement with simulation periodically rather than frequently may help incorporate simulation as a routine into training

Trainees recognised that frequent practice could improve skills but found this difficult to sustain alongside clinical work. They described favouring a pragmatic approach of more intensive sessions during initial learning followed by periodic practice for maintenance. This reflects a desire for distributed practice that can coexist with service commitments.

Adopting a pragmatic approach to implementing technical skills simulation would be to vary the frequency of use according to the training requirement- for e.g., to schedule more frequent sessions when learning a skill before reducing engagement to maintain the skill. Regular use of technical skills simulation must be scheduled, similar to the scheduling of operating theatre sessions, continuing with simulation sessions as a regular aspect of surgical training throughout the training years.

Emphasising simulation in routine training is essential for trainees with limited opportunities (for real time operating in the operating theatre)

The trainees discussed situations where access to a particular type of surgery was limited, and they viewed the use of simulation as an opportunity to maintain those skills (Table 23). For e.g., to maintain laparoscopic skills when trainees were working in a super-subspeciality where laparoscopy was not used, trainees would practise on a laparoscopic simulator. Another training scenario where trainees used simulation was to practise improving proficiency before they moved to a department that utilised a particular surgical skill. For e.g., practising laparoscopic suturing before trainees moved to the upper gastrointestinal surgery department was described as a preparatory step that helped them assimilate and impress their consultant from the start (Table 23). Simulation provided continuity of technical practice and a way to rehearse unfamiliar procedures before starting new placements.

Choosing the correct motivating goal- achieving specific scores for each exercise, participating in "leader board" style challenges and individualised training plans may be more effective than arbitrary repetition/engagement target

The trainees who participated in this study had exposure to various forms of technical skills simulation throughout their surgical training including a box trainer, VR simulator, AR simulator and the robotic simulator. The trainees were more familiar with some of the technical skills simulation modalities than others (e.g., very familiar with the box trainer but not so familiar with the AR simulator).However, with their experience with each different modality of simulation they were able to determine the motivating factors that helped them engage more frequently with simulation in a meaningful way (Table 23).

Trainees reported preferring a target score to achieve for each exercise rather than an arbitrary repetition of exercise. A frequently quoted example was their experience with the robotic simulator where the trainees achieved a score of 90% or more before they moved on to the subsequent exercise. Another motivating approach to increase and sustain engagement was to encourage the gamification of simulation use, which appealed to the competitive nature of the surgical trainees, including using a leader board type display (Table 23).Several participants explicitly contrasted the VirtaMed VR system used in this study with other simulation systems they had used previously (notably the robotic simulator). One trainee described a robotic simulator policy that required achieving a 90% score to progress to the next module; this example was provided as an illustration of a performance-gated progression model that they had found motivating. Importantly, the VirtaMed configuration used in this study did not enforce minimum performance thresholds to advance between exercises: progression on the study device was self-paced and unrestricted. Therefore, references in participants' accounts to "locked" progression or mandatory thresholds derive from trainees' prior simulation experiences rather than from the VR programme implemented here. This preference was reported by five trainees (Table 23), all referencing earlier experiences with other simulation platforms rather than the study simulator

Trainees preferred meaningful goals and visible progress markers, such as performance targets or gamified leaderboards, over arbitrary repetition. They explained that setting clear goals encouraged engagement and accountability.

No participants referenced the midpoint TPD email in interviews or questionnaires, so it cannot be determined if this had any influence on their engagement.

ARCP oversight of simulation engagement motivates trainees to increase their usage

Participants viewed discussion of simulation at ARCP as a constructive accountability measure (Table 23). They emphasised that this should remain formative and developmental, providing feedback and encouragement rather than summative assessment.

Trainees welcomed the idea of incorporating simulation as one of their annual training goals as an aspect of their regular training, including discussion and feedback from consultants in a similar manner to approaching real-life patients and surgery. Accountability for simulation engagement included the ARCP process and tracking their simulation progress over time as they would with their other training goals like the case logbook. Personalisation of their goals included discussing simulation targets, where specific skills could be identified for practising on a simulator (Table 23).

Theme 2: Early introduction of simulation in surgical training

All participants agreed that simulation should be introduced from the earliest stages of surgical training to develop basic technical and cognitive skills in a safe environment.

Simulation training should be implemented from the start of surgical education (Core Training Year 1, CT1, onwards)

Simulation training for technical skills would be best introduced from the beginning of surgical training (Table 24). All of the trainees believed simple exercises that help develop hand-eye

coordination, improve camera manoeuvring skills, economy of movement and tissue handling were essential to engage with from the start of surgical training.

With the VR simulator, modules for practising the steps in the actual sequence of a basic operation like an appendicectomy was viewed as particularly useful for junior trainees to practise before attending a session in the operating theatre (Table 24).

It is easier to teach trainees using simulation first before progressing to real life operating

Some of the senior trainees did not personally feel they gained a lot from using the simulator (Table 24). These trainees, however, recognised the value of teaching using the simulator, when they realised they would be progressing from the role of a trainee to a consultant in the immediate future where they would be expected to train their surgical trainees. The collective view was to normalise using simulation to learn a technical skill, even if the skill formed a part of a bigger operation (for e.g., suturing) before the trainee performed it on a patient.

Combined technical and non-technical skills simulation would offer a more naturalistic setting to practise the skills necessary for real world operating

The trainees did not have any experience with simulation training that combined technical and non-technical skills in one session. In fact, they had limited experience with non-technical skill simulation only when attending courses such as the ATLS. The trainees did not report access to non-technical skills training sessions during their regional training days.

Although participants had limited experience with integrated scenarios, they recognised that combining technical and non-technical skills would better reflect real clinical contexts, especially in managing stress or communication challenges during surgery. The trainees understood the value of simulating a surgical emergency in theatre or when on call where performing technical skills under pressure was required whilst maintaining communication and situational awareness with the wider team. However, as they had never participated in such a simulation before, they did not have a mental model of the experience.

Sub theme	**Example excerpts from questionnaires during the three months of using the VR simulator** **Tr- Trainee**	**Example excerpts from the semi-structured follow-up interviews** **Tr- Trainee**
Simulation training should be implemented from the start of surgical education (CT1 onwards)	Tr 1: Early stages for skill development, later stages if new more complex modules Tr 3: Very useful for CT1-CT2 for manual skills, muscle memory, hand-eye coordination. ST3-ST4 would benefit as well as they still in early stages and don't have much experience. ST5-6 would need more complex exercises Tr 5: CT1-ST4 Tr 6: Core trainees Tr 7: Early-stage trainees for improving hand eye coordination and assisting at laparoscopy by holding the camera as well as simple operations like the appendix Tr 12: Core Training and below to develop laparoscopy skills including camera holding Tr 22: I think currently this would be most useful at Core Training level for an introduction to basic operations. There are benefits at all levels in terms of hand-eye coordination and economy of movement, but I'm not convinced this is the best way to acquire these skills.	Tr 1: "Now we are pushing more towards robotic and laparoscopic. I think in the future, simulation will probably play a bigger part and will be important to start early" Tr 3: "Simulation is useful for people who haven't done anything in theatre or don't have much experience. When they progress to Core Training, they are very keen to operate appendices or diagnostic laparoscopies, so for trainers it's quite good to have already trained people for the basic skills" Tr 4: "Surgical training starts officially at CT1. So that's when u start" Tr 6: "I come in at ST1 or CT1. I want to learn or do an appendix. I have learnt the cognitive steps of doing an appendicectomy and I've done this many simulations on a model – 3 or 4, just to kind of really consolidate the cognitive steps in my head and I train here, and I go and do an appendix on a real human being supervised"

Sub theme	Example excerpts from questionnaires during the three months of using the VR simulator Tr- Trainee	Example excerpts from the semi-structured follow-up interviews Tr- Trainee
It is easier to teach trainees using simulation first before progressing to real life operating	Tr 4: Going through the steps of an operation before doing it in real Tr 11: I believe this simulator would be good for novice laparoscopic surgeon such as core surgical trainee or ST3 level to familiarise themselves with steps of surgery and dealing with potential complications Tr 13: Good at teaching the basic steps of the operation Tr 16: Helps build awareness of operative steps Tr 21: It is good at learning the steps of the operation, understanding port placement, and developing hand eye coordination	Tr 4: "As a trainer I would be much more comfortable with trainees using a simulator. You don't want to be training someone who takes 15 minutes to load a needle and then you don't want them to put it somewhere" Tr 5: "Like when you first learn to stitch skin, I was first taught by someone to do that on a model. So, it seems bizarre that we then learn to do the steps of a gall bladder on patients when there is nothing in between" Tr 7: "The robotic surgery is useful because you are suddenly using your feet for changing things, again I think for confidence and knowing that what you are going to press is ok and that suddenly the robot is not going to do something unexpected, definitely have to do the simulator before real life"

Sub theme	Example excerpts from questionnaires during the three months of using the VR simulator Tr- Trainee	Example excerpts from the semi-structured follow-up interviews Tr- Trainee
Combined technical and non-technical skills simulation would offer a more naturalistic setting to practise the skills necessary for real world operating	Tr 4: If the focus was not on technical performance, but overall performance in a stressful scenario, e.g., bleeding lap cholecystectomy while junior comes into theatre to say someone is sick on ward etc then that could be helpful Tr 7: Yes, though I have never participated in this type of simulation before Tr 9: Yes, I think that this would be possible Tr 11: Yes, This idea could be useful for management of unexpected intra-operative complications Tr 12: Yes this would be an excellent use but the obvious difficulties with cost and setup of these scenarios applies to this sim as to others	No corresponding interview data as this question was not discussed during the interviews.

Table 24 Early introduction of simulation in surgical training and the 3 subthemes. Abbreviations: CT- Core Training Year, ST- Specialist Trainee Year, Tr- Trainee, VR- Virtual Reality

Researcher observations

I had recorded two observations based on my interactions with the general surgical trainees in the three months of using the VR simulator as well as during the interviews eight months later. (Table 25)

1. ***Simulators for technical skill may share attributes for practising basic technical skills. But each simulator also has unique features that should be considered for specific advanced skills. Educators must consider the features of a simulator, the seniority of trainees and the volume of trainees who will be accessing the equipment when deciding which simulator, they want to introduce into surgical training***

   Trainees' experience with the various simulators they were exposed to, namely the box trainer, the AR simulator, and the VR simulator, was discussed. The collective opinion was that any of these simulators could be used to learn basic laparoscopic skills such as hand eye coordination, tissue handling, manual dexterity etc.

   But the trainees acknowledged the unique features of each of the simulators that should be considered when making a choice of which simulator to practise on, for specific skills. Trainee seven succinctly said in the interview "obviously there are a lot of simulators on the market, and each have their own good and bad points and it's figuring out what's the best thing."

   For example, for trainees who wanted to learn laparoscopic suturing ,the AR simulator and the laparoscopic box trainer were the simulators chosen over the VR simulator where you couldn't practise suturing.

On the other hand, the VR simulator could be used numerous times without the risk of running out of physical kit as the simulation worked with software and not physical models. Therefore, if educators wanted to choose a simulator that was predicted to be used by a large number of trainees, particularly junior trainees who needed to learn basic laparoscopy skills and steps to basic general surgical procedures, a VR simulator would be the appropriate choice.

Similarly, if the desired skill is robotic surgery, then a robotic simulator would be the appropriate choice.

2. ***Emphasise to trainees that simulation is an important adjunct to operating in real life but is never intended as a replacement***

   There was some ambiguity regarding the role simulation should play in surgical training, with an undercurrent of worry from trainees that simulation was used as a replacement for time spent in an operating theatre. Therefore, there is a requirement for reframing the concept of technical skills training; simulation should be described as an important adjunct that provides the trainee opportunities to familiarise oneself with skills that would then be used and built on by operating in the operating theatre.

Observation	**Supporting quotes**
Any of the simulator models can be used for basic laparoscopic skills including hand eye coordination, tissue handling, manual dexterity	Tr 1: "For junior trainees, these trainers are really helpful for understanding your instruments and how they work in space. So how to potentially use the camera or use your instruments in space." (interview) Tr 3: "Both of them feel nice. Both give good feedback." (interview, when discussing AR and VR simulators) Tr 7: I preferred the gamified exercises because of this. I think probably if you are junior and you are learning the basic exercises, this approach will be helpful but more senior you get you can do the basic procedures.(questionnaire) Tr 21: Felt I was able to be comfortable with the steps of the operation and develop my hand eye coordination/fluency of movement however I definitely feel that there is a limit to the benefit of the simulator. It can help with the initial stages of training but ultimately you need to be performing these operations in theatre to build up your skills further. (questionnaire)

Observation	**Supporting quotes**
Each of the simulators had unique features that should be considered when choosing the simulator to practise on depending on the skill they wanted to learn	Tr 1: "These kinds of trainers are useful is needle handling and suturing and fluidity of movement with your instruments." (interview, when discussing AR simulators) Tr 3: "I think they are both nice simulators. I think the difference was ,when we used the VR simulator, there was no suturing modules there. So that was a disadvantage. On the AR one, you actually use real instruments, so it feels more like proper operating." (interview, when comparing AR and VR simulators) Tr 4: "I suppose with the VR simulator, you can do the exercise as many times as you want and there is no limitation and can do the same thing over and over again but with the AR simulator, you are confined by the number of models. Each trainee is not going to be able to do ten. With the AR trainer you can see what you've actually done-you can check your stitches and know if it's neat or not. The VR one tells you your score, but you don't really see the result." (interview, comparing simulation models) Tr 5: "I think box trainers are useful for lap suturing." (interview) Tr 7: "The VR simulator had lots more cases and you could just repeat them without needing any extra kit. That was a big plus because we didn't have to wait for models or materials. Obviously there are a lot of simulators on the market, and each have their own good and bad points-it's figuring out what's the best thing. Maybe having both, one for repetition and one for hands-on practice, would be ideal."

Observation	Supporting quotes
Simulation is an important adjunct to operating in real life but is never intended as a replacement	Tr 1: Scores are not useful for assessment. Better used as an adjunct alongside feedback from an experienced trainer. (questionnaire) Tr 4: "I think simulation practice will be very valuable because at least when you are in theatre you know the steps and things like that. And that makes you a bit more confident and more likely to do more if you can say I know this is the next step and things like that." (interview) Tr 4: "I think that's an added value (of simulation) to run alongside the fact that you learn in the traditional sense. In general, we get less theatre time nowadays cause of just because of what's happened recently with the pandemic and all that sort of things and generally just access to theatre and we having to get through waiting lists and things like that and so if simulation is something that runs alongside as a tool it would be valuable." (interview) Tr 5: "For it to be useful I think u need to start from day 1, Core Training level, and it has to be in conjunction and progress at the rate you are progressing as a trainee in real life." (interview) Tr 6: "It's this kind of hybrid where you simulate and also focus on the procedure." Tr 18: The drawback was no dedicated time to spend using the simulator. I agree it would be valuable, but we need to be realistic about how much time can be ring-fenced for simulation training. Simulation cannot replace operative experience.(questionnaire)

Table 25 Qualitative evidence supporting the researcher observations. Abbreviations: AR- Augmented Reality, Tr- Trainee, VR- Virtual Reality

Additional reflections on simulator modality (comparing the VR simulation experience to the AR simulation)

In follow-up interviews conducted after exposure to both systems (Table 25), trainees compared the VirtaMed VR simulator used in the study with the Inovus AR simulator experienced subsequently on one day during their regional teaching day. Participants consistently valued the tactile realism of the AR system, emphasising that using their own laparoscopic instruments and physically inspecting sutures enhanced perceived realism and feedback. However, they also acknowledged that the VR simulator offered a broader range of cases, automated scoring, and unlimited practice without consumable costs.

Several trainees suggested that an integrated approach combining both modalities would be ideal, using VR for basic procedural rehearsal and the AR trainer for practising advanced motor skills such as suturing and tissue handling. These perspectives underscore that hardware fidelity alone does not determine educational value; rather, alignment between simulator capabilities and the trainee's stage of learning is critical.

Discussion

This study achieved its aim of exploring trainees' experiences of engaging with structured VR laparoscopic simulation alongside conventional surgical training. Using an interpretivist case study approach, the findings provide a rich, contextual understanding of how trainees perceived simulation as part of their real-world learning environment. The themes identified; 'varied motivators encourage engagement with simulation' and 'early introduction of simulation in surgical training', address the study's objectives by (1) identifying the factors influencing engagement, (2) outlining trainees' views on timing, structure, and educational value, and (3) generating practical recommendations for embedding simulation within postgraduate training.

Varied motivators encourage engagement with simulation

The learning processes, personalities, priorities for training, access to operating theatres, time commitments and stage of training are different for different trainees. All of these factors influence trainees' engagement with simulation training. One crucial and consistent motivating factor that affected engagement with simulation was ease of access to simulator. Similar patterns of engagement with simulation have been documented in previous studies which looked at increasing the use of simulation (443).

Additionally, several factors that could help sustain long term simulation engagement were identified. These factors included setting individualised short term and long-term simulation training learning goals, having educator and ARCP accountability and the emphasis on periodic, distributed, and deliberate use of simulation.

These motivators are independent of the type of simulator and can be introduced into any of the surgical subspeciality training programmes. Previous studies have mainly focussed the efficacy of simulation in research conditions which were invariably in isolation of routine training (443, 498). Also, performance goals have been highlighted as a motivator in surgical training, though it has not been extensively studied (499).

Participants' comments highlight potential educational value in performance-gated progression-an approach grounded in mastery learning principles that requires learners to demonstrate competence before advancing (88). Such gating can promote deliberate practice and confidence before clinical transfer. However, as several educational frameworks caution (500, 501), enforced thresholds may also risk shifting motivation from intrinsic mastery to extrinsic performance, potentially leading to superficial repetition or disengagement if targets are perceived as punitive. Within the context of this study, trainees favoured goal-oriented feedback and visible progress indicators rather than strict gating. Thus, while performance-gated systems may support structured learning, they should be

applied flexibly and formatively, aligned with individual learning needs and supported by educator feedback.

The finding that periodic rather than frequent engagement supports sustainable participation is noteworthy. Previous literature emphasises frequent use as essential for skill retention; however, this study highlights that distributed, periodic practice may be more feasible and equally effective for maintaining engagement in the context of limited time and competing responsibilities(240, 502).

Unrestricted access without setting learning objectives also results in low engagement with simulation (443). Therefore, it is important to set parameters for participation and progress based on individual training stage and learning needs.

Trainees working in subspecialties that did not involve certain surgical techniques (e.g., laparoscopy) valued simulation for maintaining skills and preparedness for future rotations. This suggests that simulation can support continuity of learning during periods of limited operative exposure-such as out-of-programme experiences, maternity leave, or reduced working hours-helping trainees maintain confidence and technical familiarity(89, 503).

Trainees particularly considered simulation practice to be beneficial when preparing ahead of time for a specific rotation so that they could make a positive impression during their first theatre session. Trainees in this study who did not achieve their self-defined objectives typically reported expectations that exceeded the simulator's capabilities (for example, seeking to practise advanced procedures not available in the software). This distinction is important in interpreting these results, as unmet objectives reflected limitations of the simulator rather than reduced engagement.

Laparoscopic suturing was one of the skills consistently mentioned as easily transferrable from simulation to real life operating both in my study as well as in other publications (504-506). This

preparatory function reinforces simulation's value as an educational bridge between practice and performance, supporting its implementation as a standard component of surgical training.

Accessibility and equitable implementation of simulation

This study highlighted that proximity to the simulator was a major determinant of engagement. Trainees reported that working at the site where the simulator was located meant they could engage with training more frequently, while the others faced logistical barriers such as travel time, on-call schedules, and associated costs. This presents an important tension between the educational benefit of simulation and the practical constraints of equitable access (118). Not all hospitals within a deanery can feasibly host high-technology simulators such as the VirtaMed device due to space, cost, and maintenance requirements (507). To mitigate these challenges, regional collaboration could enable shared simulation hubs accessible to trainees across multiple hospitals. Complementary use of lower-cost portable box trainers or web-based simulation modules could further extend access(508). Structured scheduling of simulator use during regional teaching days, or study leave may also reduce inequity. Together, these approaches could balance accessibility and resource limitations, ensuring that engagement with simulation is consistent and fair across the training region.

Role of choosing the appropriate goals: achievement of a set score for each exercise, gamification of simulation engagement

Setting structured goals and incorporating gamified elements enhanced engagement. Trainees preferred goal-oriented approaches, such as target scores, levels, or leaderboards, over arbitrary repetition. These findings echo evidence from other simulation-based disciplines showing that gamification can increase motivation and task persistence (509, 510). This aligns with adult learning theory, which emphasises the importance of self-direction and goal setting.

ARCP oversight as an incentive to engage with simulation

Simulation should be incorporated into the ARCP process as it will help educators and trainees be accountable and provide an incentive to engage regularly with simulation training (179). Trainees viewed incorporating simulation into ARCP discussions as a constructive, rather than punitive form of accountability. This approach positions simulation engagement as a shared educational responsibility, promoting reflective practice and progress review rather than assessment. Educators should guide trainees in setting realistic targets based on their learning needs, while training bodies should ensure adequate access and resources.

Not every hospital needs identical simulation equipment; with thoughtful regional coordination, trainees rotating through hospitals could access a variety of simulation experiences, aligning with national and global priorities for embedding evidence-based simulation in surgical training (179, 511).

While participants in this study viewed ARCP oversight of simulation engagement as largely positive, this approach warrants critical reflection. Embedding simulation within formal review structures, such as the ARCP, introduces elements of external accountability that may strengthen compliance but risk shifting motivation from intrinsic to extrinsic forms. According to Self-Determination Theory(512)intrinsic motivation- driven by curiosity, interest, and a sense of mastery- is associated with deeper learning and longer-term retention. In contrast, extrinsic motivation, such as performing tasks for external recognition or avoidance of negative outcomes, tends to support only short-term behavioural compliance(513, 514). While mandating simulation engagement might ensure participation, it does not automatically guarantee meaningful learning or reflective practice. Therefore, ARCP-linked simulation should be positioned as a developmental and formative process, encouraging self-regulation and autonomy rather than punitive assessment. Educators can foster intrinsic motivation by aligning simulation tasks with trainees' personal goals, providing constructive

feedback, and promoting mastery rather than performance outcomes. This balance may help sustain engagement and translate short-term compliance into authentic, long-term learning.

Early initiation of technical skills simulation in surgical training

All trainees supported introducing simulation early in surgical training to develop core laparoscopic skills, establishing it as a foundational element of surgical education.

Senior trainees also recognised the value of simulation as a teaching tool. They preferred introducing novices to procedures in simulation before progressing to live supervision in theatre, as this provided a safe, low-risk environment for learning and error correction (78, 515). Simulation, therefore, supports both technical development and the cultivation of a teaching mindset among senior trainees.

Learning technical and non-technical skills in one simulation session

Trainees recognised the value of combining technical and non-technical skills simulation though having never participated in an integrated simulation they did not have a mental model. Combining technical and non-technical skills simulation would provide a realistic setting to practise both skills simultaneously.

This finding points to an important direction for future research: developing and evaluating combined simulation scenarios that replicate the cognitive and interpersonal demands of real operating environments. Such designs could better prepare trainees for managing complex surgical situations.

How the study achieved the research aim and objectives

This study achieved its overall aim of exploring trainees' experiences of engaging with a structured VR laparoscopic simulation programme alongside conventional surgical training. Using qualitative methods within an interpretivist case study design, it captured trainees' personal meanings, motivations, and contextual challenges associated with simulation-based learning.

The findings met Objective One by identifying multiple factors influencing engagement, including access, time, accountability, and motivation. Objective Two and Three was met through trainees' reflections on the timing and structure of simulation within their training pathway, highlighting the value of early, integrated exposure and by developing actionable recommendations: to promote accessibility, schedule distributed practice, use goal-oriented and gamified structures, and incorporate simulation into formative educational discussions. Collectively, these outcomes contribute to understanding how simulation can be sustainably embedded within postgraduate surgical training.

Limitations and future directions

Nearly all general surgical trainees in the Thames Valley Deanery took part in this study. While the findings provide valuable insight, the relatively small sample size limits transferability. However, this is consistent with the exploratory, interpretivist nature of the study, which prioritises depth of understanding over breadth. Information regarding trainee fatigue and its relation to their working schedule when they engaged with the simulator was not available, and so no meaningful conclusions could be drawn about the influence of fatigue on training experience.

Future research should further explore the integration of technical and non-technical simulation, evaluate how simulation engagement evolves longitudinally across training years, and examine how institutional factors influence participation. Collaboration between educational leaders, trainees, and simulation developers will be essential to align simulation use with real-world training needs.

All strategies discussed in this study align with the NHS England Educator Workforce Strategy, which emphasises embedding innovative, technology-enhanced learning models, including simulation and immersive technologies, within training programmes (516).

Conclusion

This study achieved its aim of exploring general surgical trainees' experiences of participating in structured VR laparoscopic simulation alongside conventional surgical training. Using an interpretivist case study approach, it provided a contextual and nuanced understanding of how trainees engage with simulation within the realities of clinical training.

Simulation has the potential to play a critical role in surgical technical skills training, as demonstrated in this study, and should be tailored to individual learning needs and integrated meaningfully into existing training structures. Key findings to support trainee engagement include ensuring ease of

access, establishing structured and goal-oriented learning opportunities, and prioritising the early introduction of simulation within surgical education.

The study highlights that motivation, accessibility, and accountability are central to sustained engagement. Simulation is most effective when positioned as a formative, reflective, and complementary component of real-world training rather than as a replacement for operative experience. Addressing the logistical and motivational challenges identified by trainees, such as time constraints, variation in access, and the need for supportive faculty oversight, can help educators optimise simulation programmes for relevance and impact.

By generating evidence from trainees lived experiences, this research contributes to understanding how simulation can be embedded sustainably and equitably within postgraduate training. The findings offer practical guidance for educators and training bodies to develop accessible, learner-centred, and contextually appropriate simulation strategies that enhance skill development and confidence in the operating theatre.

Chapter Eight: Exploring the trainee experience during a combined technical and non-technical skills obstetric training session on a simulated labour ward: A rapid ethnographic study

Note on publication eight

The study in Chapter Eight was submitted as a paper to BJOG: An international journal of obstetrics and Gynaecology on 5th of February 2026, titled "Exploring a combined technical and non-technical skills obstetric training session on a simulated labour ward: a rapid ethnographic study". This paper is under review.

I have suitably modified the paper and presented the research work in Chapter Eight, complying with departmental and university regulations. The abstract can be found in Appendix Two.

Contribution statement

I am the lead author for the work presented in this chapter and for the paper submitted for publication. I conducted the study, collected and analysed the data, and authored the paper. The co-authors of the paper (Nadia Muspratt Tucker, Divya Nambiar, Ruth Houlden, Debbie Aitken, and Helen Higham) provided guidance, acted as faculty and advisors for the simulation or were the supervisors of my doctoral research and oversaw and advised on my research work.

Chapter Introduction

At the time of this study, I was the obstetric simulation trainee representative and had been asked to design a simulation for the regional training day that all obstetric ST1 and ST2 trainees were due to

attend. Trainees usually participate in non-technical skills team-based simulation in groups. I wanted the simulation to provide the trainees with an experience where they could practise their technical and non-technical skills in a naturalistic obstetric on call setting. I was also mindful of the faculty and resource constraints and took these into account in my simulation design, using low fidelity models that the deanery already owned, working within the training room that would usually be available for regional teaching and collaborating with the faculty who had already been assigned for the regional simulation that day. By adopting this approach of working within the existing simulation teaching structure, the simulation could be delivered regularly without placing additional resource burdens on the organisers.

Background

The seamless blending of technical and non-technical skills is crucial to provide safe obstetric care to patients. (517). Obstetric technical skills are procedures trainees are expected to perform, including instrumental deliveries, caesarean sections, and perineal repairs.

Technical skills also include the knowledge required to diagnose and manage obstetric and pre-existing conditions such as pre-eclampsia, diabetes, and intrauterine growth retardation. Non-technical skills, on the other hand, refer to the cognitive and social skills that are essential for patient safety and surgical excellence (518-521). These cognitive and social skills include situational awareness, decision making, leadership and communication/teamwork (520, 521). In a labour ward setting, which is fast-paced, learning to integrate technical and non-technical skills is essential for safe and effective patient care (522).

Obstetric trainees routinely participate in non-technical skills team-based simulations and have occasional technical skills simulation as part of their training (523). Technical skills simulation courses such as the ROBuST course are mandatory for obstetric trainees to attend to learn instrumental deliveries (524).

Similarly, for non-technical skills, trainees participate in team-based simulation training courses such as the Practical Obstetric Multi-professional training (PROMPT) course (525-527) which improve team performance, practitioner confidence and patient outcomes (525, 528, 529). The integration of the two skills is expected to be learnt on-the-job in an hospital setting(530).

However, this on-the-job approach can be nerve-wracking for obstetric trainees especially in the early years of training, as they have to perform a technical skill they are not entirely familiar with whilst communicating with an awake patient, their family, and the staff on a labour ward. Simulation provides an excellent opportunity for experiential learning of real-time decision making in a safe learning environment, improving performance and patient safety (181, 531).

The aim of the study was to explore ST1 and ST2 obstetric trainees' experiences of practising technical skills within a combined technical and non-technical obstetric on-call simulation and to assess the perceived educational value and feasibility of this simulation format for routine training.

The objectives were:

Objective One: To describe trainees perceived preparedness and readiness to perform the technical and non-technical skills in the simulation.

Objective Two: To identify features of the simulation that facilitate or hinder learning of technical and non-technical skills

Objective Three: To assess the feasibility and acceptability of running this combined simulation within routine regional training

Methodology: Rapid Ethnography

The study of social interactions to understand the way people interact with their surroundings is ethnography (532). The origin of ethnography is from anthropological research and has evolved to its current applications in healthcare and education.

Ethnographic research allows for the simultaneous recording and comparison of multiple data sources which are obtained in an ethnographic study (observations, interviews, and audio-visual documentary recordings) to give a rich and complex understanding of the research subject. The multiple data sources also allows for the triangulation of findings, improving the reliability of the results (251, 533-535).

Ethnography, especially in anthropological contexts, took many years to conduct. Modern adaptations to the methodology have resulted in multiple different ethnographic formats to suit a wide range of contexts, including traditional, rapid, critical, online and autoethnography (532).

The ethnographic researcher acts as a participant observer (Figure 14) taking an active role by engaging with the study subjects alternating between acting as an insider and observing like an outsider. The participant observer helps maintain objectivity, positioned somewhere between "participant as an observer" and "observer as a participant" (Figure 14) (532, 536).

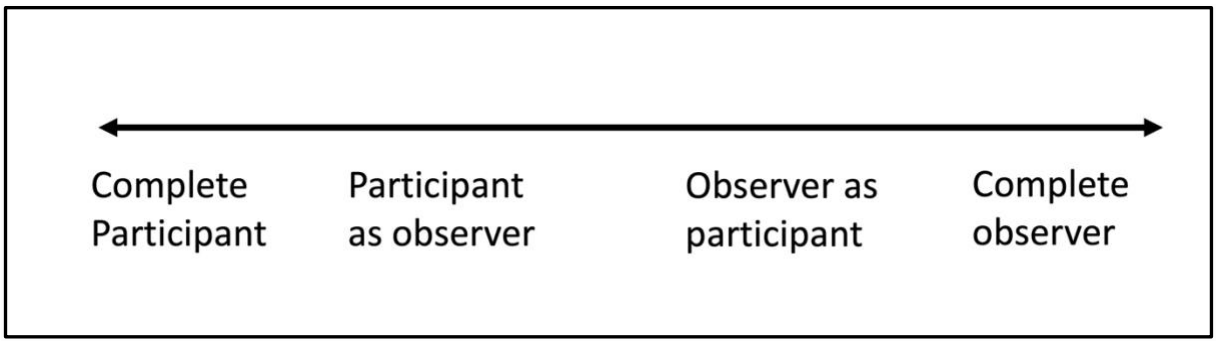


Figure 14 Gold's typology of participation by the researcher in a study. In an ethnographic study, the researcher acts as the 'participant as an observer' or the ' observer as participant(532, 536)

Methods

This study received ethics exemption from the University of Oxford CTRG (Appendix Four). Written consent was taken from all the participants. A pilot simulation was conducted in 2022 using the developed simulation script, and the ethnography study was conducted the following year in 2023.

Fourteen ST1 and ST2 obstetric trainees attended and participated in the obstetric simulation in February 2023, which was a routine part of their mandatory regional simulation training. The 14 trainees were divided into two groups and each group participated in one iteration of a 40-minute simulation followed by a 30-minute focus group interview before swapping over. There were other simulation-based activities occurring during the regional training day including CBDs and practising breaking bad news.

The inclusion criteria for choosing the participant cohort for this simulation was

- Trainees with a maximum of two years of experience in obstetrics as it helped reduce variability in experience levels.
- Expected competence in the technical skills included in this simulation (537): RCOG training matrix lists the procedures obstetric trainees are expected to perform at each stage of their training. Compared to more advanced trainees, this cohort has a consistent and limited skill set across the group which reduced the potential for variability in the study. For example, ST2 trainees can perform a straightforward non-rotational forceps and kiwi delivery, a straightforward caesarean section, and an episiotomy repair.

None of the participating trainees were beyond ST2 or had more than two years of postgraduate experience in obstetrics.

The faculty in the simulation and development of simulation materials

The four faculty members, namely two obstetric consultants and two senior obstetric trainees, with experience in both technical and non-technical skills simulation facilitated the simulation for both the pilot and this study, including reviewing and approving the simulation script, materials and learning outcomes. The clinical scenarios and the management of the conditions included in the simulation, which were based on the RCOG guidelines, were finalised after a consensus agreement with the faculty involved (Table 26).The complexity of the clinical scenarios and the technical skills the trainees were expected to perform in the simulation was very carefully determined keeping in mind the knowledge and skill expected at the experience level of ST2. The faculty had been trained to use the RCOG adapted Non-Technical Skills for Surgeons (NOTSS) tool and had experience using it (538). The full simulation script can be found in Appendix Four.

Simulation timeline	**Expected actions to be performed by the trainees**	**Technical skills (TS)/ Non-technical skill (NTS)**
At handover	1. Team members introduce themselves 2. Receive handover of labour ward board from coordinator midwife 3. Establish if there are any patient concerns that require immediate attention	Situational awareness (NTS) Communication and teamwork (NTS)
Immediately after handover	Consultant to discuss with members of the team: • Identify learning needs and goals of each member of the team • Prioritise workload (ward round, assessment of room 1, antenatal ward round, review of patients in MAU) • Appropriately delegate workload to members of the team (ideal allocation would be- ST5 to assess patient in room 1, ST3 for antenatal ward round, one Senior House Officer (SHO) to review patients in MAU and consultant and second SHO for labour ward round).	Situational awareness (NTS) Decision making (NTS) Communication and teamwork (NTS) Leadership (NTS)
Assessment of room 1 and decision for instrumental birth	ST5 • To introduce themselves to patient and midwife • To establish the history	Decision making (NTS) Communication and teamwork (NTS)

Simulation timeline	Expected actions to be performed by the trainees	Technical skills (TS)/ Non-technical skill (NTS)
	• To perform the relevant abdominal and VE and correctly identify the abdominal and VE findings • Communicate findings of delay in second stage and malposition of foetal head to patient and midwife • Counsel patient regarding options and recommendation of rotational instrumental birth in theatre (called trial of instrumental birth) • Communicate with coordinator midwife and consultant regarding patient in room 1 • Consent patient for the procedure, including discussing management of risks and possible additional procedures e.g., caesarean section and episiotomy	Performing the examination (TS) Knowledge of procedure and risks to counsel patient (TS)
Labour ward round	Consultant and SHO to perform a ward round with the coordinator midwife • Prioritise the patients on labour ward to decide the order of patient review • For each patient, identify if they are any immediate concerns, plan next steps for investigations and management • Include and communicate plans with coordinator midwife • Include the SHO in the discussions	Situational awareness (NTS) Decision making (NTS) Communication and teamwork (NTS) Leadership (NTS)

Simulation timeline	Expected actions to be performed by the trainees	Technical skills (TS)/ Non-technical skill (NTS)
		Knowledge of management of routine clinical situations on labour ward (TS)
Antenatal ward round	ST3 • To introduce themselves to the midwife on the antenatal ward • Identify any immediate concerns and prioritise patients to decide the order of review • Discuss each patient with the midwife, address concerns, discuss management • Manage the emergency- hyperstimulation (contracting more than 5 times in a 10-minute period) • Identify the patient causing concern, discuss immediate management with midwife • Discuss the unwell patient with the consultant and the coordinator midwife on labour ward to arrange for transfer of patient to labour ward	Situational awareness (NTS) Decision making (NTS) Communication and teamwork (NTS) Knowledge of management of routine antenatal clinical situations (TS) Recognising the unwell patient (TS)
MAU	SHO • To discuss with the midwife and prioritise patients in order for review • Review patients and make suitable management plans • Identify the unwell patient with Acute Fatty Liver of Pregnancy (AFLP)	Decision making (NTS) Communication and teamwork (NTS)

Simulation timeline	Expected actions to be performed by the trainees	Technical skills (TS)/ Non-technical skill (NTS)
	• Escalate concerns about patient with AFLP to consultant and coordinator midwife and organise an urgent senior review • Arrange for transfer of patient with AFLP to labour ward and handover to the coordinator midwife on labour ward about patient	Leadership (NTS) Knowledge of management of routine obstetric clinical situations (TS) Recognising the unwell patient (TS)

Simulation timeline	**Expected actions to be performed by the trainees**	**Technical skills (TS)/ Non-technical skill (NTS)**
In theatre for instrumental birth	ST5 1. Communicate to the consultant that supervision is required in theatre for the required training e-portfolio evidence 2. Perform the WHO check using the WHO check list 3. Clean and drape 4. Catheterise 5. Confirm vaginal findings 6. Communicate with anaesthetist, midwife, and patient 7. Decide to proceed with rotational instrumental birth 8. Perform the rotation of foetal head between contractions 9. Apply forceps and perform forceps delivery using the correct technique 10. Perform an episiotomy at the time of crowning of the foetal head 11. Deliver the baby and handover to the midwife after delayed cord clamping 12. Manage the third stage of labour and deliver the placenta with controlled cord traction 13. Examine the perineum including rectal examination to identify any tears 14. Repair the episiotomy using the appropriate technique 15. Enquire about blood loss and manage appropriately 16. Perform a swab and instrument count with the theatre staff at the end of the procedure 17. Sign out of theatre at the end 18. Debrief patient and staff after procedure	Situational awareness (NTS) Decision making (NTS) Communication and teamwork (NTS) Leadership (NTS) Performing a rotational instrumental delivery (TS) Repair of an episiotomy (TS)

Table 26 The schematic with the expected actions the trainees were required to perform during the simulation, including the technical skills and non-technical skills. Abbreviations: AFLP- Acute Fatty Liver of Pregnancy, MAU- Maternity Assessment Unit, NTS- Non-technical skills, SHO- Senior House Officer, ST- Specialist trainee year, TS- Technical skills, VE- Vaginal Examination, WHO- World Health Organisation

Each faculty member was responsible a zone within the simulation (the labour ward board, theatre/room 1, antenatal ward and the MAU), playing the role of the staff members in charge of each of these areas (midwife coordinating labour ward, anaesthetist in theatre/midwife in the room, midwife in charge of antenatal ward, midwife in MAU respectively). During the simulation, the faculty would prompt trainees with pertinent clinical information at crucial junctures based on the simulation script provided to them (Box 5 has an example, Appendix Four contains the complete simulation script).

Instructions to faculty acting as coordinating midwife in charge of labour ward
Timeline:
At 10 mins:
The participants read their instructions for 2 mins. The team should have gathered, looked over the delivery suite board, assigned members of the team for delivery suite ward round, assessment of the woman in room 1, antenatal ward round and Maternity Assessment Unit (MAU) reviews. Best practice: asking for each team member's learning objectives for the day, prioritising induction of labour (IOL) and triaging which patients can be brought to the delivery suite. If no one has been assigned to perform antenatal ward round by 10 mins, there will be an emergency in the antenatal ward that should prompt one member of staff to go there.
At 10 min – 25 mins:
Antenatal ward round : May take 15 mins- in a separate room.
In the main room:

1. Assessment of room 1 and decision for trial. Proceed with trial including performing the procedure
2. Del suite ward round, checking cardiotocographies (CTGs) and blood test results
3. MAU patient being assessed

At 25 minus- 35 mins

1. Trial in theatre may be ending
2. MAU patient plans should be in place
3. MAU patient should be assessing, and bloods reviewed and escalated appropriately. If this has not happened at 25 mins, there should be an emergency buzzer to MAU as patient is feeling dizzy
4. Team should have finished their various activities and re-group including checking labour ward board as it has changed.

35- 45 mins:

1. See new patients on labour ward
2. Manage MAU unwell patient.

Box 5 Faculty instructions provided to the educator acting as the coordinating midwife on labour ward. Abbreviations: CTG- Cardiotocography, IOL- Induction of Labour, MAU- Maternity Assessment Unit, mins- minutes

The layout for the simulation

The simulation was set up in two rooms. The large training room was divided into distinct zones (Figure 15) representing the labour ward board, the operating theatre with a model of a pregnant abdomen for examinations and instrumental deliveries , and the MAU. The simulation model used was a low-technology, silicone-covered, part-task simulator. The smaller room, a short walk away

from the larger training room, was set up as the antenatal ward, allowing for participants to realistically transition between different areas of care.

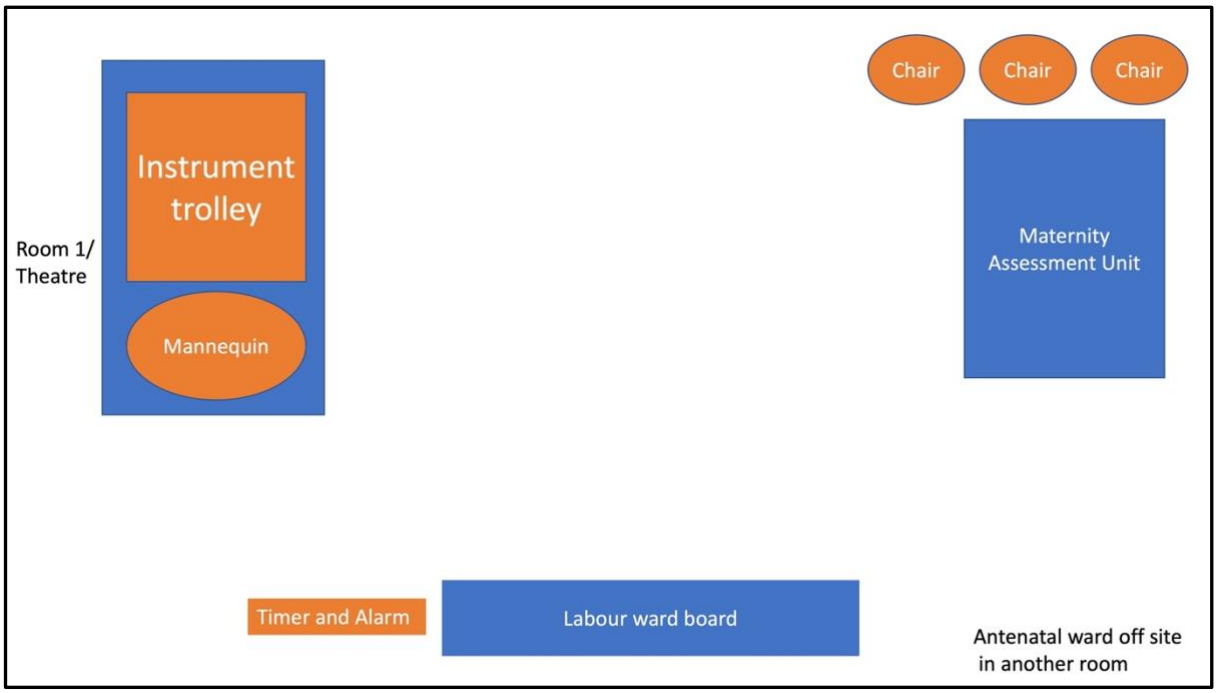


Figure 15 Layout of the main simulation training room. The main simulation room was a large training room which was divided into zones to represent the labour ward board, the maternity assessment unit (MAU) and the operating theatre which also acted as room 1 on labour ward when the patient in room 1 required an examination prior to their operative procedure. The antenatal ward was located in a separate room down the corridor from the main simulation training room

Activities within the simulation

The simulation had a series of specific clinical scenarios for trainees to navigate. Trainees performed actions based on the NOTSS tool and the RCOG guidelines for assisted vaginal birth and management of labour (Appendix Four). The technical skills included performing of a rotational instrumental delivery in theatre, conducting the labour ward and antenatal ward rounds and treating patients in the MAU Trainees were required to apply the relevant knowledge and physical hand skills required to perform these tasks.

Each faculty member was provided with the simulation script relevant to the role they were playing and the zone of the simulation they were managing. Faculty followed the script with regards to the timeline for the events unfolding in the simulation, and the various clinical scenarios of the patients

that the participants would need to manage on the simulated labour ward, the antenatal ward, and the MAU (Box 5 and Appendix Four).

ST5 Registrar
You are an experienced ST5 who has returned to delivery suite after an academic 2-year OOPR, 4 months ago. The fellowship was linked to a London hospital providing 3000 deliveries/year and you covered a few on calls as a locum but feel a little anxious about doing operative deliveries.
You have an annual review of competency progression (ARCP) in 3 weeks, this is a waypoint for moving into ST6. You have returned to work less than full time (LTFT), working clinically part time, and completing a PhD in your academic time. You have only had delivery suite sessions every other week as part of your working pattern, the next session is in 2 weeks. You have to complete an objective structured assessment of technical skills (OSAT) for rotational delivery prior to your ARCP, otherwise you will not have completed your matrix requirements for ST5.

Box 6 Participant instruction for the ST5 registrar in the simulation. There were similar role specific instructions for each participant. Out of Programme for Research (OOPR) refers to the trainee pausing their clinical training to participate in research. Abbreviations: ARCP- Annual Review of Competency Progression, LTFT- Less than full time training, OSAT- Objective structured assessment of technical skills, ST- Specialist trainee year

I delivered the pre-simulation brief, which was a 10-minute discussion with the participants familiarising them with the simulation setup (Figure 15) and discussing my role as the participant observer collecting the ethnographic data. The participant roles were assigned, and they were handed participant instructions (Box 6). The participant roles were consultant, ST5 registrar, ST3 registrar, two Senior House Officers (SHOs), patient and observer. The ST2s were assigned the more senior roles in the simulation, namely that of the consultant and registrars (Table 27). Participant instructions contained information about their role (their experience, personality traits etc.) and specific training objective (Box 6 and Appendix Four).

Role in the simulation	**Participants in group 1** **Pseudonym, training grade**	**Participants in group 2** **Pseudonym, training grade**
Consultant	Mellie, ST2,	Daisy, ST2
ST5	Joseph, ST2	Hana, ST2
ST3	Uma, ST2	Catherine, ST2
SHO 1	Gemma, ST1	Maya, ST1
SHO 2	Tina, ST1	Justina, ST1
Observer	Andrew, ST2	Ada, ST2
Patient	Fenella, ST1	Elle, ST1

Table 27 The roles for trainees within the simulation. The complexity of the clinical scenarios in the simulation was carefully chosen to ensure suitability for an ST1 and 2 to manage even if they were acting outside their usual role. All names were changed to pseudonyms for anonymity. Abbreviations: SHO- Senior House Officer, ST- Specialist Trainee Year

Data collection

Data was collected from the notes maintained by the participant observers in the simulations, the research diary of the ethnographic researcher, the faculty field notes, audio recording of the simulation and focus group interviews at the end of each simulation.

- Participant observation: The four faculty members, two trainee observers and the ethnographic researcher all acted as participant observers. They maintained field diaries, noting body language (uncertainty, confidence, anxiety etc), observed actions, professionalism (technical skills, communication etc.), movements within the simulation setting, clinical decisions taken and the timing of the decisions.
- Focus group interviews: The participants, faculty members and the ethnographic researcher gathered to discuss their experience at the end of each simulation. The notes made by the faculty and the ethnographic researcher acted as prompts during the discussion.
- Documentary data: Audio recordings from the labour ward board, the antenatal ward, and the focus group interviews were transcribed for detailed analysis. Additionally, documentary data from the field diaries were reviewed. The ethnographic researcher also tracked trainee movements using hand-drawn diagrams (Figures 16 and 17).

Data analysis

Data analysis followed an iterative and cyclical approach consistent with ethnographic methodology, in which interpretation began during fieldwork and develops alongside ongoing data collection(539, 540). Field notes, research diary entries, faculty notes and audio transcripts were reviewed repeatedly to build a detailed understanding of how trainees experienced the simulation.

A thematic analysis approach was used to interpret the dataset(497). Coding proceeded inductively to allow themes to emerge directly from participants' accounts and observed behaviours, reflecting the interpretivist orientation of this study. A deductive component was then incorporated, guided by

the study's objectives: trainees perceived preparedness and readiness to perform the technical and non-technical skills in the simulation, features of the simulation that facilitated or hindered technical and non-technical skills, and the feasibility and acceptability of running this combined simulation within routine training. All data sources, including field diaries from faculty and trainee observers, the researcher's ethnographic diary, movement diagrams, audio recording transcripts of the simulation and focus group transcripts, were imported into NVivo to support systematic coding, constant comparison, and organisation of emerging themes.

Comparing insights across these multiple sources enabled the identification of consistent patterns and points of divergence. Attention was paid not only to verbal accounts but also to non-verbal communication, spatial movements and interactions with the simulated environment, consistent with established approaches to analysing behaviour in clinical ethnography(541). Reflexive notes were also used throughout the analytic process to document developing interpretations and ensure transparency in analytic decision-making. These contextual details helped illuminate how trainees enacted technical skills, managed workload, communicated with team members, and responded to real-time complexity within the simulation.

Positionality statement

I am an obstetrics trainee with extensive experience in designing, facilitating, and participating in both technical and non-technical skills simulations. The faculty members involved in this study also have extensive clinical and simulation experience, especially with the use of the NOTSS tool to assess non-technical skills .

This background informed the development of clinical scenarios within the simulation, to ensure the cases were suitable for ST1-2 trainees though the trainees were assuming more senior roles during the simulation. The case complexity was carefully chosen to ensure even the ST2 acting as the "consultant" in the simulation could carry out the appropriate tasks.

My clinical background positioned me as an insider within the simulation, enhancing my role as an observer-participant during the ethnographic data collection. The insider perspective enabled the opportunity to empathise with the trainees' anxiety, body language and concerns and to appreciate the nuances of each clinical scenario.

However, it was important to remain mindful of unconscious assumptions that I might make, due to my clinical background, on the behaviour of trainees within the simulation and their management of clinical scenarios. Reflexive strategies were employed from the outset to put the participants at ease by discussing my role and reassuring the participants that the simulation was not designed to include any adverse outcomes.

Maintaining rigour through triangulation

To maintain rigour in this study, multiple sources of data were used to triangulate the findings and minimise the risk of misinterpretation and bias. The involvement of the faculty, trainee observers, trainees and the ethnographic researcher provided diverse perspectives, representing multiple viewpoints and offered a comprehensive understanding of the simulation experience.

Results

Fourteen ST1-2s attended the regional simulation teaching day and participated in the study. Six were ST1s and eight ST2s. The roles and group allocation as well as the pseudonyms for each trainee are detailed in Table 27.

Data triangulation and sources: The themes and findings reported below draw on multiple, specified data sources: participant observation field notes and faculty field diaries (which informed descriptions of behaviour, body language and task sequence), movement tracking diagrams (which evidenced spatial and role allocation and workflow interruptions), simulation audio transcripts and

focus-group interaction transcripts (which provided trainees' reflections and explanations). Where a finding is primarily supported by one data source I indicate this in the text (observation, diary, movement diagram, or focus group interaction).

Group 1's actions during the simulation

At handover, Group 1 completed all expected actions, including team introductions, receiving the labour ward board from the coordinating midwife, and confirming whether any patients required urgent review (field notes). Immediately after handover, learning needs were not discussed, and workload prioritisation occurred only once the labour ward round had already begun. Although this sequence differed from the expected structure, no delays occurred in assessing the patient in room 1, and all patients ultimately received timely review. The MAU midwife later used the emergency buzzer to request medical input, and the antenatal midwife also prompted the team regarding outstanding patient reviews, which facilitated final allocation of responsibilities. Once allocated, roles aligned with expected patterns: the ST5 assessed room 1, the ST3 undertook the antenatal ward round, the consultant and one SHO conducted the labour ward round, and the second SHO was assigned to MAU.

Joseph (in the ST5 role) conducted the assessment of the patient in room 1. He introduced himself, elicited the relevant history, performed abdominal and vaginal examinations, correctly identified malposition and delay in the second stage, and recommended a rotational instrumental birth in theatre. He also completed the counselling and consent process independently, as expected. Field notes recorded that although the information provided was clinically accurate, its detail appeared to heighten the simulated patient's anxiety, suggesting reduced ability to adjust the communication to patient needs. His body language was described as inclusive; kneeling, maintaining eye contact, and using open gestures, while the simulated patient appeared anxious but engaged (ethnographer's diary).

During the labour ward round, Mellie (consultant role) and the SHO initiated the review with the coordinator midwife, beginning in room 1 before continuing to other patients. Mellie delegated the continued assessment of room 1 to Joseph and proceeded to review patients on the labour ward board, prioritising room 9 next. Each patient was discussed with the coordinator midwife, and appropriate management plans were developed and communicated.

Gemma (SHO) attended the ward round but contributed little verbally and was not routinely included in discussion; however, movement-tracking diagrams and later handover interactions showed she had understood and retained all plans, enabling her to effectively brief Joseph when Mellie left the ward to attend MAU. According to the ethnographer's diary, Joseph appeared to adopt an overview or "helicopter" perspective when taking responsibility for coordinating ward activity later in the simulation.

Uma (in the ST3 role) carried out the antenatal ward round. She introduced herself to the midwife, correctly identified and prioritised the emergency of hyperstimulation, and advised prompt administration of Terbutaline (antenatal midwife diary). She then reviewed remaining patients in order, incorporating cues from the midwife into her clinical reasoning. When uncertain, she planned to escalate appropriately and sought senior guidance, demonstrating awareness of her limits. Uma correctly identified a patient with pre-eclampsia as unwell and discussed the case with the consultant before the consultant left for theatre; together they agreed further planning would occur once theatre duties were complete.

No trainee had initially been allocated to MAU. When the MAU midwife interrupted the labour ward round to request review of patients, the consultant instructed a recheck of observations, but further deterioration prompted use of the emergency buzzer. All doctors on labour ward moved to MAU, leaving the ward temporarily unattended. This was noted by the coordinator midwife, prompting the consultant to reassign roles. Mellie (consultant) and Tina (SHO) then undertook the MAU reviews. All patients were assessed, and appropriate plans were made. The patient later

identified as having AFLP was recognised as seriously unwell; although the consultant initially required prompting regarding the diagnosis, the team escalated appropriately, discussed management with the coordinator midwife and arranged transfer to labour ward, with plans to involve the wider MDT.

Joseph communicated his need for supervision before going to theatre. He performed the WHO checklist correctly and began the procedure. Some basic preparatory steps such as draping and catheterisation were forgotten initially but were completed after prompting (field notes). He confirmed the vaginal findings, rotated the foetal head appropriately, carried out the instrumental delivery, and managed the third stage of labour. Although Joseph delegated several tasks to a single team member, communication with the theatre team remained constructive.

Joseph's body language relaxed noticeably after the baby was delivered, and he performed the episiotomy repair with confidence, engaging in casual conversation with staff and patient (ethnographer's diary). He completed the procedure with a sign-out and debrief.

Group 2's actions during the simulation

Group 2 completed all expected handover actions. Learning needs were raised by Hana before she left for the antenatal ward, which prompted brief discussion but did not lead to any adjustment of task allocation. Observational notes describe Hana's body language as hesitant and awkward when raising this issue, and Daisy (consultant role) appeared visibly challenged, with defensive body language noted in the research diary.

Workload was prioritised early; however, delegation occurred without team discussion, and tasks were allocated arbitrarily rather than collaboratively. As a result, the distribution of responsibilities differed from expected patterns: Hana was sent to the antenatal ward round, Catherine assessed

room 1, Daisy conducted the labour ward round, Justina reviewed a non-urgent labour ward patient, and Maya was sent to MAU.

Several trainees contributed to the assessment of the patient in room 1. Catherine performed the initial review, accurately identifying malposition and the need for a trial of instrumental birth in theatre. She began the consent process but had difficulty using patient-friendly language; her explanation "sounded robotic", according to the research diary, and the consent form remained unsigned. Hana subsequently took over both consenting and performing the procedure in theatre. Because responsibility transferred between trainees, consent had to be repeated, causing delay before the form was signed.

The labour ward round began early, and a complete review was eventually achieved. However, the order of patient review was not optimal, as the consultant assigned tasks without team consultation. Although the responsibility for clinical assessments broadly aligned with trainees' experience levels, the lack of coordinated delegation created workflow inefficiencies and required later reshuffling of staff roles. Plans for each patient were made and communicated to the coordinator midwife. The SHO initially assigned elsewhere joined the ward round before reviewing her own patients later in the simulation, and she demonstrated appropriate clinical judgment, requesting relevant investigations and forming suitable management plans.

Hana was initially tasked with the antenatal ward round, which was appropriate for her level of skill but unexpected given competing responsibilities. She was called away mid-round to undertake the instrumental delivery, leaving the antenatal midwife to request a replacement. Justina (ST1) was the only available trainee and accepted the role, despite limited experience. The antenatal midwife's field diary noted that Justina appeared confident and adaptive despite her level of seniority. Hana had made several immediate management plans before leaving the ward round, but uncertainty was not escalated. Justina correctly identified high-risk patients but did not escalate concerns to a senior trainee on returning to the labour ward. A patient with worsening pre-eclampsia had been discussed

with both Hana and Justina; however, no escalation occurred, despite abnormal blood results being recognised. The antenatal midwife raised this again with Justina, who acknowledged the need for senior input but did not communicate this to the consultant, reflecting a missed escalation opportunity.

Maya was asked to review patients in MAU immediately after handover. Her initial approach was appropriate: she reviewed the list, requested timely CTGs, assessed symptomatic patients, and identified a case of very low blood sugars requiring urgent action. She escalated concerns appropriately by activating the emergency buzzer. There was brief confusion about which team member should respond to the MAU emergency. The consultant initially attempted to attend but returned to labour ward due to the need to supervise Hana; Catherine instead went to MAU to support Maya. Maya arranged transfer of the unwell patient to labour ward after escalating concerns and, with prompting, considered involving the MDT. The diagnosis of AFLP was reached with support, and body language indicated shared awareness of the patient's acuity. Although Maya communicated effectively with the consultant using an "Situation-Background-Assessment-Recommendation" (SBAR) structure, there was some loss of continuity, as neither she nor Catherine followed up the patient after transfer, and the team briefly lost track of the patient's location, as noted in field diaries.

Hana informed the consultant early that she required supervision in theatre. The consultant attended but left several times due to workload pressures, resulting in intermittent supervision. Hana's body language appeared diffident initially, and she communicated cautiously with the team and patient. Despite this, she performed the WHO checklist and key procedural steps accurately. Her confidence visibly increased after delivery of the baby, as noted by the consultant and recorded in the research diary. She completed third-stage management and episiotomy repair independently. The sign-out and debrief were brief and rushed, as the consultant was again called away to attend competing clinical tasks

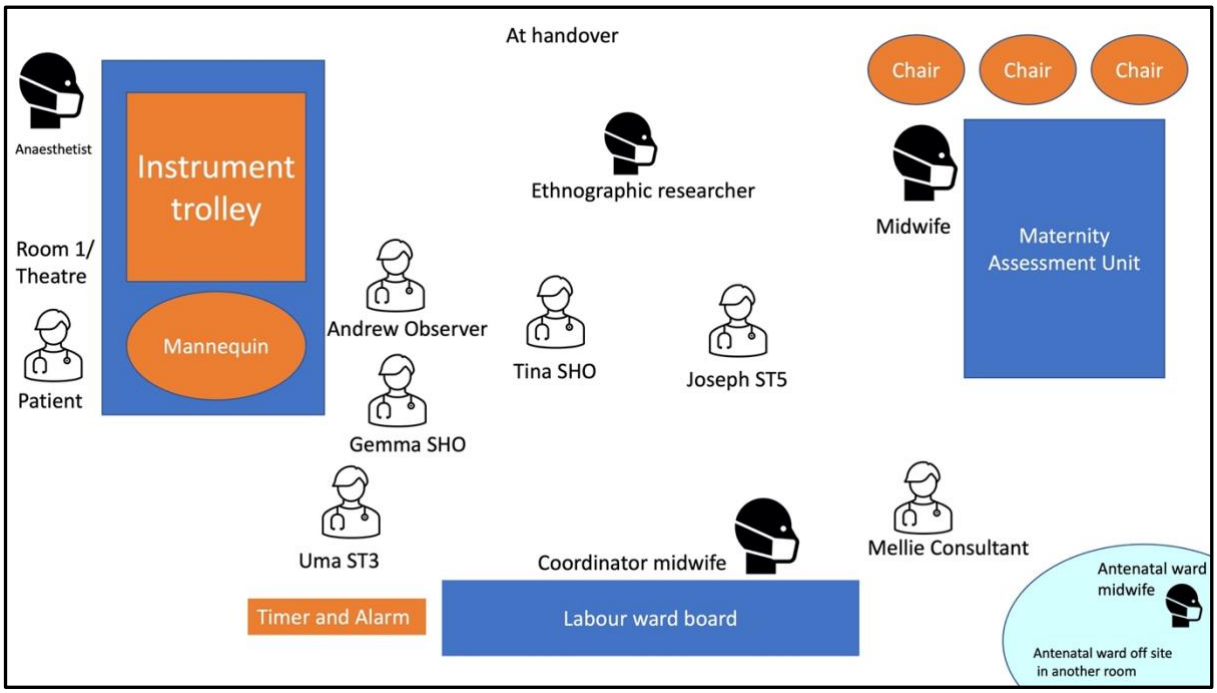


Figure 16 Group 1, positions assumed by participants and faculty at the start of the start of the simulation during the 8 am handover at the labour ward board. Abbreviations: SHO- Senior House Officer, ST- Specialist trainee year

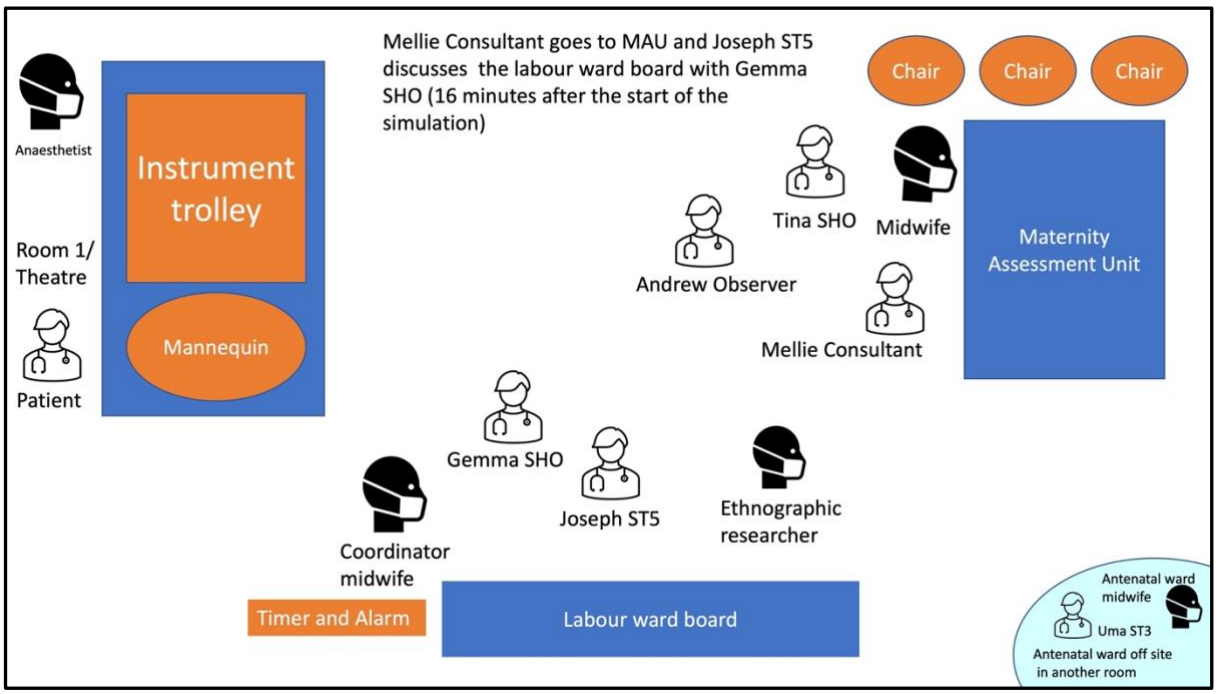


Figure 17 Tracking the movements of group 1- 16 minutes after the simulation had started. The Antenatal ward round was being conducted by Uma in another room. Room 1 had been assessed by Joseph and decision had been made for trial of instrumental delivery in theatre. Joseph had returned to the labour ward board to catch up with Gemma and the coordinator midwife regarding the plans made for the other patients on labour ward on the ward round. Abbreviations: MAU- Maternity Assessment Unit, SHO- Senior House Officer, ST- Specialist Trainee Year

Objective One: Trainees perceived preparedness and readiness to perform technical and non-technical skills in the simulation

A) Uncertainty and hesitation during unfamiliar or higher-pressure tasks

Across both groups, trainees demonstrated notable uncertainty when undertaking tasks that were either unfamiliar or carried significant perceived responsibility, particularly obtaining consent for the rotational instrumental birth and conducting the antenatal ward round. These tasks required independent clinical reasoning, specific knowledge, patient communication, and decision-making, which several trainees reported (and demonstrated) as areas where they felt underprepared.

Ethnographic and faculty field notes recorded visible signs of nervousness, including hesitant speech, reduced eye contact, and uncertain body language:

"Uncertainty was present about certain situations that required further review of guidelines. Was calm and thinking things through."

-Antenatal midwife, observation in the research diary

During the antenatal ward round, there were issues with escalation of a deteriorating patient, highlighting an area where the expected non-technical skill of communication was not performed. In one instance, two different trainees were aware of a deteriorating pre-eclamptic patient, yet this concern was not communicated to the consultant:

"Antenatal ward was neglected… SHO was sent eventually after some time but forgot to catch up with the consultant about what was going on there."

- *Antenatal midwife, during focus group interaction*

This lapse was further highlighted in a dialogue between the antenatal midwife and Justina:

Midwife: "Did you feedback about the unwell patient on antenatal ward?"

Justina: "I went to Hana, but she was still in theatres and didn't get a chance."

Midwife: "That's something even Hana didn't communicate back… there was a patient on the ward who was quite unwell. Two people took rounds, but that information wasn't communicated…"

-Conversation between antenatal ward midwife and Justina during the focus group interaction

Trainees openly acknowledged this uncertainty:

".. I learnt that I didn't know a huge amount.. There was a lady with severe pre-eclampsia that was getting worse and just trying to make plans about when you are going to deliver people is actually quite a tough call. And unless you know what you are doing I guess"

Uma, discussed their experience of conducting an antenatal ward round for the first time (focus group interview)

B) Challenges communicating risk and procedures to patients

Both groups showed uncertainty when discussing the instrumental birth and obtaining consent. For some trainees, the challenge was using patient-friendly language:

"Discussion on forceps sounds very robotic. Found it difficult to use patient friendly language to talk. Maybe she has never done this before?"

- *Ethnographic researcher, observation in the research diary of Catherine*

For others, the issue was overloading the patient with technical detail, contributing to visible anxiety:

"The discussion about complications made the patient more and more anxious and this was not picked up… it was like he was trying to remember the complications rather than having a conversation."

- *Ethnographic researcher, observation in the research diary of Joseph*

These observations indicate that while trainees understood the steps of the procedure, their readiness to communicate complex information empathetically and clearly was still developing.

Objective Two: Features of the simulation that facilitate or hinder learning of technical and non-technical skills

A) Realistic simulation conditions exposed integration challenges of technical and non-technical skills

Trainees generally demonstrated competence with procedural steps when performing rotational instrumental birth, drawing on prior simulation and clinical experience. However, the theatre environment, team communication, and concurrent cognitive demands introduced authentic complexity. This complexity exposed areas where technical steps were known, but fluency was disrupted by stress, attention-splitting, and communication burden:

"Joseph ST5is the clear leader in charge of the procedure in theatre. Displayed body language that showed medium level of stress (probably appropriate considering this is a rotational delivery). In theatre, a relaxed atmosphere, friendly attitude was maintained."

- *Ethnographic researcher, observation in the research diary of Joseph in theatre during the rotational delivery*

"Hana ST5 appeared diffident, and this showed in the body language and communication with the theatre team and patient. The steps of the procedure was performed accurately."

- *Ethnographic researcher, observation in the research diary of Hana in theatre during the rotational delivery*

Hana later reflected that the unfamiliar setting heightened challenge:

"If it had been in a room, I would have been able to trick myself… but because it was so different, in theatre…"

- *Hana (ST5), during the focus group interaction, reflecting on her experience performing an instrumental delivery in a theatre which she has never done in real life before.*

Similarly, the labour ward round required trainees to integrate knowledge with decision-making, communication, and prioritisation. This integration was variably successful and depended heavily on how tasks were allocated:

"Examine her and check she is on the correct antibiotics, fluids and septic screen results…"

- *Mellie to the coordinator midwife during the simulation, from the audio transcript*

"Would you be able to liaise with Hana ST5… it's something she would like to do…"

- *Daisy to Catherine after assessment of room 1 regarding the trial of instrumental delivery in theatre, from the audio transcript*

These interactions show trainees practising realistic integration of non-technical skills with technical skills.

B) Emotional and cognitive load shaped performance

A particularly illustrative pattern occurred immediately after delivery during the theatre procedures. Trainees' emotional relief and increased confidence were consistently observed once the baby was delivered:

"The body language visibly relaxes… Joseph smiles… chattier."

- *Observations of the ethnographic researcher about the change in body language of Joseph immediately after the delivery of the baby*

Daisy remarked on feeling comfortable delegating to Hana:

"I find I am willing to trust my colleagues… I let her deal with whatever tears and postpartum haemorrhage (PPH)."

- *Reflection of Daisy about task delegation in theatre, focus group interaction*

C) Familiar skills enabled smoother performance and confidence

Episiotomy repair was consistently performed with confidence, reflecting greater familiarity:

"When you started suturing, you looked super confident… you knew how to do it very well."

- *Discussion between the ethnographic researcher and Joseph, focus group interaction*

Joseph agreed:

"Suddenly I felt like I could relax now."

- *Reflection made by Joseph ST5 about the relief he felt when he was repairing the episiotomy*

A trainee observer also described how familiarity shapes concentration:

"During the suturing… you have to be present in the moment… but also aware of what's going on outside."

- *Statement by the observer from group 2 during the focus group interaction about the relationship between performing the technical skill of suturing that is familiar with the situational awareness required when in theatre and on call on labour ward*

Similarly, managing unwell patients in MAU reflected real-world experience:

"Consultant was unsure of AFLP initially, but correctly identified patient was very sick…"

- *Observation by ethnographer, research diary*

"We're thinking she has Acute Fatty Liver of Pregnancy… we've stabilised her and sent off bloods."

- *Catherine to the coordinator midwife regarding management of the patient with AFLP, audit transcript of the simulation*

These examples show that familiar clinical contexts supported confidence, whereas unfamiliar tasks created opportunities for learning.

Objective Three: Feasibility and acceptability of running this combined simulation within routine regional training

A) Simulation supported realistic experiential learning

Across both groups, trainees reported that the simulation felt realistic in terms of workload pressure, team dynamics, multitasking, and role negotiation.

"It's nice to do a trial run as a team… you're not going to be all by yourself. It takes the pressure off."

- *Mellie, reflecting on her experience during the simulation, focus group interaction*

"Board round felt more realistic… we do that all the time."

- *Mellie, reflecting on her experience during the simulation, focus group interaction*

Although some elements felt artificial, this did not detract from learning:

"Theatre felt more artificial but still valuable."

- *Mellie, reflecting on her experience during the simulation, focus group interaction*

B) The simulation encouraged reflective behaviour and mental rehearsal

Many trainees reported that the simulation prompted reflection on how they would behave in real practice:

"I guess that conversation we just had about mental rehearsal but reemphasising that. If you had asked me this morning what is an important thing to do before we go into theatre, I would have hopefully said mentally rehearse everything, but I still didn't do it. And so, re-emphasising that."

- *Reflection by Joseph about the benefit of practising the steps of the procedure in simulation and mentally rehearsing it in real life, focus group interaction*

Others described adaptive learning:

"I felt that as it went on it felt more real. But that might have been because I just relaxed more. And then you sort of go with it."

- *Uma, who felt it became easier to suspend disbelief and participate in the simulation as it progressed, focus group interaction*

C) The simulation supported safe exploration and practice beyond usual roles

Participants valued having space to attempt tasks they would not yet perform independently in real life:

"I felt more comfortable doing things in simulation than in real life… I could take my time and discuss things."

- *Catherine reflected on her experience during the simulation, focus group interaction*

Justina (ST1), who took on an ST3-level antenatal ward round, described the simulation as enabling safe experimentation:

"I thought because it doesn't feel a 100% real it was a good thing cause otherwise you would be so panicked and stressed that you wouldn't be able to explore. Like in a real-life situation if someone asked you to go and do an antenatal ward round. I can try and, but I wouldn't be making any decisions but here I felt like I was able to just push myself and see cause nothing bad is going to happen and no one is going to die. So that's kind of a good thing. I definitely felt that.. A part of it is to have a plan in your mind if you have to do it again, you have already done it before. Like now I'll know what my first step is."

- *Justyna, reflecting on her experience performing the antenatal ward round in the simulation, focus group interaction*

These reflections reinforce the feasibility and perceived value of delivering combined technical–non-technical simulations within routine training.

Discussion

Evidence supports the use of simulation to teach technical skills and non-technical skills in obstetrics (542-545). The rapid ethnographic study presented in this chapter aligns with evidence from the wider literature and supports combining technical and non-technical skills within a single simulation session to enhance the training experience. This echoes findings from multidisciplinary simulation research showing that integrated team and technical practice improves performance, confidence and communication(181, 546-548)

The trainees in this study valued the opportunity to practise both technical and non-technical skills in one simulation because it offered a realistic, whole task learning environment, mirroring the complexity of clinical practice. This is consistent with the theory of whole-task training and cognitive load considerations described by van Merriënboer & Kirschner, where integrated tasks support the development of schema used in real practice (549, 550).

Additional to the use of combined technical and non-technical skills simulation, this study used rapid ethnography which is a relatively new approach for educational research in surgery (533, 551). Unlike the other qualitative and quantitative methodologies, I considered, rapid ethnography allowed me to observe and document trainees' experiences from various perspectives simultaneously and in real time as the simulation unfolded. Rapid ethnography lends itself to being used for observing and interpreting behaviour and experiences in a wide range of educational settings, both real and simulated. Subtle details, such as facial expression and body language which might otherwise go unnoticed, were captured during the study. This strength of the methodological approach I have chosen reflects the established value of ethnographic approaches for capturing micro-behaviours and contextual cues in complex clinical environments (541, 552).

The simulation presented in this study diverged from the traditionally offered simulation training in obstetrics which typically focuses on either technical skill development or non-technical skills team based training (553, 554).

Given limited time available for trainees to engage in educational activities, including simulation, within their training programmes, innovative strategies are required to maximise the learning opportunities from each session (555). Previous approaches discussed in literature include the introduction of simulation curricula which integrate technical and non-technical skills training, practising these skills in a simulated theatre environment, introduction of a surgical task during a non-technical skills simulation and the introduction of crisis resource management for anaesthetists (556-561). The current findings support this direction of travel by showing that integrated practice reflects the cognitive, emotional and team complexity described in crisis resource management literature(519, 562-564). This study adds to that evidence by demonstrating that multiple linked tasks; labour board management, ward rounds and theatre procedures, can be delivered in one cohesive session using low-technology equipment, suggesting feasibility for routine use. It is important to emphasise that the study reports behavioural observations and trainee self-reported experience; it did not include objective performance measurement tools or validated competency scores. Therefore, claims about skill development are limited to perceived readiness, observed fluency of tasks and behaviours rather than measured improvements in technical competence.

An important consideration when adapting this simulation model is to consider the experience level of the participants. Simulation scenarios should include some tasks with which trainees are familiar and confident, and others that challenge them but not so far beyond their capabilities as to overwhelm them. In this study, tasks familiar to trainees (e.g., episiotomy repair) were performed fluently, while more complex, decision-heavy tasks (e.g., antenatal ward rounds, consenting for instrumental birth) triggered hesitancy or required prompting, consistent with how novices manage complex tasks which require a higher cognitive load. This aligns with principles from instructional

design and cognitive load theory: complex, integrated tasks benefit from prior exposure and gradual scaffolding of learning demands (565, 566).

For trainees to progress from initial, knowledge-based performance to more integrated and fluid skill performance, prior exposure to the technical steps (through part-task practice or previous simulation) is required so that the technical routine can be integrated with the non-technical demands of leadership, communication and situational awareness. The level of difficulty in combined simulations should therefore slightly exceed trainees' current capabilities but stop short of overwhelming them, to support optimal learning. This is consistent with established guidance for complex skill training in healthcare simulation(567, 568).

The scope to adapt this simulation is considerable. Immediate application would be to incorporate this simulation as a routine offering to all O&G trainees for both obstetric and gynaecological scenarios. Additionally, the stimulation can be used to help trainees who are to step up into senior roles (i.e., ST2 trainees stepping up to ST3 registrar role, ST5 trainees stepping up into the ST6 senior registrar role and ST7 trainees stepping up into consultant roles) as it provides a realistic environment to practise technical skills whilst delegating, maintaining situational awareness etc in a complex on call environment. This type of simulation could be used to support those returning to training after a career break (after maternity leave, research break, illness, etc.) as one session could deliver multiple learning opportunities in a structured but flexible format. Finally, beyond obstetrics, similar simulation programmes should be incorporated in all surgical subspecialities. Recent consensus and reviews emphasise that all healthcare professionals require both technical and non-technical skills training, and integrated simulation represents a promising, resource-efficient method to address this (569).

Study Limitations

By capturing and reporting the experience of one group of O&G trainees of a similar level of experience at a singular point in time, the generalisability of the findings could be affected. The choice to invite this particular cohort of trainees in O&G has been explained previously in the study and was carefully balanced with the potential impact on generalisability.

The faculty who were involved in the development and the facilitation of the simulation were experienced obstetricians frequently involved with simulation training, had educational qualifications and were specifically trained on using the NOTSS tool. Their previous experiences could introduce a potential for bias and could have influenced their recorded data in the research diaries. Since we were aware of this potential introduction of bias, we accounted for its impact by frequent discussions during the process of data analysis to critique the analysis as well as the involvement of my supervisors to provide an outsider's perspective as they had no obstetric knowledge (though they were experts in simulation and education).

O&G trainees are accustomed to participating in simulation training that addresses technical and non-technical skills separately, which differs from practice in many other surgical subspecialties. Consequently, additional trainee preparation- specifically the introduction of routine non-technical skills training- should be planned prior to the implementation of combined technical and non-technical skills simulation for other surgical subspecialities.

I was also mindful of the potential psychological impact associated with asking trainees to step outside their usual day-to-day clinical roles. To mitigate this, I worked closely with the faculty and research team to ensure that the clinical scenarios were pitched at a level of knowledge and technical competence appropriate for an ST2 trainee. In addition, the pre-brief and debrief were deliberately designed, in collaboration with faculty, to explicitly address the roles trainees would adopt during the scenarios. This included preparing participants for the expectation that ST2 trainees would be

'playing' more senior roles, such as that of the consultant. Role allocation was structured accordingly: ST2 trainees assumed the senior roles of consultant and registrar, while ST1 trainees undertook supporting roles, including observer, patient, and SHO. This approach aimed to support psychological safety while enabling meaningful engagement with the intended learning objectives.

Another limitation is the absence of MDT representation within this version of the simulation. This is important because the absence of MDT participants or faculty means the findings about team dynamics are limited to trainee- obstetric faculty interactions and do not capture how actual MDT members would respond. In the future however, an easy adjustment to would be to involve the obstetric MDT in the planning, as participants and as faculty of the simulation. For example, the roles of the midwife coordinating labour ward, antenatal ward midwife and MAU midwife within the simulation could be played by midwifery staff with simulation experience.

Conclusion

This rapid ethnographic study showed that combined technical and non-technical simulation is a feasible and acceptable approach for ST1-ST2 obstetric trainees and that it offers clear educational value: trainees demonstrated greater readiness and fluency on familiar technical tasks but showed hesitation and reliance on prompting for complex decision-making, consenting, and escalation tasks, indicating that readiness to integrate technical and non-technical skills remains developing; the simulation's realistic workload, role negotiation and concurrent task demands revealed both facilitators and barriers of learning and the format proved practicable within routine regional training using low-fidelity resources and existing faculty, providing multiple learning opportunities in one session without undue burden. The study demonstrated that integrated simulation exposes important readiness gaps while supporting experiential learning and can be scaled or adapted for wider training needs, though future iterations should include clearer role allocation, escalation pathways and MDT involvement to maximise learning.

Part IV: Discussion

Chapter Nine: Discussion, limitations, conclusions, and implications for practice and research

This thesis examined the challenges associated with technical skills surgical training and addressed the question of how simulation-based technical skills training can be meaningfully implemented within postgraduate surgical education. Specifically, it explored the barriers and facilitators to the effective use of simulation and evaluated strategies for embedding simulation into routine surgical training in a way that aligns with existing educational structures and service constraints, with a particular focus on trainees' perspectives on factors that encourage or discourage engagement with simulation alongside regular clinical training.

This chapter synthesises the insights from the exploratory and empirical components of the thesis. It integrates findings from the review of surgical curricula, the two systematic reviews (including the updated review examining surgical training during the COVID-19 pandemic), the identification of barriers to simulation implementation, and the empirical exploration of simulation interventions, in order to provide a coherent interpretation of how simulation can support technical skills development in contemporary surgical training.

The thesis was structured in four parts. The first part examined the historical evolution of surgical training and identified systemic changes that have adversely affected opportunities for technical skills acquisition. It also outlined the methodological approach and my positionality, providing a rationale for the qualitative and interpretivist design adopted. The second part established gaps in the existing literature and curricula regarding the implementation of simulation for technical skills training, highlighting structural and organisational barriers that limit its routine use. The third part presented two empirical studies in which simulation was incorporated into routine training and explored through trainees' experiences. The final part brings these strands together, placing the

findings within the wider educational literature and critically considering their limitations, conclusions and implications for practice, policy and future research.

Taken together, the findings of this thesis demonstrate that while simulation is an evidence-based and effective adjunct for surgical technical skills training, its inconsistent and ad hoc implementation limits its educational impact(240, 570, 571). Evidence suggests that simulation used alongside traditional surgical training is more effective than traditional training alone; however, the challenge lies not in demonstrating efficacy, but in achieving sustainable and meaningful integration into postgraduate training programmes(112, 570). These considerations informed the overarching research question underpinning this thesis: How can simulation-based technical skills training be implemented for postgraduate surgical trainees?

Discussion

The COVID-19 pandemic acted as a catalyst for the re-evaluation of surgical training, although many challenges in surgical technical skills training predated the pandemic(2).The post-COVID period presented an opportunity to reconsider how surgical training might be structured and delivered; however, the optimal way forward was not immediately clear. There was uncertainty among key stakeholders, including surgical educators, education researchers and trainees, regarding how best to balance service provision with training needs. Any restructuring of surgical training must therefore consider the constraints identified in the exploratory work presented in Part II of this thesis, including findings from the curricula review, the two systematic reviews and the literature review of barriers to the use of simulation.

Proposed model of technical skills training in surgical subspecialities using findings from Chapters Three, Four, Six, Seven and Eight

Learning technical skills in surgery is a continuous and progressive process that has traditionally relied heavily on access to the operating theatre. However, the operating theatre does not always

provide an optimal learning environment for the acquisition of new technical skills. Time pressures to complete procedures efficiently, variable availability of senior supervision, service demands that limit protected training time, and unstructured learning opportunities all influence the quality and consistency of technical skills development(176, 572, 573). From an educational perspective, the use of simulation to support surgical technical skills learning is not a new concept. Historical accounts describe the use of organic materials and cadaveric dissection for skills acquisition as early as 600 BCE in Sushruta's surgical training practices (574, 575).

Contemporary evidence similarly supports simulation as an effective adjunct for technical skills training when used consistently and within the scope for which it was designed, namely as a complement to real-world operating rather than a replacement for it (240, 576).Despite this longstanding history and evidence base, findings from this thesis and the wider literature indicate that simulation continues to be used inconsistently and often opportunistically within postgraduate surgical training(240, 577).Given these constraints, it is prudent to explore opportunities for technical skills training outside of the operating theatre that are intentionally planned and proactively integrated to enhance, rather than replace, learning within the clinical environment(240).

The findings from Chapter Four highlighted the importance of adopting a multimodal and structured approach to technical skills training, moving away from reliance on a single mode of learning. From an educational standpoint, the acquisition of surgical technical skills requires repeated practice, timely feedback and opportunities for consolidation. Simulation training on its own is insufficient to produce competent surgeons; however, viewing simulation as isolated or one-off events limits its educational value and fails to support longitudinal skill development (240, 577).Moreover, simulation requires deliberate planning and appropriate use of available resources, including faculty time and infrastructure. Inconsistent utilisation risks under-realising the educational potential of simulation programmes and contributes to variability in training experiences. From a financial perspective, providing technical skills simulation requires investment in resources: equipment, faculty, and infrastructure. Under using these resources by providing infrequent

simulation training sessions is not cost-effective and does not realise the full potential of simulation-based education(578).

Using the findings from Chapters Three, Four, Six, Seven and Eight, a model for surgical technical skills training is proposed (Figure 18).This model presents a holistic approach to technical skills development, recognising that knowledge, technical skills and non-technical skills are interdependent components of surgical competence. Knowledge forms the foundation upon which all surgical skills are built and may be acquired through multiple sources, including formal teaching, self-directed learning, examination preparation, guideline review, journal clubs and study groups, as reflected in the surgical curricula reviewed in Chapter Three (146-155, 160).

Technical skills should be developed through a combination of in-theatre and out-of-theatre learning opportunities (93, 579, 580). Within the operating theatre, learning typically occurs under direct supervision, beginning with simpler procedures or components of procedures and progressing towards more complex tasks through instructional scaffolding over the course of training (581, 582). The scope of procedures undertaken is determined by the requirements of the relevant specialty curriculum (583).

Simulation provides structured opportunities to develop technical skills outside of the operating theatre and can be delivered across a range of settings, including informal self-directed practice, bespoke courses, and locally, regionally or nationally organised programmes(584, 585). Simulation encompasses a wide range of modalities, from low-technology solutions such as box trainers and simple organic models to higher-fidelity options including VR, AR, low/mid/ high fidelity models, cadaveric and animal tissue simulation(585, 586).

A key feature of the proposed model is the scheduled and protected use of simulation, analogous to operating theatre sessions. Evidence suggests that unrestricted access to simulation alone is insufficient to promote meaningful engagement; rather, integrating simulation into rotas and formal

training schedules is more likely to encourage regular use(443, 478). For example, monthly scheduled simulation sessions have been reported as beneficial in orthopaedic training (587). Embedding simulation within training structures signals its educational value to trainers, trainees and the management, supporting sustained engagement.

Within this model, simulation and operating theatre experience should be used in a cyclical and complementary manner. Simulation allows trainees to practise and refine technical skills in a controlled environment, helping to flatten learning curves before clinical application. Subsequent operating theatre experience then enables trainees to contextualise and further develop these skills, addressing procedural nuances and complexity. Simulation may also be used to target specific technical challenges or less frequently encountered skills. While similar complementary approaches have been advocated in the literature, routine implementation within everyday surgical training remains limited (240, 588-591).

As highlighted by trainees in Chapter Seven, the attitudes and practices of trainees and educators play a critical role in reinforcing the value of simulation. Viewing simulation as an extension of operating theatre teaching, rather than as a separate or optional activity, may help integrate simulation more effectively into training. Explicit discussion of learning objectives that can be addressed through simulation, alongside clinical targets, may further support continuity between simulated and real-world learning environments. Notably, the literature reviews undertaken in this thesis identified limited research exploring the impact of such integrated educational attitudes on surgical technical skills development, representing an area for further investigation.

Integration of technical and non-technical skills, based on the findings from Chapter Eight

The practice of surgery requires the integration of both technical and non-technical skills. Non-technical skills, including communication, teamwork, situational awareness and decision-making, are essential for patient safety and effective functioning within healthcare teams and should therefore be given equal consideration when planning surgical training (592, 593). In the proposed training model (Figure 18), non-technical skills training is included alongside technical skills development, with opportunities for learning both within and outside of the operating theatre. While a detailed exploration of non-technical skills training is beyond the scope of this thesis, the findings presented here recognise that both technical and non-technical skills are fundamental to competent surgical practice.

Further development of trainees' skills should include opportunities to combine technical and non-technical skills training within the same educational activity. As explored in Chapter Eight, simulation offers a valuable environment in which technical skills can be practised alongside non-technical skills, particularly during later stages of skill development where integration and automatisation are required (482). Providing opportunities for trainees to rehearse technical procedures while simultaneously managing communication, leadership and decision-making demands reflects the realities of surgical practice and may enhance transfer of learning to the clinical environment.

Surgical curricula redesign to explicitly implement simulation, based on findings from Chapter Three

The curricula review presented in this thesis revealed limited explicit guidance for educators and trainees on how technical skills training should be delivered using simulation. This lack of direction creates the potential for inequity in training experiences and suboptimal use of available simulation

resources. While surgical curricula typically provide comprehensive lists of technical skills that trainees are expected to acquire, they offer comparatively little guidance on how these skills might be developed across different learning environments.

The findings of this thesis suggest that modification of curricular approaches to technical skills training is required. In addition to defining *what* skills trainees should acquire, curricula should provide explicit guidance on *how* simulation may be used alongside clinical training to support skill development. Intentional curricular signposting may also support consistency across training sites and help educators and trainees plan training more effectively.

When implementing simulation at a curricular level, each curriculum should consider including:

- a list of relevant simulation courses aligned to curriculum requirements
- examples of simulation modalities that may be used to support regional teaching
- simulation options suitable for trainee self-directed or home-based practice
- guidance for local educators on planning short, frequent simulation sessions integrated into routine training, including advice on the training faculty need to undertake to provide simulation training.

An example of this approach is provided in Table 28 which presents a modified version of a technical skills table from the paediatric surgery curriculum reviewed in Chapter Three. The table has been adapted to prompt educators and trainees to consider three complementary avenues for skills development: learning in a clinical environment, learning in a simulated environment and learning from other sources (152). Depending on the specific skill, other sources may include courses, reviewing surgical videos, structured discussion with supervisors and peers, and self-directed study.

By explicitly embedding simulation within curricular documentation, educators and trainees are supported to plan training more deliberately, reducing reliance on opportunistic exposure and increasing the likelihood that simulation is used strategically to complement clinical experience.

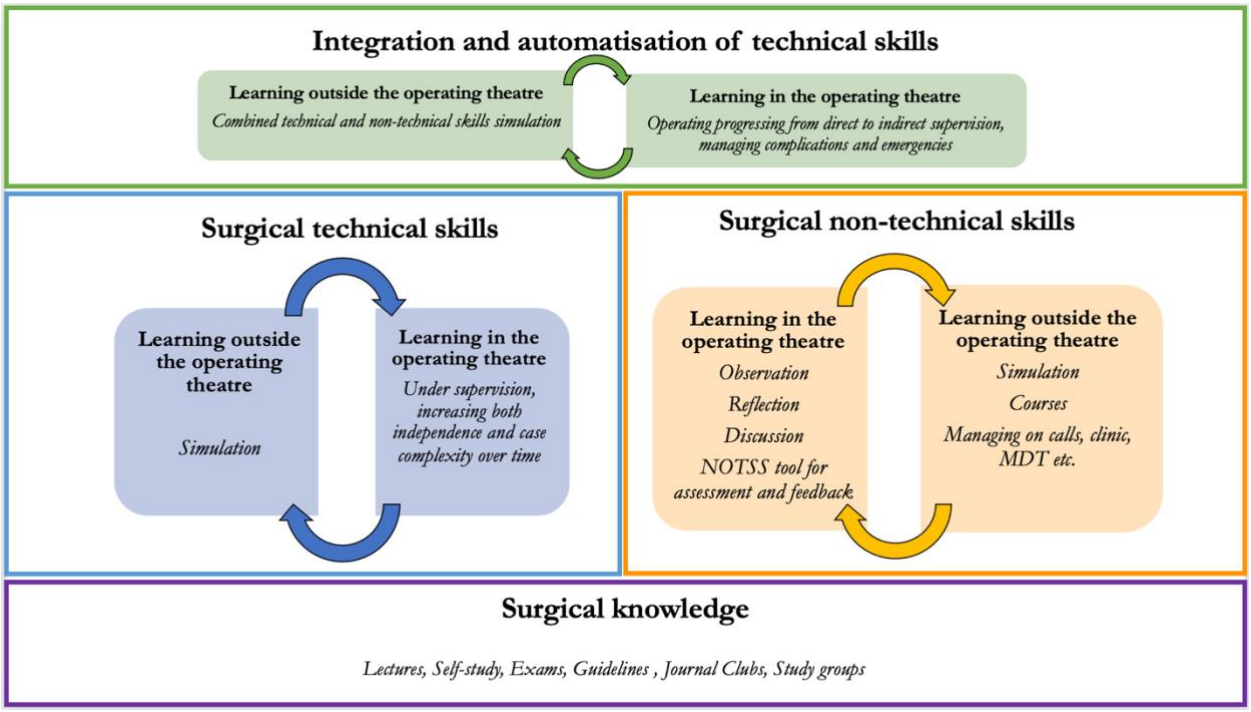


Figure 18 Proposed surgical training model with the implementation of simulation with surgical training. The model emphasises the continuous acquisition of surgical knowledge throughout training which forms the foundation of surgical training. Knowledge is learnt from various sources, including lectures, self-study, preparing for and taking exams, reading guidelines, participating in journal clubs and study groups. Trainees should have the opportunity to learn technical and non-technical skills both in the operating theatre as well as outside of the operating theatre. The model recognises that technical and non-technical skills should be learnt separately in some contexts but also practised together at other times, where technical and non-technical skills can be integrated together. Abbreviations: MDT- Multidisciplinary Team, NOTSS- Non-Technical Skills for Surgeons

Topic	**Head and neck swellings**	**Learning in a clinical environment**	**Learning in a simulated environment**	**Other sources of learning**
Category	General surgery of childhood			
Sub-category:	Management of benign surgical conditions			
Objective	-To be able to assess a child presenting to the outpatient clinic or acutely with a head/neck swelling as the primary presenting symptom To be able to formulate a differential diagnosis and an investigation and management plan -To be able to treat the child appropriately up to and including operative intervention if required -To be able to communicate the above information at the required level to patients/ parents/patients/ parents/another team members/ referral source	*CBD* *Mini CEX*	*-OSCE simulation* *- Role play, observed counselling of actors playing parents* *-Combined simulation of technical and non-technical skills of an on call*	*E-learning on paediatric head and neck swellings*

Topic	**Head and neck swellings**	**Learning in a clinical environment**	**Learning in a simulated environment**	**Other sources of learning**
Knowledge	Patterns of symptoms and relation to likely pathology, relevant anatomy, and age of child Relevance of embryonic development of head and neck structures Differential diagnosis Place and value of investigations	*-CBD* *-Workplace discussions*	*- Combined simulation of technical and non-technical skills of an on call* *- Use of VR simulation to support the recognition and assessment of abnormal anatomy*	*-E learning* *-Exam preparation* *- Self study* *- Journal Clubs*
Clinical Skills	Ability to assess child Ability to form a viable investigation and treatment plan Ability to communicate with all relevant groups	*-Mini CEX* *-CBD*	*-Part task simulation* *- OSCE simulation* *-Role Play*	*- Exam preparation*

Topic	**Head and neck swellings**	**Learning in a clinical environment**	**Learning in a simulated environment**	**Other sources of learning**
Technical Skills and Procedures	ST5 and 6: Excision skin lesion Excision/biopsy of lymph nodes Surgery for thyroglossal cyst Surgery for branchial cysts and branchial remnants ST7 and 8: Excision skin lesion Excision/biopsy of lymph nodes Surgery for thyroglossal cyst Surgery for branchial cysts and branchial remnants	*-Formative OSATS progressing to summative OSATS*	*- Low fidelity part task simulation* *-Technical skills simulation courses using silicon part task trainers, animal models or cadaveric models* *- Combined simulation of technical and non-technical skills with the procedure/s as the technical skills +/- management of a complication*	*-Review of surgical videos and discussion with trainer or peers* *-Self-study of steps of the operation, anatomical knowledge, procedure complications etc.*

Table 28 Modified technical skills table from the paediatric surgery curriculum presented in Chapter Three. The table has been modified to direct educators and trainees who use the curriculum to consider avenues of technical skills training in three categories: learning in a clinical environment (e.g., in the operating theatre), in a simulated environment and from other sources (e.g., acquiring knowledge)(152). Abbreviations: CBD- Case Based Discussion, CEX- Clinical Evaluation Exercise, OSATS- Observed Structured Assessment of Technical Skills, OSCE- Observed Structured Clinical Examination, ST- Specialist Training Year, VR- Virtual Reality

Integration of simulation into the ARCP process, based on findings from Chapter Seven

The ARCP process (or similar individual standardised evaluation of training progression) is an important annual landmark in the training year in the NHS and acts as both an assessment to verify that the trainee is making expected progress but also acts as a pastoral checkpoint (594, 595). As presented in Chapter Seven, incorporating discussion of simulation engagement into the ARCP process, alongside the setting of individualised engagement targets, emerged as a strong motivating factor for trainees.

Importantly, this approach does not require simulation engagement to be narrowly defined or standardised. Trainees should be able to demonstrate engagement with simulation using a broad range of modalities appropriate to their learning needs, including self-directed practice, participation in organised simulation sessions, and the use of simulation to teach junior colleagues. Allowing such flexibility recognises the diversity of training contexts and promotes trainee autonomy in selecting learning strategies that best support their technical skills development. The findings suggest that the motivational impact of ARCP-linked simulation review lies not in assessment or enforcement, but in prompting reflection and prioritisation. Setting individualised targets (without associated penalties if engagement targets are not achieved) encourages trainees to view simulation as an accessible and legitimate training resource, rather than an additional burden. Caution, however, should be exercised when framing this intervention as without care it could be viewed by trainees as another burden, another tick box exercise or another source of criticism of their engagement with their technical skills training. This aligns with the broader educational role of ARCP as a structured opportunity for reflective discussion and forward planning.

Emerging evidence supports the feasibility of integrating simulation into formal training structures. Shah et al. (2023) reported positive experiences among both trainees and faculty following the integration of simulation into early years surgical training in Scotland (480). However, the literature

identified in this thesis did not reveal studies in which simulation engagement was explicitly incorporated into ARCP processes, either formally or informally. This represents an important gap in the evidence base and highlights the need for further longitudinal evaluation of the educational impact, acceptability and sustainability of linking simulation engagement to ARCP discussions.

Innovation to implement simulation: A pragmatic approach to improving use based on the findings from Chapters Six, Seven and Eight

A) Pragmatic interventions to support simulation engagement in surgical training

Several pragmatic interventions to support simulation engagement were identified in Chapter Seven. These included:

- encouraging exposure to simulation from early in training
- emphasising periodic engagement with simulation, even where frequent use is not feasible
- setting individualised targets for both simulation-based and clinical technical skills development
- incorporating discussion of simulation engagement within ARCP processes
- supporting trainees to develop skills in teaching using simulation
- Building explicit opportunities for regular simulation-based education into the timetables of trainees

These findings suggest that meaningful improvements in simulation use can be achieved through targeted modifications to existing training structures, rather than through large-scale infrastructural change. The interventions described do not require the creation of new simulation centres or wholesale redesign of training programmes; instead, they rely on intentional use of existing resources and formal training processes. Importantly, they also recognise the competing demands on trainee and faculty time and seek to embed simulation within established educational workflows. While these interventions may appear modest in isolation, their cumulative effect may be substantial when

implemented consistently. By legitimising simulation as a routine component of training, reinforcing its value through formal structures such as ARCP, and encouraging early and sustained engagement, these approaches address several of the barriers to simulation use identified in the exploratory phases of this thesis (Chapter Six).

B) Choice of simulator

Surgical trainees across subspecialties are required to develop competence in a wide range of technical procedures. Although the literature demonstrates that simulation used alongside traditional training is superior to traditional training alone, there is insufficient evidence to suggest clear superiority of one simulation modality over another for many technical skills, with several modalities demonstrating broadly equivalent educational efficacy (76, 78, 596, 597).

As a result, decisions regarding simulator selection should be guided by educational purpose, trainee needs and contextual factors, rather than assumptions of inherent superiority. Educators and training programme directors should consider the specific features, advantages and limitations of available simulators when planning investment in simulation resources (598).

Figure 19 provides an illustrative example focused on laparoscopic surgery, informed by findings from Chapter Seven and supported by existing evidence(76, 599-602). Commonly available simulators for laparoscopic training include low/mid/high fidelity models including box trainers, VR simulators, AR simulators, and animal or cadaveric models. All of these modalities can support the development of core laparoscopic skills such as hand-eye coordination, ambidexterity and economy of movement; however, their suitability varies depending on training objectives and trainee stage.

For example, VR simulators offer a wide range of basic exercises and simulated procedures, allowing repeated practice without reliance on physical consumables. These features may be particularly advantageous for junior trainees early in training(600, 601). However, current VR platforms may have limited capacity to support suturing skills. In contrast, AR simulators and box trainers allow

trainees to practise laparoscopic suturing but require ongoing provision of physical materials and maintenance (599, 601). Animal and cadaveric models provide high-fidelity experiences that closely approximate operative conditions, but access is often limited and their use is typically confined to structured course settings (602).

When selecting simulators, educators should therefore align modality choice with trainee learning needs, curriculum requirements and local constraints. For example, training programmes with large cohorts of junior trainees may prioritise simulators that support early skills acquisition across a broad user base, whereas programmes focusing on more advanced trainees may prioritise modalities that support suturing and complex procedural rehearsal. At a regional or deanery level, a distributed approach in which different hospitals host different simulator types may enable trainees to gain exposure to a range of modalities as they rotate through training sites.

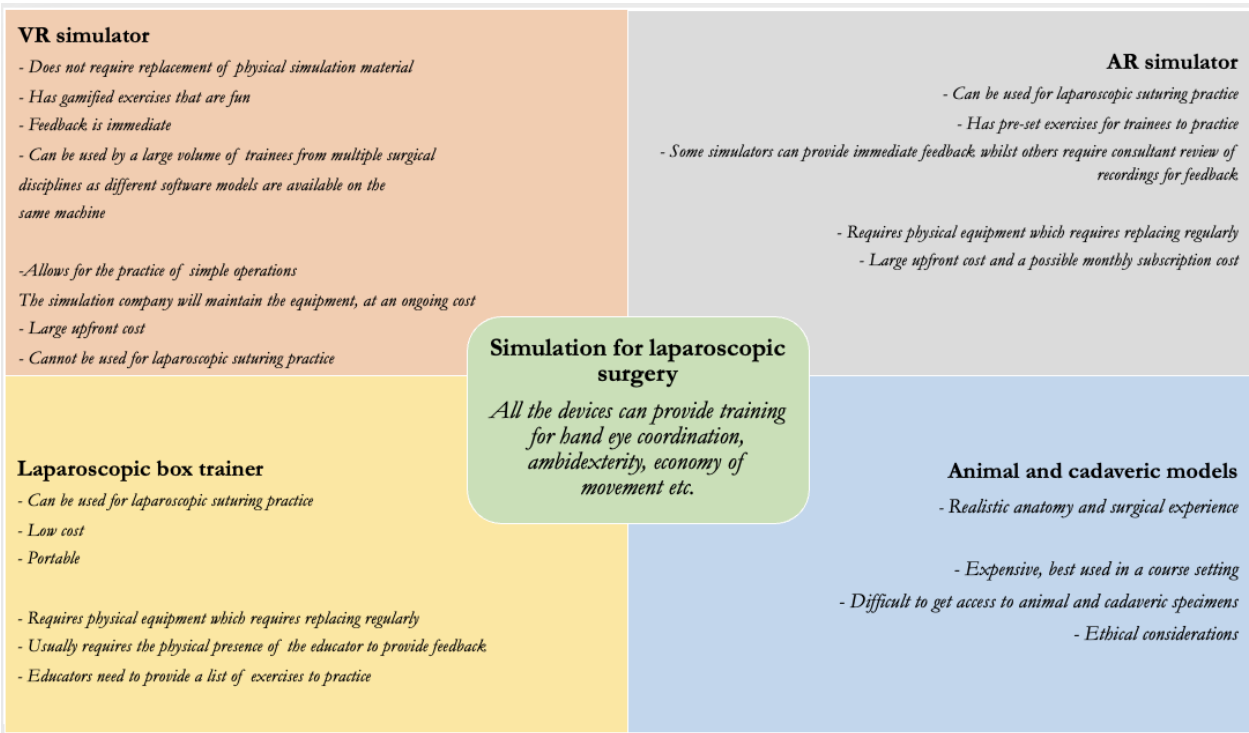


Figure 19 Comparing the features of simulators for laparoscopic surgery based on the results presented in Chapter Seven and evidence in published literature (76, 599-602). The perceived advantages of each simulator are listed first, followed by the perceived disadvantages- information that surgical educators must consider when deciding on which simulator/s to acquire for their hospital/deanery. Abbreviations: AR- Augmented Reality, VR- Virtual Reality

C) Combining technical and non-technical skills in one simulation session

Combining technical and non-technical skills training within a single simulation session offers a coherent approach to reflecting the realities of surgical practice. Such an approach allows trainees to rehearse procedural skills while simultaneously managing communication, decision-making and teamwork demands and makes deliberate use of limited training time and simulation resources. This model aligns with later stages of skills development, where integration and automatisation of technical skills are required for effective performance in complex clinical environments (482). Previous studies exploring combined technical and non-technical skills simulation have reported a range of outcome measures, including associations between technical and non-technical performance and the cognitive load experienced by trainees during technical tasks, and have generally noted educational benefits of combined training approaches (561, 564, 603).However, these studies have primarily focused on performance metrics rather than the perspectives of trainees themselves. In contrast, the empirical work presented in this thesis contributes qualitative insight into trainees' experiences of participating in combined technical and non-technical skills simulation, addressing a gap in the existing literature. The potential applications of this integrated simulation model are wide-ranging. It may be used as a regular component of regional training programmes to support ongoing consolidation of skills, as illustrated in the proposed training model (Figure 18). Beyond routine training, combined simulation may be particularly valuable for clinicians returning to practice following a period away from training, such as out-of-programme experience or maternity leave. Simulation has been shown to support safe and effective return to clinical practice by providing opportunities to rehearse both technical and non-technical skills; however, existing studies do not describe models that deliberately integrate both skill sets within a single simulation session (604-606).

The simulation described in Chapter Eight has been implemented over the past two years within regional obstetrics training and as part of return-to-training support, with consistently positive trainee feedback (Appendix Five). While these findings are exploratory and context-specific, they

suggest that combined technical and non-technical skills simulation is both acceptable to trainees and feasible within existing training structures.

D) Opportunities to implement solutions across a wide range of surgical specialties

Findings from the curricula review indicated that surgical curricula developed by the ISCP share broadly similar structures and approaches to training across specialties. Although the empirical studies in this thesis were conducted with general surgical and obstetric trainees, the principles underpinning the simulation models, including structured integration with clinical training, alignment with curricular requirements and attention to trainee experience, are likely to be transferable across surgical subspecialties.

That said, direct transfer of simulation content between specialties would be inappropriate without modification. Any implementation would need to be adapted to reflect specialty-specific procedural requirements, training pathways and local contexts. The contribution of this thesis therefore lies not in proposing a uniform simulation package, but in offering a flexible framework that may be adapted by educators to support technical skills training across a range of surgical disciplines.

Surgical technical skills training in the context of Maslow's hierarchy of needs

Maslow's hierarchy of needs is a psychological theory describing fundamental human requirements for wellbeing and motivation (Figure 20) (607). Maslow originally conceptualised these needs as hierarchical, with lower-level physiological and safety needs requiring fulfilment before higher-level needs such as self-esteem and self-actualisation could be addressed. Subsequent critiques have suggested that these needs may coexist and be met simultaneously rather than sequentially(608). The application of Maslow's framework to medical and surgical training is not new and has previously been used to reflect on trainee motivation, wellbeing and professional development (609-611). Viewed through this lens, surgical training must attend not only to the acquisition of technical competence but also to the broader conditions that enable trainees to engage and develop

confidence. A self-actualised trainee at the end of training may be characterised by confidence in managing complex clinical situations, mastery of required technical skills and readiness for independent practice within their chosen subspecialty. Achieving this outcome requires attention to several interrelated needs throughout training. Within the specific context of surgical technical skills training, the findings of this thesis highlight the relevance of the following considerations.

a. Safety and security

Training environments, both in simulation and in the operating theatre, must be psychologically safe. Psychological safety has been defined as individuals' perceptions of the consequences of taking interpersonal risks in a given context, including the ability to speak up, ask questions and make mistakes without fear of humiliation or punishment (612, 613).Surgical practice is inherently stressful, with the potential for complications and error (614-616). The findings of this thesis reinforce the importance of supportive supervision and educator behaviour in enabling trainees to engage meaningfully with both simulation and clinical learning, particularly when developing new technical skills. An important aspect of faculty development is to train faculty specifically for simulation; so that they acquire skills to be able to provide psychologically safe simulation training for their students(617, 618).

b. Sense of belonging

A sense of belonging and adequate pastoral support are essential for trainees to thrive (619, 620). Pastoral care is provided through multiple relationships, including senior trainees, clinical and educational supervisors, training programme directors and heads of school. As discussed earlier in this chapter, incorporating discussion of simulation engagement into ARCP processes may contribute to trainees feeling that their learning efforts are recognised and valued (594, 621). Peer-to-peer teaching and shared simulation experiences may further strengthen collegiality and professional identity, supporting engagement with technical skills development (622, 623).

c. Self-esteem and confidence

Progression in technical skills training is closely linked to trainee confidence and self-esteem.

Structured opportunities to practise technical skills outside the operating theatre, coupled with visible improvement and constructive feedback, may support trainees in recognising their own progress. The findings from this thesis suggest that engagement with simulation can contribute to increased confidence in the operating theatre, particularly when educators acknowledge and reinforce the relevance of simulation-based learning to clinical performance (588, 624, 625).

Figure 20 summarises Maslow's hierarchy of needs and illustrates its relevance to surgical technical skills training. While Maslow's model is not presented as an explanatory or predictive framework within this thesis, it offers a useful lens for reflecting on how educational structures, educator behaviours and training environments may support or hinder trainee development. Addressing psychological safety, belonging and confidence alongside technical skill acquisition may help educators create conditions that enable trainees to progress towards independent and competent surgical practice.

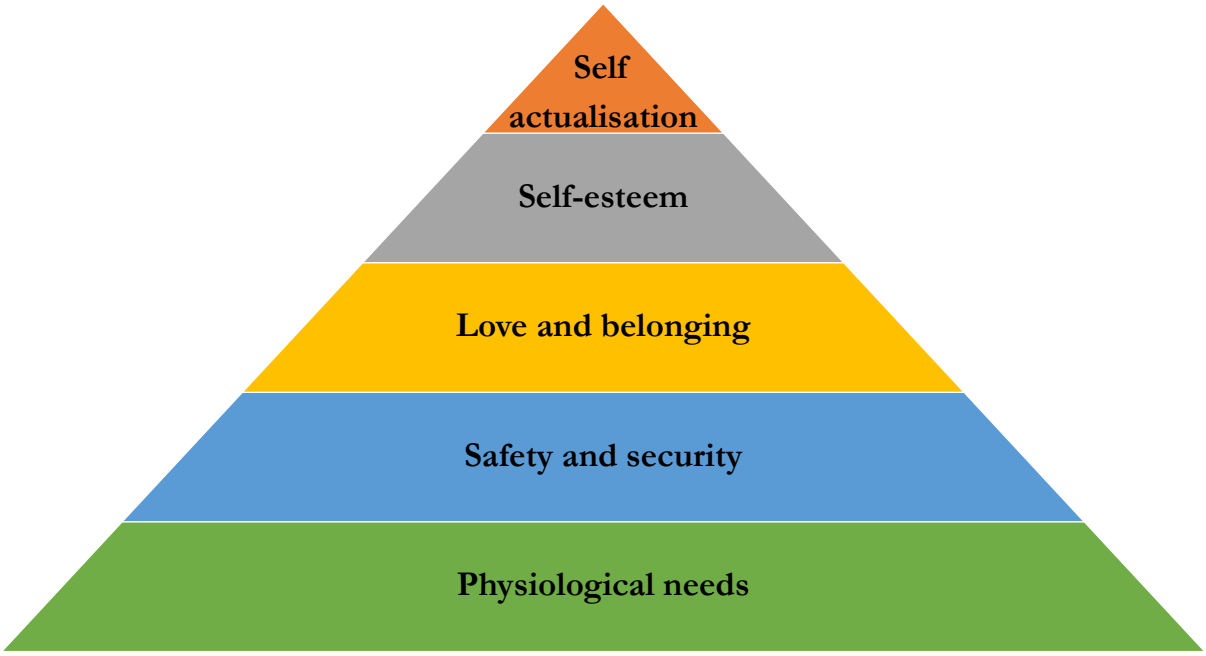


Figure 20 Maslow's hierarchy of needs is a psychological theory about the motivators for human behaviour. Abraham Maslow described five basic categories of needs: physiological, safety and security, love and belonging, self- esteem, and self- actualisation (607). In the context of surgical technical skills training, addressing these needs will aid educators in helping trainees achieve self-actualisation- mastery of their chosen surgical subspeciality, ability to manage complex patients and fulfilling their academic potential. Educators can create psychologically safe training environments for learning in as well as out of the operating theatre (safety and security), foster a sense of community through pastoral care (love and belonging) and help build confidence through structured training programmes that demonstrate progress and improved surgical performance (self-esteem)

Application of the Pareto Principle to improving surgical technical skills training through simulation

The exploratory work in this thesis identified multiple avenues for improving surgical technical skills training through simulation. In practice, however, postgraduate training programmes operate within complex systems where time, faculty availability and competing service demands limit the feasibility of addressing all challenges simultaneously. As a result, educators and training institutions must make decisions about where to focus effort in order to achieve meaningful educational improvement. Despite this, there is limited guidance within surgical education literature on how best to prioritise specific interventions related to simulation implementation. One conceptual approach that may support such decision-making is the application of quality improvement principles, specifically the Pareto Principle (626).

The Pareto Principle is a recognised tool for process improvement and is widely used within quality improvement initiatives to support prioritisation (627-630). It proposes that a small proportion of contributing factors, often described as the "vital few", account for a large proportion of observed effects, while the remaining factors represent the "trivial many" (627-630). Although commonly associated with industries such as manufacturing and business, the Pareto Principle has increasingly been applied within healthcare to support prioritisation of interventions aimed at improving efficiency, safety and outcomes (627-630).

In the context of surgical technical skills training, the Pareto Principle offers a useful conceptual framework for focusing attention on defining high-impact interventions rather than attempting to address all identified barriers simultaneously. Though this thesis does not present a formal Pareto analysis, it illustrates how such a framework may be used pragmatically within local training contexts to guide decision-making.

I have used the local training conditions for O&G within the Thames Valley deanery to highlight the relevance of this approach. While structured obstetric simulation is well established at both

deanery and local levels, provision of simulation for gynaecological technical skills is more variable, despite national concern regarding declining gynaecological operative exposure, as highlighted in the RCOG's O&G Surgical Skills Interim Report(631). Simulation delivered locally in each hospital in the deanery by practice development teams is often multidisciplinary and focused on obstetric emergencies or obstetric non-technical skills, with variability in scope and frequency depending on local interest, staffing and funding. Although simulation activity is increasingly expected of educators, there is no consistent or formalised training pathway for simulation faculty within postgraduate surgical education, with preparation for simulation teaching largely reliant on individual motivation and self-directed learning.

Applied conceptually, the Pareto Principle suggests that prioritising a small number of high-impact interventions, may yield disproportionate benefit. Within this context, such interventions may include rebalancing simulation provision to better address gynaecological technical skills needs, embedding gynaecological simulation within existing obstetric and multidisciplinary simulation infrastructure, introducing non-technical skills simulation for gynaecology and establishing structured pathways for simulation faculty development. Explicitly linking simulation engagement and teaching activity to existing training structures, such as ARCP and educational supervisor discussions, may further reinforce these priorities.

The Pareto Principle framework may also be applied to trainee-specific concerns. By drawing on trainee feedback and stakeholder perspectives, training programmes could identify the limited number of barriers that most strongly influence engagement with simulation and target these preferentially. Future work could apply formal quality improvement methodologies within individual deaneries to identify deficiencies and judiciously invest their resources towards interventions that would have the biggest impact in improving their educational programmes.

Implications for Policy

Alignment with NHS England educator workforce strategy, the NHS Long Term Workforce Plan, the NHS 10 Year Health Plan, and the GMC 2024 report on workplace opportunities

The NHS Long Term Workforce Plan has clearly articulated the intention to substantially expand the domestic medical workforce, including a planned doubling of medical school training places by 2031 (425). Predictably, expansion at undergraduate level will require a proportional increase in postgraduate training capacity, including surgical training. As demonstrated in this thesis, however, pre-existing challenges in surgical technical skills training were already evident prior to the COVID-19 pandemic and were further exacerbated by reductions in operative exposure during and after the pandemic. The Fit for the Future: 10 Year Health Plan for England situates workforce development as a central enabler of NHS sustainability and explicitly emphasises the need for education and training models that are adaptable, technologically enabled and capable of delivering high-quality care under increasing service pressure (632). At the same time, the plan cautions that innovation alone will not resolve systemic constraints, highlighting the importance of supporting the workforce to deliver reform. Within this context, increasing trainee numbers without corresponding changes to training structures risks placing additional strain on existing programmes and may compromise training quality.

Incorporating technical skills simulation as a routine component of surgical training, used deliberately as an out-of-operating-theatre opportunity to support learning, practice and consolidation of skills, represents one potential mechanism for mitigating these pressures. The findings of this thesis suggest that simulation may help address variability in operative exposure; however, its educational value is contingent on structured integration rather than ad hoc availability. This position aligns with the broader direction of national workforce policy, which emphasises

modernisation of training alongside expansion, rather than reliance on increased clinical throughput alone (516).

Specialty specific guidance further reinforces this need. The RCOG Surgical Skills Project Interim Report identifies declining operative exposure, particularly in gynaecological surgery, increasing procedural complexity and trainee concerns regarding readiness for independent practice as key challenges facing O&G training(631).While the report recognises simulation and virtual learning as important components of future surgical training, it also emphasises the need for structured, evidence-based implementation and alignment with curricular and workforce priorities. The findings of this thesis are consistent with this position, particularly in highlighting the mismatch between training need and simulation provision, and the risks of assuming that simulation will be effective without appropriate integration and educator support.

Discussions of implementing simulation-based training at scale are therefore incomplete without explicit consideration of faculty development. Both the NHS England Educator Workforce Strategy and the NHS 10 Year Health Plan stress that supporting educators through protected time, professional development and recognition is essential for workforce sustainability and retention(632). The Educator Workforce Strategy also explicitly promotes the adoption of evidence-based educational technologies, including simulation, in ways that are equitable, efficient and sustainable (516). The findings of this thesis reinforce that without consistent and structured approaches to faculty development, expansion of simulation-based training risks being uneven in quality and difficult to sustain.

Faculty development should also be viewed as a professional development opportunity for senior trainees and consultants. The GMC 2024 report on workplace experiences highlights access to professional development opportunities and protected training time as important contributors to staff wellbeing and retention (633). Establishing clearer pathways for simulation faculty development within postgraduate surgical training may therefore support not only educational quality but also wider workforce objectives articulated in current national and specialty-level policy. As part of both

faculty development and curricular redesign, attention must also be paid to existing national frameworks and guidance for simulation-based education. Nationally produced toolkits provide valuable benchmarks for assessing the quality of locally delivered simulation programmes and can support consistency in educator development (634-636). In addition, standards produced by the Association of Simulated Practice in Healthcare offer guidance for evaluating simulation centres, programmes and educator preparation, and represent an important resource for maintaining quality and supporting sustainable implementation (637).

Limitations

The empirical studies reported in this thesis were conducted within a single UK postgraduate training region, the Thames Valley deanery. This regional focus limits the direct generalisability of the findings, as regional education culture, leadership priorities, availability of simulation infrastructure and faculty engagement may have influenced both the implementation of the simulation interventions and trainees' experiences of them. While postgraduate surgical training programmes in the UK are quality assured through nationally consistent mechanisms, this does not eliminate local variation in how training is delivered in practice. As such, the findings should not be assumed to be universally applicable without consideration of local context. Although examples such as the PROMPT course in obstetrics demonstrate that locally developed simulation initiatives can be scaled nationally and internationally when supported by robust structures and faculty engagement (525, 527, 638-640), the transferability of the approaches described in this thesis would require careful adaptation rather than direct replication.

The qualitative methodological approach adopted in this thesis represents both a strength and a limitation in this thesis. Qualitative methods were selected deliberately to address the research questions, which focused on understanding trainees' experiences and the contextual factors influencing engagement with simulation. This approach enabled rich, in-depth exploration of issues

that are poorly captured by quantitative metrics. However, the relatively small sample sizes inherent to qualitative research limit the ability to draw conclusions about the prevalence of views expressed or to make claims about the effectiveness of the simulation interventions in improving technical competence or clinical outcomes. The findings therefore provide insight into mechanisms of setting up the specific simulations presented in this thesis, perceptions of the cohort who took part and contextual influences specific to the Thames Valley region rather than evidence of educational efficacy and should be interpreted accordingly.

In addition, the empirical studies did not include examination on how engagement with simulation influenced trainees' technical skills development over the entirety of their training or their subsequent performance in the operating theatre. Nor did the studies compare alternative models of simulation implementation. As a result, the findings cannot determine whether the approaches described represent optimal or superior strategies, only that they were acceptable and feasible within the contexts studied. This limitation reflects the exploratory nature of the research and highlights the need for further evaluation using complementary methodological approaches.

Areas for future research

This thesis explored trainees' experiences of participating in simulation-based technical skills training integrated into routine surgical education. The findings raise several unanswered questions and highlight areas where further research is required. The simulation described in this thesis has been implemented within routine obstetric training and are in the process of being introduced into general surgical training within the Thames Valley deanery. Further work is required to examine how these approaches may be adapted for other surgical subspecialties and training contexts. There is also potential to explore the applicability of the principles described to non-surgical specialties and to multidisciplinary team training.

Longitudinal research is needed to understand the longer-term impact of integrated simulation on trainee development, including trainee satisfaction, confidence, and the extent to which simulation influences the quality and efficiency of learning within the operating theatre over the course of training. Further evaluation is also required to examine how developing trainees as simulation educators influences faculty capacity, sustainability of simulation programmes and educational culture.

Qualitative research methods remain particularly valuable in this context. As demonstrated in this thesis, qualitative approaches (particularly case study and ethnography as methodologies) enable exploration of nuanced experiences and contextual factors that significantly influence uptake and effectiveness of educational interventions. Continued use of qualitative and mixed-methods research may help identify strategies for simulation implementation that have been overlooked by predominantly quantitative approaches (641).

Two barriers identified consistently throughout this thesis , faculty development and curricular integration, remain under-researched despite their importance. Further work examining how simulation educators are trained and supported, and how simulation is explicitly embedded within curricula, will be critical to the long-term success of simulation-based technical skills training in surgery.

Final reflections

Surgical technical skills training requires ongoing adaptation in response to sustained pressures on postgraduate training in the UK and internationally. The findings of this thesis suggest that, for trainees to acquire and consolidate technical skills effectively, training must move beyond reliance on opportunistic operative exposure towards a more structured and multimodal approach. Simulation, when used as an adjunct to clinical training and integrated deliberately within existing training systems, represents one component of such an approach.

This thesis adopted a pragmatic perspective on simulation-based education, working within the constraints of contemporary surgical training and the wider healthcare system. Rather than proposing wholescale redesign of training structures, the work focused on understanding how simulation might be implemented meaningfully in routine practice, informed by trainees' experiences and existing educational processes. In doing so, it highlighted the importance of alignment between simulation provision, curricular expectations, educator practices and trainee motivation.

The overarching aim emerging from this work is not the universal or indiscriminate use of simulation, but the sustained and thoughtful integration of simulation-based technical skills training across surgical subspecialties, alongside continued learning in the operating theatre. Achieving such integration requires coordinated effort across multiple levels of surgical education, including national training bodies, Royal Colleges, regional and local educators, simulation specialists, education researchers and trainees themselves.

Ultimately, the contribution of this thesis lies in offering empirically grounded insight into how simulation can be incorporated into postgraduate surgical training in ways that are feasible, acceptable to trainees and responsive to current workforce and service realities. Continued attention

to implementation, educator support and evaluation will be essential if simulation is to fulfil its potential as part of a comprehensive approach to developing a competent surgical workforce capable of delivering safe and effective patient care.

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Appendices

Appendix One- Assessing the quality of the qualitative research presented in the thesis

I have used the "big- tent" criteria model presented by Sarah J Tracy to assess the quality of the qualitative research in this DPhil thesis (Tracy, 2010). The eight criteria presented provide an expansive and flexible framework to evaluate qualitative research.

Reference: Tracy, S.J. (2010). Qualitative quality: Eight "big tent" criteria for excellent qualitative research. Qualitative inquiry, 16(10), 837-851.

Criteria for quality	**Various means, practices, and methods through which to achieve quality**	**Evaluation of the qualitative research in this thesis**
Worthy topic	The topic of the research is • Relevant • Timely • Significant • Interesting	Research into surgical training is both relevant and timely especially after the deleterious impact of the COVID-19 pandemic, where elective operating was completely stopped and emergency operating, and educational activities were reduced. The DPhil research presented in this thesis commenced at the end of the pandemic, at a time where there were significant concerns being expressed locally, nationally, and internationally regarding technical skills training in surgical specialities. The exploratory research in this thesis summaries the deficiencies with technical skills training both before and during the COVID-19 pandemic. The evidence from chapter six revealed a large literature gap in research into implementation strategies for technical skills simulation into surgical training. I have presented two studies that has the potential to be adapted to any surgical speciality

Criteria for quality	**Various means, practices, and methods through which to achieve quality**	**Evaluation of the qualitative research in this thesis**
Rich rigor	The study uses sufficient, abundant, appropriate, and complex • Theoretical constructs • Data and time in the field • Sample(s) • Context(s) • Data collection and analysis processes	I chose to apply the qualitative methodologies of case study and ethnography to my research based on the research question and the study contexts. E.g., for the study in chapter eight, I chose rapid ethnography as it captured data from multiple sources simultaneously. For the study in chapter seven, I followed the trainees up after the initial three months so that I could understand the medium to long term influence of engaging in a structured simulation programme. I designed my simulation studies to fit within the training contexts of the trainees who participated in the studies. Each of the simulations were for 40 minutes followed by the focussed group interviews, which allowed enough time for the trainees participating to perform the tasks planned within the simulation and discuss their experiences afterwards. The design of the studies and the analysis of the data were conducted by me with frequent discussions with the experienced faculty involved with the simulation to ensure interpretations made by me were accurately representative of the source data

Criteria for quality	**Various means, practices, and methods through which to achieve quality**	**Evaluation of the qualitative research in this thesis**
Sincerity	The study is characterized by • Self-reflexivity about subjective values, biases, and inclinations of the researcher(s) • Transparency about the methods and challenges	In the preface, I have described my background and the assumptions I had when I started my research. In chapter two, I described my positionality within my research and the philosophical viewpoint that underpins my research. Throughout my thesis, I have made efforts to express the reasoning behind the choices I made. The thematic analysis I conducted in chapters four, six, seven and eight were discussed with my supervisors, my research group and stakeholder collaborators to ensure my conclusions were representative of the data and of the context of the research itself. I also have provided explanations in the relevant chapters for the choices I made- e.g., choosing 2 years as the pre-COVID time period for the systematic review in chapter four. I endeavoured to remain open and honest about the limitations of my studies throughout the thesis- recognising and acknowledging the impact these limitations may have on the transferability of the findings rather than masking or hiding them

Criteria for quality	**Various means, practices, and methods through which to achieve quality**	**Evaluation of the qualitative research in this thesis**
Credibility	The research is marked by • Thick description, concrete detail, explication of tacit (non-textual) knowledge, and showing rather than telling • Triangulation or crystallization • Multivocality • Member reflections	I collected multiple sources of qualitative data(two questionnaires and semi structured interviews) to provide thick description and detail of the trainees' experiences with simulation during the simulation programme as well as during their overall surgical training. Similarly, my ethnographic study in chapter eight includes multiple data sources as well as qualitative data from focus group discussions of all the trainees and faculty involved in the simulations. The ethnographic study presents evidence observed by the faculty members present during the simulations and acts as data from a source that is both an expert and a participant immersed within the simulation. Representing multiple perspectives of the same event lends credibility to the observations and allows for reflection by the researchers
Resonance	The research influences, affects, or moves particular readers or a variety of audiences through • Aesthetic, evocative representation • Naturalistic generalizations • Transferable findings	My research seeks to resonate with surgical trainees and educators, as I explore in depth the difficulties both these stakeholders face with technical skills training, given the logistical and infrastructural educational constraints faced daily. Also, as the literature review in chapter six revealed, the barriers to the implementation of simulation are similar across various countries, and so my empirical work can be adapted to surgical training globally

Criteria for quality	**Various means, practices, and methods through which to achieve quality**	**Evaluation of the qualitative research in this thesis**
Significant contribution	The research provides a significant contribution • Conceptually/theoretically • Practically • Morally • Methodologically • Heuristically	As discussed in chapter nine, my research extends existing knowledge of implementing technical skills simulation, improves educational practices in surgical specialities and generates ongoing research. My research is practically significant, and the findings can be readily implemented into educational practice, which has already occurred since I conducted my studies. The use of qualitative research is less common in surgical education research, so my studies significantly contribute to the literature gap that exists to understand trainees' experiences using qualitative methodologies
Ethical	The research considers • Procedural ethics (such as human subjects) • Situational and culturally specific ethics • Relational ethics • Exiting ethics (leaving the scene and sharing the research)	I followed the ethical processes in the university at the time the studies were conducted and have CTRG approved exemption. I still considered my ethical duties to the participants, taking informed written consent for participation. I followed data protection rules and anonymised the data before analysis. My exploratory studies are based on published work and service evaluation and are also ethics exempt. I have discussed the findings of my studies with the stakeholders directly involved with the studies themselves before presenting the findings at regional, national, and international conferences. I have collaborated with regional education training programme directors for general surgery and O&G to incorporate my simulations into routine training. I have submitted three of the chapters as papers to reputed journals for publication which are currently being peer reviewed. I aim to submit three more papers after the submission of this thesis.

Criteria for quality	**Various means, practices, and methods through which to achieve quality**	**Evaluation of the qualitative research in this thesis**
Meaningful coherence	The study • Achieves what it purports to be about • Uses methods and procedures that fit its stated goals • Meaningfully interconnects literature, research questions/foci, findings, and interpretations with each other	During my doctoral studies, I uncovered a large literature gap with regards to the implementation of technical skills simulation and chose to practical implementation strategies to study. Having focused on trainees' experiences, I chose qualitative methodologies for my studies to understand the subjective nature of experiences when participating in simulation training. I have interconnected my findings with psychological theory that are relevant, meaningful and enhance rather than limit my argument and analysis (Maslow's hierarchy of needs and Pareto analysis). I have answered my research question as I have presented practical simulation strategies and redesign of surgical training that implements simulation to improve technical skills.

Table 29 An evaluation of the quality of my qualitative research using the "Qualitative Quality: Eight Big-Tent Criteria for Excellent Qualitative Research" by Sarah J. Tracy

Appendix Two- Abstracts of publications or papers under peer review

Study from Chapter Three: Under peer review- Current Surgery Reports

Simulation use in technical skills training in the UK: A review of postgraduate surgical curricula

Purpose of Review

Effective surgical training requires structured curricula that specify learning outcomes and educational methods. In the UK, postgraduate surgical curricula include the General Medical Council's Generic Professional Capabilities and Capabilities in Practice, encompassing both technical and non-technical skills. Simulation is recognised as an evidence-based tool for effective technical skills surgical training; however, its integration into surgical curricula has not been reviewed. This study aimed to analyse UK surgical subspecialty curricula to assess the guidance provided on technical skills training, focusing on the use of simulation. Fifteen postgraduate curricula from all 12 UK surgical subspecialties were obtained from Royal College websites in December 2023. Each curriculum was manually reviewed using predefined categories. Keyword searches for 'simulation' and 'technical skills' guided the extraction of relevant content, which was compiled into a structured spreadsheet. A descriptive narrative analysis identified key themes and examples pertinent to surgical educators.

Recent Findings

The review covered 1,570 pages across 15 curricula. 'Simulation' appeared 269 times, with marked variation among specialties. Most curricula adhered to the Intercollegiate Surgical Curriculum Programme framework, describing shared training phases and educational strategies. Although

simulation was included as a formal learning component, it was generally referenced in broad terms and inconsistently embedded. Only the paediatric surgery, obstetrics and gynaecology, and ophthalmology curricula provided more specific guidance on simulation use.

Summary

This review reveals a notable lack of specific guidance on technical skills training and simulation use within UK surgical curricula. Curricula clearly state required skills and assessments but lack detailed instruction on teaching methods, potentially leading to inconsistent local implementation and training variability. Surgical curricula lag behind non-surgical specialties like anaesthesia in simulation integration. The review recommends revising curricula to explicitly embed evidence-based simulation alongside traditional training to improve standardisation and training quality nationally.

Study from Chapter Four: Under peer review- Current Surgery Reports

Exploring the deficiencies in technical skills postgraduate surgical training prior to the COVID-19 pandemic: A systematic review and thematic analysis

Purpose of the review:

Postgraduate surgical training has evolved significantly, transitioning from traditional apprenticeship models to more structured competency-based programs. Despite these changes, concerns persist regarding the adequacy of technical skills (TS) training, exacerbated by modern challenges such as working time restrictions and the impact of the COVID-19 pandemic. This systematic review aimed to explore and understand TS training for doctors in postgraduate surgical training programs, focusing on issues prior to the COVID-19 pandemic. The search strategy was registered with PROSPERO a priori. Following PRISMA guidance, literature searches were conducted on electronic databases: Medline, Embase and grey literature using specific search criteria of studies published from 2016 to 2018. Studies that discussed TS postgraduate training in surgical specialities

were eligible for inclusion. Data were extracted and analysed using inductive coding and thematic analysis. **Recent findings:**

Seventeen studies were included in the final analysis, predominantly from high-income countries. Thematic analysis revealed two main deficiencies in TS training: inadequate use of a multimodal approach and insufficient structure in training programs. Simulation training, while beneficial, was underutilised. Additionally, there were significant global discrepancies in training length and required competencies, with trainees often feeling less independent than expected upon programme completion.

Summary:

The review identifies critical areas for improving surgical training, emphasizing the need for a multimodal training approach and a more structured framework for delivery. These findings are particularly relevant for post-pandemic recovery efforts in surgical education, providing a foundation for targeted improvements in training programs.

Study from Chapter Five: Under peer review- Current Surgery Reports

Investigating the impact of the COVID-19 pandemic on postgraduate surgical technical skills training: a systematic review

Purpose of the review

Surgical training was significantly affected during the COVID-19 pandemic due to several factors, including the postponement of professional exams, fewer hands-on surgical training opportunities and redeployment. This systematic review aimed to explore the impact of the COVID-19 pandemic on post-graduate technical skills training in surgical specialities. The systematic review was conducted following the guidelines set out by PRISMA with the inclusion of studies on surgical

training from any of the 12 specialities. The studies were screened in duplicate. A thematic analysis was conducted on the extracted data.

Recent findings

Fifty-three studies reported a significant impact on technical skills training due to the pandemic with statistically significant reduction in operating compared to before the pandemic. Only a few studies discussed the use of simulation, to which about 50% of the trainees had access , but was underutilised during the prolonged downtimes where trainees could not operate but could have practised in simulation. There was a lack of evidence regarding recovery planning, with only one study that discussed the use of the independent sector as a potential avenue to provide trainees with opportunities for technical skills training. Worries regarding progression, exam cancellations and loss of technical skills were reported by most of the studies in this review.

Summary

There is an opportunity for a paradigm shift in surgical training with technical skills simulation as an essential adjunct to learning in the operating theatre after the pandemic. These findings underscore the need for adaptable, equitable recovery measures to address training deficits.

Study from Chapter Six: Published- Indian Journal of Surgery

Mind the Gap: A Scoping Literature Review and Thematic Analysis to Understand the Barriers to Using Technical Skills Simulation in Surgical Training

Purpose

To identify barriers to implementing technical skills simulation in surgical training.

Methods

A scoping literature review was conducted in September 2024 by searching Medline and EMBASE databases using predefined terms. The included studies were thematically analysed to understand the barriers to implementing technical skills simulation for surgical training.

Results

Of the 201 studies identified, 20 met inclusion criteria, representing diverse global regions and using quantitative (n = 13), qualitative (n = 4), and review (n = 3) methodologies. Six key interrelated barriers were identified: (1) limited faculty availability and support, (2) inadequate simulation space, (3) lack of technical staff, (4) funding constraints, (5) insufficient trainee time and engagement, and (6) absence of long-term sustainability planning.

Conclusion

Implementation of technical skills simulation in surgical training faces six interrelated barriers spanning faculty, infrastructure, staffing, funding, trainee engagement, and long-term strategy. Addressing these challenges requires coordinated efforts in faculty development, curriculum reform, and strategic resource planning, alongside a cultural shift to embed sustainable simulation in surgical education**.**

Study from Chapter Seven: Published- Advances in Simulation

Exploring trainee experiences in a structured virtual reality laparoscopic training programme for general surgeons: A longitudinal case study

Background

The acquisition and maintenance of technical skills in surgical specialties has become increasingly challenging for postgraduate trainees, exacerbated by factors such as the shift from traditional apprenticeship models, reduced operative time, and the impact of the COVID-19 pandemic. Virtual reality (VR) simulators offer a promising adjunct to traditional surgical training, though their integration into routine practice remain underexplored.

Objective

This qualitative study investigates the experiences and motivations of general surgical trainees who engaged with a VR laparoscopic simulator as part of a structured training program.

Methods

A case study methodology was chosen to explore the laparoscopic simulator experiences of 22 general surgery trainees over a period of three months. In this time each of the trainees practised a minimum of five repetitions across 25 laparoscopic simulator exercises. The study was designed using Kopta's theory of technical skill learning, focusing on the cognitive phase, where trainees repetitively practised individual steps with feedback. Data collection involved qualitative questionnaires, semi-structured interviews (of seven of the trainees eight months later), and quantitative data from the simulator. The qualitative data was analysed using thematic analysis, and descriptive statistical tests were applied to the quantitative data for triangulation.

Results

The study identified key factors influencing trainee engagement, including ease of access, the importance of periodic rather than frequent simulation sessions, and the value of setting specific performance goals. The findings suggest that simulation can effectively complement traditional surgical training when incorporated into routine practice, with potential for broader application if barriers such as time constraints and access issues are addressed.

Conclusion

This study contributes to the literature on surgical education by highlighting the need for targeted strategies to enhance the use of simulation as an adjunct alongside more traditional training.

Study from Chapter Eight: Under peer review- BJOG: An international journal of obstetrics and gynaecology

Exploring a combined technical and non-technical skills obstetric training session on a simulated labour ward: a rapid ethnographic study

Objective

To explore how early-stage obstetric trainees integrate technical and non-technical skills during a simulated obstetric on-call shift.

Design

Rapid ethnographic study.

Setting

Simulated labour ward environment within a UK tertiary maternity unit.

Sample

Fourteen UK obstetrics and gynaecology Specialist Trainees in Years 1 and 2.

Methods

Participants undertook a 40-minute simulated obstetric on-call shift involving concurrent management of patients across the labour ward, antenatal ward, and maternity assessment unit, followed by a facilitated focus group discussion. Data collection incorporated participant observation, faculty and researcher field notes, movement-tracking diagrams, audio recordings, and focus group interviews. Data were analysed thematically and interpreted in relation to trainees' perceived preparedness, learning facilitators and barriers, and the feasibility of this simulation format for routine training.

Main Outcome Measures

Observed integration of technical and non-technical skills, trainee preparedness, and perceived educational value of the simulation.

Results

Trainees demonstrated confidence and fluency in familiar technical tasks, including episiotomy repair and management of the third stage of labour. In contrast, uncertainty and reliance on prompting were observed during complex decision-making, consenting for instrumental birth, and escalation of care, highlighting challenges in integrating technical and non-technical skills under pressure. The realistic workload and competing clinical demands revealed both effective teamwork behaviours and communication lapses. Participants valued the psychologically safe environment for experiential learning, reflection, and rehearsal of unfamiliar responsibilities.

Conclusions

Combined technical and non-technical obstetric simulation is feasible, acceptable, and educationally valuable for early-stage trainees.

Appendix Three- Documents related to the VR study in Chapter Seven

CTRG form

Title:

Understanding the role of a virtual reality (VR) simulator in simulation training for surgeons in the Thames Valley Deanery

Team:

Miss Aditi Siddharth: Registrar in Obstetrics and Gynaecology, University of Oxford

Mr. Sotiris Mastoridis: Academic Clinical Lecturer & Registrar in Surgery, Nuffield Department of Surgical Sciences, University of Oxford

Mr. Michael Silva: Consultant Surgeon &Training Programme Director for speciality training in General Surgery, OUH NHS Foundation Trust

Prof. Helen Higham: Director OxSTaR Centre, Nuffield Division of Anaesthetics, University of Oxford, and Consultant Anaesthetist OUH NHS Foundation Trust

Aims:

To analyse the impact of using a virtual reality simulator in the simulation training curriculum for surgical trainees in the Thames Valley Deanery

Purpose:

The goal of surgical training is to develop the skills to help transition novice doctor to expert surgeon; one who is safe, efficient and works well in a multidisciplinary team. Hands-on training is vital for surgical skills, making surgical training unique when compared to other branches of medicine [1]. In the past, surgical skills were solely acquired through an apprenticeship model; the trainee was mentored by a consultant over a few years and progressed from supervised to unsupervised operating [2]. Due to changes to working patterns including the introduction of the European Working Time Directive, this apprenticeship model of training changed into the model of training we have today- competency based and curriculum-based training [3]. Teaching outside of

the operating theatre setting became vital to help increase operator skills in order to compensate for the reduced time trainees had within work hours. Simulation is one solution, providing transferrable skills for trainees to apply in the operating theatre [4]. Simulation has been adopted to varying degrees into surgical training over the last 20 years, but its role hasn't been fully optimised [5].

The COVID-19 pandemic increased demand on healthcare resources and required drastic measures to provide the necessary care for the rapid influx of infected patients. This included cancellation of elective surgery, redeployment of staff to cover COVID-19 wards, cancelling face to face teaching and simulation, disruption to examinations and moving to phone consultations in clinic [6]. Healthcare delivery became service oriented, and training opportunities were scarce. The damage this has caused to training in surgical specialities is still being evaluated with no robust data on the efficacy of recovery measures.

Evaluating the training we provide in this period of recovery gives us a unique opportunity to evaluate and adapt how surgeons are trained in the future, with effective and efficient solutions that have not previously been considered .

With this quality improvement project, we would like to understand if using a virtual reality simulator can help surgical trainees practice common operations safely outside the operating theatre and the impact this has on their confidence and technical skills.

Design/method:

This project has been registered as a quality improvement project with the OUH Trust- Ulysses ID 7728.

All trainees have regular regional training days as part of the teaching programme for surgical trainees in the Thames Valley Deanery, spread out over the year. Simulation training is inculcated into their training programme, using the box trainer, though a virtual reality simulator has never been used before. This simulation programme uses a structured approach, expanding on familiar

techniques the trainees are already used to. This is a 3-month training module delivered through the regional teaching sessions for all general surgical trainees in the Thames Valley deanery.

Description of the training

An initial face to face teaching day at the Churchill Hospital (the usual setting for teaching). During this session, the setting of learning outcomes for this training programme will be discussed and the importance of engaging with the simulation and faculty will be emphasised (this is routine practice for simulation training).

The surgical trainees will be set up on the VirtaMed simulator and be shown how to use it. A baseline assessment will be recorded for each trainee on the simulator. The trainees will be provided with an information sheet and consent form (Section A and B).

The trainees will be advised to continue practice of laparoscopic skills using a box trainer (either at home or the box trainer that is available at every department they have been posted at). The surgical trainees will perform the exercises provided by the training programme director using the home/ departmental laparoscopic box trainers, recording individual training (date, exercise performed, time spent on the lap box, any thoughts on skill progress etc)in a journal (Section C, Section D).

The trainees will be contacted after the face-to-face session to complete a baseline questionnaire (Section E). This is a free-text questionnaire, where we could record their views on simulation, their personal learning objectives, their expectations for this programme as well as the impact (if any) that Covid has had on their training. There is also a section to record their confidence rating for performing various aspects of their job and their experience of simulation training to date. This is estimated to take approx. 20 mins to complete, and names will be recorded only for the purpose of tracking the responses to compare to their scores on the simulator and final questionnaire. The names will then be removed to anonymise the responses.

Laparoscopic VR trainer exercises:

The trainees will have assigned time to train on the VR simulator based at the Churchill Hospital. The procedures to practice will include appendicectomy and cholecystectomy, as well as exercises to improve hand-eye coordination. There will be simulated complications like vascular injury during a cholecystectomy for trainees to improve their skills at managing complications. The simulator automatically records time taken to complete tasks and error rates (e.g., failed clip positioning or incorrect placement of the Endo loop on the base of the appendix). The simulator also gathers information on hand movements. The tasks also increase in difficulty as you progress through the programme. There will be an assessment after 3 months of starting the programme to compare progress to the baseline assessment

The trainees will have a mid-point check, where they will be contacted by email by the training programme director; to track their progress, keep them motivated and resolve any questions that may arise from using the simulator.

The trainees will attend a face-to-face session 3 months after the programme is started, for a final assessment on the simulator. The metrics recorded on the simulator will be compared to the data recorded at the baseline assessment to assess progress. We will follow up the trainees 3 months after the programme ends via questionnaire or semi structured interviews, to check on how this experience translated into real-world operating experience (Section F and G). A thematic analysis will be performed on any qualitative information we collect that will help us plan future training sessions.

Outcomes measures:

Primary objective: To measure changes in surgical trainees' technical skills in laparoscopic procedures using simulation-based education

Outcome measure: Assessment of technical skills using the metrics collected by the VirtaMed simulator during the baseline assessment, scores during trainees practice sessions and final assessment.

Secondary objective: To measure changes in confidence in various clinical settings e.g., managing on call duties, independent operating on a theatre list and performing set procedures like cholecystectomy and appendicectomy after simulation-based education

Outcome measure: Confidence is rated via a self-reported measure on a scale of 0-10 with 0 being the lowest confidence rating [7]. This scale will be used in the baseline questionnaire and will be compared to self-reported confidence at the end of the programme.

Secondary objective: Explore inherent biases the trainees have with regards to simulation and how that changes with this training experience

Outcome measure: Qualitative analysis of the baseline questionnaire and comparing it to responses received at the end of the programme and at the 3-month follow-up.

Secondary objective: Does the use of the VR simulator help the student achieve their learning outcomes?

Outcome measure: Analysis of baseline questionnaire to identify each trainee's learning outcomes and assess if these were achieved at the end of the programme (using another questionnaire or semi-structured interview).

Secondary objective: Exploring the role the VR simulator and the box trainer play in skill progression

Outcome measure: Using qualitative data collected with the questionnaire and semi structured interviews, identifying themes of the role simulation plays within training and how this can be optimised.

Dissemination/plans:

This study forms part of the lead investigator's DPhil and we would hope to present the findings at relevant conferences and publish the work in a peer reviewed journal.

Do you think your proposal falls into the category of:

Research □ Audit □ Service evaluation Yes

Please add more information supporting your view below:

We have reflected carefully on the question of whether the analysis of this training programme on simulation is research or service evaluation and feel that it falls into the service evaluation domain because:

- The simulation training provided is an extension to what is routinely provided through the deanery regional teaching programme. It is an essential part of training surgeons. During this recovery after the pandemic, its vital we evaluate and adapt the programme to fit the needs of the trainees.
- There will be no impact on service delivery- attendance at regional teaching is mandatory and the trainees will be relieved of their clinical duties to attend the training and covered for on calls for the duration of the teaching. This is the accepted policy across all the hospitals in the deanery, and no exceptional steps will be taken outside the norm for this training day.
- We are not exposing our staff to novel training but extending our analysis of existing training to gain a clearer idea of how to improve what we currently offer.

References:

1. Hurreiz, H., The evolution of surgical training in the UK. Advances in medical education and practice, 2019. 10: p. 163.

2. Franzese, C.B. and S.P. Stringer, The evolution of surgical training: perspectives on educational models from the past to the future. Otolaryngologic Clinics of North America, 2007. 40(6): p. 1227-1235.

3. Fitzgerald, J. and B. Caesar, The European Working Time Directive: a practical review for surgical trainees. International journal of surgery, 2012. 10(8): p. 399-403.

4. Sturm, L.P., et al., A systematic review of skills transfer after surgical simulation training. Annals of surgery, 2008. 248(2): p. 166-179.

5. Rosen, J.M., et al., Simulation in plastic surgery training and education: the path forward. Plastic and reconstructive surgery, 2009. 123(2): p. 729-738.

6. White, E.M., et al., Surgical education in the time of COVID: understanding the early response of surgical training programs to the novel coronavirus pandemic. Journal of surgical education, 2021. 78(2): p. 412-421.

7. Meyer, A.N., et al., Physicians' diagnostic accuracy, confidence, and resource requests: a vignette study. JAMA internal medicine, 2013. 173(21): p. 1952-1958.

Attachments of the CTRG form

Section A:

VR Simulation Programme Information sheet

Welcome to the Thames Valley general surgery simulation programme. This is a 3-month pilot, to help you advance your training and help us understand how to improve the simulation training we provide.

Overview of the 3-month simulation pilot

27/6/22, face to face teaching:

Attend the all-day teaching at the Churchill Hospital

Meet the team from VirtaMed Lapros

Learn to use the VR simulator

Record a baseline assessment on the VR simulator

At home practice:

Perform the exercises provided by the course organiser using the home laparoscopic trainer

Record your training (date, exercise performed, time spent on the lap box, any thoughts on skill progress etc)

VR trainer exercises:

You will be assigned time to train on the VR simulator at the Churchill Hospital.

Mid-point check:

You will be contacted in August to check on your progress

Final assessment in September 2022 (date tbc):

Using the VR laparoscopic simulator, an assessment will be performed to check on skill progression. It will help us understand how the simulator assesses skills and helps you see the progress you have made. You will be asked to provide the personal logs you maintained during the 3-month period. As this is the first time we are running this programme, we would like your consent to contact you during and follow-up with you after the pilot to learn more about your experience (please read through and sign the attached consent form). We are also interested in understanding how a simulation programme like this can help with your skills in the operating theatre. All the information gathered during this project (data from the simulator, personal logbooks, questionnaires, interview transcripts etc) will be anonymised and may be used for publications and for funding applications. You can opt out at any stage, and this won't affect the training you receive.

Section B:

Consent form: VR Simulation Programme

Please circle the answers, provide your name, and contact details and your signature

Please read the statements below: Please initial each box

1. I confirm that I have read and understand the information sheet provided. 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, and without any adverse consequences or penalty.

3. I agree to take part in the study. Taking part in the project will include being interviewed and recorded (audio) and I am happy to be contacted for the same.

4. I understand that this research is likely to be written up and published.

5. I understand that my personal details such as name and contact details will be anonymised in any publications or funding applications.

6. I give permission to be quoted directly (only if fully anonymised) in research output.

7. I am happy to be contacted for a follow-up interview after the pilot ends.

Name:

Training grade:

Preferred contact details (email address/mobile number):

Signature:

Section C:

Examples of other simulation modalities general surgical trainees have used

Laparoscopic simulation training that trainees already had access to in the deanery- Modified MISTELs Skills etc.

Laparoscopic simulation training: Trainee pack

Welcome to the Thames Valley HST laparoscopic simulation training program. It is envisaged that the program will develop over time. This pack includes the pilot phase programmeweintendrollingoutfromthefirstweekofJanuary2021.Hereyouwillfindthe skills to be assessed for all trainees between ST3-6.

Training and assessment

InitiallytheprogramwillbepilotedfortraineesinST3-6.Differentskillswillbeassessed between ST3/4 and ST5/6.Each exercise must be completed according to standard procedures as described below.

ST Grade	Skill
3/4	Modified MISTELs skills
5/6	Enterotomy closure with omental patch

You will be expected to contact your local training lead (see below) at the start of your attachmenttoidentifythelocaltrainingequipmentandperformaninitialassessment.You will then be required to practice in your own time and have an interim and final assessment during the year

with your trainer. If you have 2 six-month placements in the year an assessment should be performed at the start and end of each attachment. These assessments will be used in the pilot project as part of the ARCP assessment.

Trainee leads

We now have trainees in place as the **local trainee leads** who will help coordinate training, developtheprogrammeviaaregionalcommitteeandcomeupwithnewsimulationmodels for use in practice and assessment in the future.

Following are the trainee leads in Trusts within the deanery (redacted)

Oxford:

Reading:

Bucks

Wexham Park

Milton Keynes:

Score and training tracker

To keep a record of your scores and progress, as well as log practice sessions, an online tool is now available. The website can be found at http://www.smbari.co.uk/smlapsim/.Please register using your first name and surname separatedbyafullstop(firstname.surname),clicktheregistertabandaccepttheprivacy policy to begin using the website.

LoggingyourpracticesessionsandscoresaremandatoryandwillbescrutinisedatARCP.

Fortraineeswiththehighestscore,therealsoisatop5leaderboardforbothgroupsonthe website.

Trainerscanvalidateyourscoresviaanemailalertthatworksthroughthewebsite.Localtrainerleadshavebeen addedtothesystemtovalidateassessments. However, a local consultant trainer who is not on the list but is happy to validate your assessment, can be added to this bank of assessors by emailing (redacted)

MISTELs equipment required

1.



2.



3.



Modified MISTELs instructions and scoring

For all tasks the timer starts when the instruments are inserted into the simulator.

Task	Task detail and penalty	Allowed time(AT)	Time taken (TT)	Penalty	Score(AT–TT–penalty)
1	Ball transfer–transfer6ballsfromthecontainertothestandswithone hand then replace them in the container with the other hand Penalty–dropped or misplaced peg=16points	300seconds			
2	Circular cutting–cutpre-drawn5cm^{2}circlefromgauze/glove Penalty–percentage of area of deviation from a perfect circle	300seconds			
3	Intracorporeal knot tie–knot placed through two pre-marked points on cut Penrose drain/suture model Penalty-Failed/insecure knot=50points;Numberofmmfrommarked position = penalty; Number of mm gap if edges failed to approximate = penalty	600seconds			
	Overall score				

Trainee : _____

Assessor : _____ Date:_____

Closure of enterotomy and omental patch Setup

NB 1.Moisten swab prior to use

2. Timer starts when instruments inserted into the simulator–NOT when the needle mounted

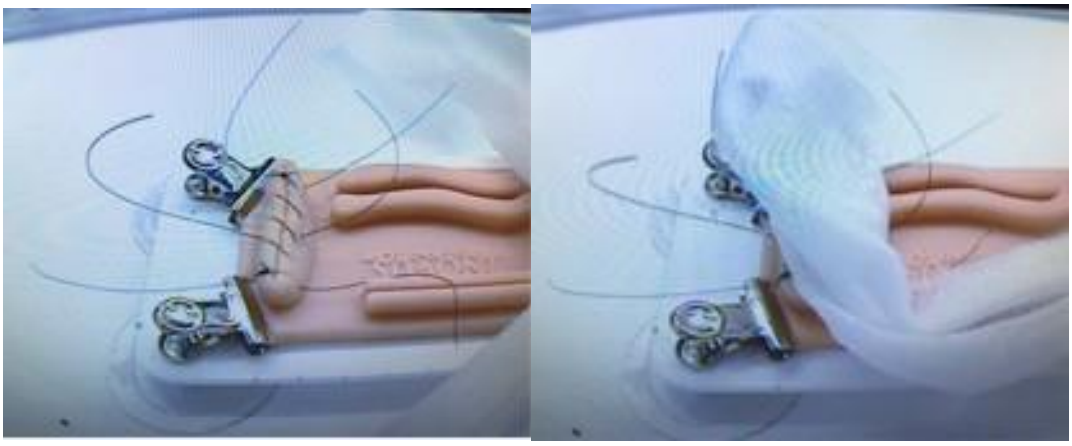


Technique

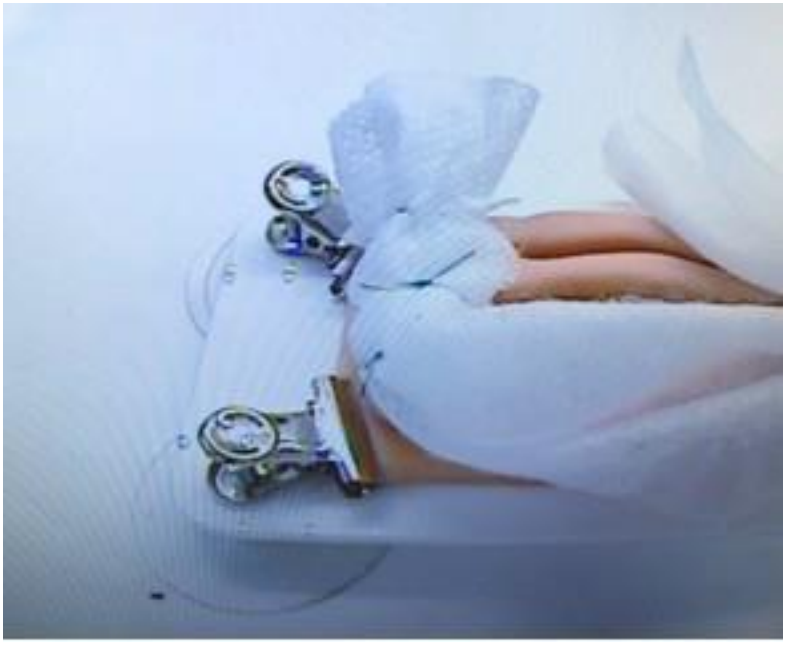
1. Performclosureofenterotomywithcontinuoussuture–anyappropriatemethodof knot tying is allowed (intra-/extra-corporeal).



2. Selectappropriateomentalpatchandplacex3serosalinterruptedsuturestofix patch in place.



3. Tiesuturesusingappropriatemethodtoholdpatchinplacewithappropriate tension.



Closure of enterotomy and omental patch scoring guidance

Level	**Score**
Guidance required OR Development needed	0
Minimal guidance/lacking fluency OR Satisfactory	1
Fluently performed without guidance OR Outstanding	2

Procedure

Enterotomy closure and omental patch-Steps	**Score**
Performs adequate continuous closure of enterotomy	
Identifies and selects appropriate omental patch	
Places sutures inadequate position adjacent to enterotomy	
Sutures patch in place adequately–sutures not too loose or tight	
Follows an agreed, logical sequence or protocol for the procedure	
Consistently handles tissue well with minimal damage	
Demonstrates a sound technique of knots and sutures/staples	
Uses instruments appropriately and safely	
Proceeds at appropriate pace with economy of movement	
Total	

Trainee: _____

Assessor: _____ Date: _____

The Inovus AR laparoscopy simulator



Figure 21 Inovus Augmented Reality (AR) laparoscopic box trainer setup used during the regional training day. The image shows a trainee performing a simulated laparoscopic task using the Inovus box trainer connected to a laptop interface that displays real-time visual feedback of the operative field, with an AR overlay



Figure 22 Augmented reality (AR) Inovus laparoscopic box trainer used in the simulation training programme. The Inovus Medical® LapAR system integrates physical laparoscopic instruments with an AR interface displayed on a connected laptop, enabling real-time visualisation of simulated intra-abdominal procedures

Section D:

Simulation Log for VR VirtaMed Pilot

Tabulate:

Date

Time spent for the session (in mins)

Device used: Box trainer/VR machine Activity performed

Thoughts/reflections

Section E:

Baseline questionnaire (and where the results are reported in this thesis)

1. Were you on track in your training before the pandemic, with regards to the various aspects of the training? (table, in chapter)
2. Did the pandemic affect your training? How? Which areas of training are still on track and where do you think you need support? (table, in chapter)
3. What are your personal learning objectives from this simulation programme? (table, in chapter)
4. Describe the role simulation has played in your training so far. Think of the various forms of simulation- simulation to improve technical skills (e.g., laparoscopic box simulators, robotic surgery simulator), simulation to improve non-technical skills (e.g., team-based simulation) or a combination of the two. (table, in chapter)
5. How frequently have you engaged with simulation before? Give examples where possible. (table, in chapter)
6. What are the barriers in your experience to inculcating simulation into your routine? (table, in chapter)
7. Has your past experiences of simulation made an impact on your training? Expand with examples. (table, in chapter)

8. In your opinion, what are the expectations with regards to this 3-month pilot using a virtual reality simulator in combination with the home laparoscopic box trainer? Do you expect this experience will be of benefit? What do you predict will be the challenges during this programme? (table, in chapter)
9. Rate your confidence in performing a laparoscopic appendicectomy on a scale of 0-10, with 0 being the lowest confidence rating
10. Rate your confidence in performing a laparoscopic cholecystectomy on a scale of 0-10, with 0 being the lowest confidence rating
11. Rate your confidence in managing intra-operative complications (e.g., vascular injury during a laparoscopic cholecystectomy) on a scale of 0-10, with 0 being the lowest confidence rating
12. Overall, as a surgical registrar, how confident do you feel managing the on call? Rate your confidence on a scale of 0-10, with 0 being the lowest confidence rating
13. Overall, as a surgical registrar, how confident do you feel managing an elective theatre list independently? Rate your confidence on a scale of 0-10, with 0 being the lowest confidence rating
14. Do you think the pandemic has had an impact on your confidence to do your job? In which area (managing an on call, running a theatre list, performing specific surgeries, managing complications) has your confidence been affected the most? Can you quantify this change using the confidence rating scale of 0-10, with 0 being the lowest confidence rating? E.g.: I was 8/10 confident in performing this procedure before the pandemic but now I'm 6/10.
15. Using the confidence scale described above, how confident do you think a surgical trainee should be at CCT/ as a new consultant? Do you think you are on track to achieve that?
16. Do you think this simulation training will help improve your confidence rating?

Section F

Follow-up questionnaire

Impact on individual skills with simulator use

From a scale of 1 to 10, indicate how useful the simulator was to improve this skill with 10 being the most useful. Also, please comment on the impact use of the simulator has had on each of the following skills.

Q1: Hand-eye coordination: 1 2 3 4 5 6 7 8 9 10 (table, in chapter)

Q2: Economy of movement: 1 2 3 4 5 6 7 8 9 10 (table, in chapter)

Q3: Learning/practising the steps of the operation: 1 2 3 4 5 6 7 8 9 10 (table, in chapter)

Q4: Planning ahead and anticipating complications: 1 2 3 4 5 6 7 8 9 10 (table, in chapter)

Q5: Managing complications: 1 2 3 4 5 6 7 8 9 10 (table, in chapter)

Q6: Are there any other skills this simulator training helped improve? List them below with your comments and use the scale to help us understand how useful the simulator was

1 2 3 4 5 6 7 8 9 10 (table, in chapter)

Feedback after use of the VirtaMed simulator

Q1: Frequency of simulation use- Were you satisfied with how frequently you used the simulator? Would more use have benefitted you? Expand on your answer (thematic analysis)

Q2: What was the biggest challenge for using the simulator? (thematic analysis)

Q3: What is the simulator good at, in terms of the hardware/software/ interface/programming/ exercises available? (thematic analysis)

Q4: What can be improved with the simulator? Where there any difficulties with using the machine itself? (thematic analysis)

Potential uses for the simulator

Q1: Stage of training- In your opinion, at what stage of training (CT1,2, ST3… etc) is this simulator most useful for? Why? Or do you think there are benefits to using this simulator at any stage of training? (thematic analysis)

Q2: Could this simulator be used to assess trainee technical skills? Please expand on your answer. (thematic analysis)

Q3: Could this simulator be used as part of a combined technical skills & non-technical skill team simulation? E.g.: A scenario where you are the primary surgeon operating on the simulator where a complication arises, and you are expected to manage the complication in a simulated theatre with the wider MDT team (anaesthetists, theatre staff etc). (thematic analysis)

Q4: Were you able to practise on a department/home lap trainer box? Expand on your answer as to what the impact of this practice was? Or if you did not, what were the barriers? (thematic analysis)

Were personal objectives met? Impact on confidence

Q1: You had listed your personal objectives for the 3-month simulation pilot. Were these expectations met? Expand on how the simulation did or did not help you meet your personal objectives. (table, in chapter)

Q2: Did the simulation training have any impact on confidence in operating/running the on call/managing complications/overall confidence? (thematic analysis)

Section G:

Interview guide

Introduction:

1. Introduce myself and the purpose of the interview.
2. Explain the semi-structured nature of the interview (allowing for both pre-determined questions and the opportunity to share experiences and insights)
3. Confidentiality and informed consent
4. More detailed responses are welcome.

Comparing VR and AR Simulators

Goal: Compare the experience of using VR vs AR. Does the platform matter for learning?

1. Tell me about your experience of using the VR simulator. (thematic analysis)
2. How would you describe your experience using the Augmented Reality (AR) simulator in comparison to the VR simulator? (thematic analysis)
3. What are the main advantages of using AR for surgical training? In your opinion, what are the main limitations of the AR simulator? (thematic analysis)
4. In your opinion, in what ways does the platform (VR vs AR) make a difference in terms of learning and skill development? Please elaborate. (thematic analysis)
5. Does frequency of use of a simulator have an impact on learning? Do you think you see a benefit even when you use it infrequently? (thematic analysis)

Structured Approach to Technical Skill Simulation

Goal: Determine the impact of a structured approach on adherence

1. Did you find the structured approach beneficial for your learning and skill development? Why or why not? (thematic analysis)

2. Did the structured approach affect your adherence to the training program? If so, in what ways? (thematic analysis)

Impact of Simulation Training on Real-Life Practice

Goal: Assess the impact of simulation training on real-life practice

1. Has simulation training had an impact on your real-life surgical practice? Can you provide examples of specific skills or techniques that you have improved or implemented as a result of simulation training? (thematic analysis)

Ideal Integration of Technical Skill Simulation into Training

Goal: Determine trainees' perspectives on implementing simulation training into surgical training

1. In your opinion, what would be the ideal way to implementing technical skill simulation into the general surgical training programme? What aspects of sim training do you think could be improved or enhanced to make it more effective? (thematic analysis)
2. Are there any specific resources or support systems that you believe would facilitate the integration of sim training into the training programme? (thematic analysis)

Closing:

Do you have something else you would like to add to what we have discussed?

Section H:

Response from CTRG



Joint Research Office
enabling successful research through coll

Oxford University Hospitals
NHS Foundation Trust

Miss Aditi Siddharth
DPhil student
Nuffield Department of Clinical Neurosciences & OxSTaR,
University of Oxford
by email

8 August 2022

To whom it may concern

Understanding the role of a virtual reality (VR) simulator in simulation training for surgeons in the Thames Valley Deanery

This letter is to confirm that representatives of the Joint Research Office study classification group have reviewed the work referenced above.

It was determined that the activity described is best understood as an evaluation of training. As such, it is not subject to the Department of Health's *UK Policy Framework for Health and Social Care Research* (2017). It requires neither sponsorship nor research ethics review.

This opinion can be reviewed by reference to the HRA's algorithm, available at http://www.hra-decisiontools.org.uk/research/ and attendant leaflet, *Defining Research,* or by reference to The Health Care Quality Improvement Partnership (HQIP)'s *Guide for Clinical Audit, Research and Service review.*

Should you require further information, please do not hesitate to contact me.

Sincerely,

DocuSigned by:
BA168DF4624B463...

Dr Karen Melham
Sponsorship and Ethics Lead

Research Services | Research Governance, Ethics & Assurance Team
University of Oxford, Boundary Brook House, Churchill Drive, Headington, Oxford OX3 7GB
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researchsupport.admin.ox.ac.uk

Figure 23 Response from CTRG

Section I:

Qualitative and quantitative data generated by the VR study

Anonymised abridged transcript (and the corresponding themes/subthemes where applicable)

This appendix presents the anonymised transcripts of the semi-structured interviews conducted with seven general surgical trainees (Trainee 1 to Trainee 7) who used the virtual reality (VR) laparoscopic simulation, had been exposed to other types of simulation during their training and later trialled an AR simulator as part of their regional training. The interviews explored trainees' perceptions of simulation within their surgical education, including engagement, motivation, structure, and perceived educational value.

To protect confidentiality, all identifying details- including personal names, hospital sites, geographical references, and employer identifiers - have been removed. The participants' numerical identifiers correspond with those used in the main text of Chapter Seven, ensuring traceability without compromising anonymity.

While every effort has been made to retain the integrity and tone of the interviews, minor edits were undertaken for clarity and readability before placing the transcripts into this appendix. These included:

- correction of typographical and grammatical errors from the original transcripts I had used for thematic analysis
- removal of verbal fillers, repeated words, or incomplete sentences that did not affect meaning; and

- condensation of interviewer prompts and extended conversational interjections to ensure conciseness and suitability for inclusion within a written thesis.

No substantive content, interpretation, or participant meaning was altered. Any sentences removed were done solely where repetition or potential identification risk occurred, and such omissions.

Trainee 1

A: What was your experience using the VR simulator and how would you describe your experience today using the AR simulator compared to the VR simulator?

Trainee 1: The VR simulator surprised me with how much better the software has become- it was not glitchy, the instruments actually tracked properly through space, and the exercises seemed relatively appropriate, like the appendix. The bad points on that VR simulator were that some of the task-based "games" were not particularly challenging or did not push what you can do on the simulator. The haptic feedback provided some sense of resistance, which felt quite good, but it was still somewhat lacking, particularly with suturing. Some bits were a little glitchy overall.

A: How did today compare?

Trainee 1: Today was very brief, but I think that the physical nature of what you are working on is helpful. Being able to use your own instruments is good and having that tactile feedback is really important for surgery, particularly laparoscopic surgery.

A: If you had to choose between AR and VR, which would you prefer for your training, and why?

Trainee 1: That is difficult to answer because we spent far more time with the VR system going through the different tasks. Today we only had a brief task, so I can't extrapolate completely. From first principles, I think it makes sense that a more haptic or tactile system like AR is potentially more applicable to what we need, but it might be more limited in terms of the number of models and exercises available. If I think of something like the robotic simulator, that system has many, very good exercises to train you for certain tasks. So, a well-designed VR simulator with good software

could be excellent, but for laparoscopic work I can see why having these physical models is useful. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: choosing the correct motivating target)]*

A: What did the robotic simulator have that these two experiences didn't capture?

Trainee 1: The robotic simulator accepts that you will not get tactile feedback- that's just how the robot works- but its software is much better. Someone has clearly spent more time developing the tasks to make them useful. The best tasks don't necessarily have any anatomical relevance.
It's gamified to improve your skill: you might be passing needles through tissues, for example, and the key is that the sponge or tissue model behaves realistically. When you pass the needle through, the motion looks and feels as you expect. That realism is what matters.

A: What do you think is the impact of frequency of simulator use?

Trainee 1: Practising suturing on a box trainer- the more you do it, the better you get. I'm sure the same is true with VR. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: periodic vs frequent engagement)]*

A: So, you think frequency is a key element of simulation?

Trainee 1: To a point. You need enough repetition to get past your learning curve. Once you've reached your plateau, there's probably limited extra benefit, but there'll be a minimum number of times you must repeat a task. That applies to VR, robotic and other trainers- you need that skilling-up period before you consistently achieve good scores. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: periodic vs frequent engagement)]*

A: What about using a structured approach to simulation, like the way we did with the VR programme (baseline, midpoint reminders, etc.) compared with unstructured access?

Trainee 1: It has to be structured. People won't use resources unless they are incentivised. If you say trainees must clock up a set number of hours and achieve target scores, they will do more and benefit from it. *[Theme 1 – Varied motivators encourage engagement with simulation (subtheme: structured use and ARCP accountability)]*

A: Has simulation enhanced your daily surgical work?

Trainee 1: I came to simulation quite far into my training, so I don't think it's had a big impact. But I can see that I would have gained a lot if I'd had access earlier. *[Theme 2 – Early introduction of simulation in surgical training (subtheme: early exposure)]*

A: Are there particular examples where you wished you had used, or were glad to have used, simulation?

Trainee 1: Always suturing techniques- those are key laparoscopic skills- and dissection. The software isn't yet advanced enough to teach complex anatomy or difficult cases. These trainers are most useful for needle handling, suturing and economy of movement. For junior trainees, they help understand instruments and spatial relationships – how to use the camera and instruments in space. *[Theme 2- Early introduction of simulation in surgical training (subtheme: teach before real life operating)]*

A: Is there an ideal way to integrate simulation into training?

Trainee 1: An AR trainer would be very helpful at SHO level. The jump from holding a camera to operating is big. Trainers would prefer to know someone has had structured practice before performing in theatre. At registrar level, trainees coming onto upper GI or suturing-intensive jobs should develop those skills early. When software improves, it could help people practise complex pathology and scenarios, not just the simple ones. Pilots get difficult simulations; we only get easy ones. *[Theme 2- Early introduction of simulation in surgical training (subtheme: simulation first before operating)]*

A: Do you think access during medical school would have helped?

Trainee 1: Probably not for me- but times have changed, and simulation will likely play a bigger role in the future.

A: How could simulation support assessment or recruitment?

Trainee 1: It would require a long programme with repeated assessments to differentiate levels of ability. Most people can be trained, though some find hand-eye coordination harder. It might identify a few unsuitable candidates, but it wouldn't perfectly predict success.

A: What resources or systems would help integrate simulation into training?

Trainee 1: It needs to be available locally – each hospital should have one. We need dedicated skills labs, people to maintain them, regular sessions (weekly or fortnightly), and a clear curriculum with assessments. Targets keep people engaged. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: ease of access and accountability)]*

Trainee 2

A: Tell me about your experience with the virtual reality simulator and how it compares to augmented reality.

Trainee 2: The augmented-reality experience was vastly better. As much as VR tries to mimic haptic feedback, with AR there's nothing quite like handling something physical. You can inspect your stitch by taking out the model and physically looking at it-seeing it on a screen is one thing, but physically checking tension and accuracy is another. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: realism and feedback)]*

A: What do you think are the advantages and limitations of using simulation like augmented reality for training as compared to all other types of simulation or no simulation at all ?

Trainee 2: The benefit is that it's a less-pressured environment to practise in, and it's easier to get feedback automatically without relying on self-assessment. It's good to have around.

A: Does frequency of use affect what you get out of simulation?

Trainee 2: Of course, the more you practise, the better, but there's a fine balance before it becomes a tick-box exercise. Once that happens, people focus on quantity instead of quality. A few well-spaced, meaningful sessions can already make you better than before. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: periodic vs frequent use)]*

A: Would less frequent use still help?

Trainee 2: Yes- as much or as little as needed. I know it's hard to justify cost if people use it

infrequently, but allowing flexible access is better. Making people use it just to meet numbers encourages gaming the system.

A: How did the structured VR programme feel compared with open access?

Trainee 2: I appreciate the reason for a structured programme – people are less likely to use it if it's always just there. For me, as a senior trainee, I take responsibility for my learning: if I'm on a job with plenty of laparoscopic work, I may not need to use the simulator; if I'm on a rotation with little laparoscopy, I would. The option to use it when it's valuable is better than forcing it. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: structured vs self-directed use)]*

A: Would it help to focus simulation on posts with less laparoscopic exposure?

Trainee 2: Exactly. That would be better, though it requires organisation. Many of us don't live in [Redacted for anonymising] where the simulator was located. After a full laparoscopic day, driving back to meet targets doesn't feel justified. But when you're in a non-laparoscopic job, you miss those skills and think, "I should practise." *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: emphasis for limited opportunities)]*

A: Would the portability of the AR simulator help?

Trainee 2: Yes, totally. It's just a box trainer and a laptop- easy to transport. It would hugely benefit people in non-laparoscopic posts who wouldn't have to come into work in the evenings. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: ease of access)]*

A: How has simulation helped you in your real job?

Trainee 2: Mainly laparoscopic suturing. You can get deskilled after time away, so it's good for top-ups. Learning simple procedures like appendicectomy is more relevant to juniors, but having simulators that guide you through operative steps would be extremely useful- especially for major operations where remembering the sequence can be difficult. *[Theme 2- Early introduction of simulation in surgical training (subtheme: practising steps of an operation)]*

A: Would simulation be useful for medical students?

Trainee 2: For students, it's more about camera-holding skills than cutting. AR doesn't teach that yet, but that would be ideal.

A: What about using simulation for recruitment?

Trainee 2: It's good. When I interviewed, we had a laparoscopic skills station. Simulation can test skill progression and provide objective evidence over time rather than just a single performance under pressure.

A: Anything else to add?

Trainee 2: For me, learning and reinforcing the **steps of an operation** is the key thing missing. Textbooks are outdated and rarely integrate laparoscopic work. Simulation could fill that gap. *[Theme 2 -Early introduction of simulation in surgical training (subtheme: teaching through simulation first)]*

Trainee 3

A: Can you talk me through your experience of using VR simulation compared to today's experience of using AR simulation?

Trainee 3: I think they are both good simulators. The difference was that when we used the VR simulator, there were no suturing modules- that was a disadvantage. It was quite limited in terms of modules. It was just appendix, hernia and gall bladder for general surgeons. Once you have mastered them, it becomes routine and boring. They are promising more modules soon on this AR simulator, so hopefully there will be more. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: variety of exercises)]*

A: What about the actual feel of doing things?

Trainee 3: Both of them feel nice. Both give good feedback.

A: So, you think the tactile feel is equal?

Trainee 3: I think so. It's quite subjective, though. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: realism and feedback)]*

A: You were one of the people who used the VR simulator the most. Why was that?

Trainee 3: It's because I was local here [Redacted for anonymising] and I had a lot of time. I just used it. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: ease of access plays a critical role)]*

A: What do you think is the impact of frequency of use on what you get out of simulation?

Trainee 3: The more you use it, the better you become – it's as simple as that.

A: Is there a ceiling to that?

Trainee 3: I think initially if you want to master it, the more you use it, the better. Then maybe you can reduce the number of sessions once you are happy, just to maintain skills. When I was ST4 in [Redacted for anonymising], I used the box trainer for suturing a lot initially. I mastered it, and after that I could go months without practising and still pick it up quickly again. Initially you need more sessions to learn; then fewer to maintain. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: periodic vs frequent engagement)]*

A: With the VR programme, it was structured, with targets and a set of exercises to complete. How did you find that?

Trainee 3: It's nice to have structure, especially when you start and you're a novice. Once you've done all the structured training, it's nice to have some variety and self-direction. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: structured vs self-directed practice)]*

A: Which experience did you find most useful?

Trainee 3: When I started VR simulation, I had already done a lot of laparoscopic work – over 200 appendicectomies and 100 cholecystectomies. So, it's hard to say how it helps someone without experience. Simulation is useful for people who haven't done anything in theatre. It's good for them to learn the basics so trainers can then teach them procedures rather than simple skills. When trainees struggle with basics, it's difficult to spend time teaching them on patients. They should pick up those basic skills before coming to theatre – that's what simulators are for. *[Theme 2- Early introduction of simulation in surgical training (subtheme: simulation first before operating)]*

A: So, if you were to design an ideal surgical training programme, what would that look like?

Trainee 3: People who know early that they want to do surgery should start basic skills training from medical school or foundation level. By core training they can be ready to operate on appendices or do diagnostic laparoscopies. For trainers it's good to have people already confident in basic skills. The problem is you can't make people learn. They have to be motivated to use simulation themselves. We have so many boxes in hospitals, but no one uses them. They're in on-call rooms, sitting idle. People want to operate, but they're unwilling to practise. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: motivation and access barriers)]*

A: Has simulation helped you in real life?

Trainee 3: Yes, especially suturing. I used to practise a lot – suturing, suturing, suturing – and later when I was on the upper GI firm, the consultant could see I was capable, so I was allowed to perform. It works that way: if you show you can do it, people will let you do more. *[Theme 2- Early introduction of simulation in surgical training (subtheme: building confidence through practice)]*

Trainee 4

A: You've done both VR and AR simulation. How do they compare?

Trainee 4: The tasks were the same. On VirtaMed (VR), the focus was on lap appendicectomy. The AR system surprised me- I thought it would be fully virtual, but it had a real physical model with virtual overlay. That took a bit of time to get used to. With VR, you accept that it's not fully realistic, but you can adapt faster. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: realism and feedback)]*

A: Do you think frequency of use matters?

Trainee 4: Whether simulation or not, the more times you do something, the better you get. But simulation often repeats the same scenario, and each operation in real life is different. Even so, practising the steps is still valuable. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: periodic use)]*

A: Do you think simulation helps to learn the steps of an operation?

Trainee 4: Yes, definitely. Simulation is particularly good for learning procedural steps. When you're a bit more junior and you don't know how to do an operation, being able to practise the full sequence is valuable. In theatre you may only do parts, simulation allows you to go through the whole thing. It builds confidence and familiarity with what comes next. *[Theme 2- Early introduction of simulation in surgical training (subtheme: learning steps of an operation)]*

A: Do you think structured repetition helps?

Trainee 4: If you repeat a task several times you get better. Even if told to do it five or ten times, the practice helps. I think people adhere to programmes when required to do them. There's value in repetition but also in simple box training.

A: Has simulation helped you in real life?

Trainee 4: Not sure I can pinpoint a direct example, but being familiar with instruments and basic laparoscopic skills from simulators is valuable. I wouldn't want to be suturing laparoscopically for the first time on a patient. *[Theme 2-Early introduction of simulation in surgical training (subtheme: simulation first before operating)]*

A: How early do you think simulation should be introduced?

Trainee 4: From when you choose a surgical career – CT1 at the latest. It can only help. *[Theme 2-Early introduction of simulation in surgical training]*

A: What about feedback?

Trainee 4: The simulators give data and step-by-step videos, which is good. It would be even better to show your performance to a consultant or have AI feedback. I'm cynical about some metrics – path smoothness or distance moved – those don't mean much. But seeing data for yourself and for a whole cohort across years would be interesting. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: structured review and ARCP accountability)]*

Trainee 5

A: How did the VR simulation compare to the AR?

Trainee 5: I'd only used the VR simulator infrequently. I found the AR one limited- you can't choose your instruments, no diathermy. You have to use scissors for the appendix, which leads to bleeding that wouldn't occur if I could choose the proper instrument. The VR was clunky and difficult to use; it took 20 minutes to work out how to select instruments. I wouldn't rush back to [Redacted for anonymising] to use either one. They're still not realistic enough. *[Theme 1-Varied motivators encourage engagement with simulation (subtheme: ease of access and realism)]*

A: Have you liked any simulation before?

Trainee 5: Box trainers are useful for laparoscopic suturing, but simulated operations aren't there yet. Every new version gets a little better in haptic feedback, so we're getting closer.

A: How would you integrate simulation ideally?

Trainee 5: Robotic simulation seems to have the best programme. For laparoscopy, access and assessments are key. People won't practise unless there's assessment. Access isn't always easy – at [Redacted for anonymising] it took 15 minutes each way and the room was often locked. Teaching matters too. No one has formally taught me laparoscopic suturing - I learned from YouTube. We need trained teachers, so we don't pick up bad habits. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: teaching and motivation)]*

A: Has simulation impacted your real-life work?

Trainee 5: No, not really, but that's partly because access wasn't easy or the simulators weren't user-friendly. The robotic simulator might change that. *[Theme 2- Early introduction of simulation in surgical training]*

A: What would you do differently if you were in charge of surgical training?

Trainee 5: Simulation should start from day one-core training- progressing in line with trainee development. It needs structure and proper teaching. Like when I first learned to stitch skin on a

model; it seems odd that we then learn a gallbladder on patients with nothing in between. Patients would prefer us to have done it first on realistic simulators. *[Theme 2- Early introduction of simulation in surgical training (subtheme: teach via simulation first)]*

Trainee 6

A: How was your experience with the VR simulator and today with the AR simulator?

Trainee 6: I already had some idea that VR isn't the best model. I've done a master's in simulation, so had more exposure than average. VirtaMed actually exceeded expectations- it was better than I thought. It still had the usual limitations: it tries to be realistic but isn't entirely, limited by processing power. It's a good tool to learn the cognitive steps of a procedure but not for transferring technical skill to theatre. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: realism and feedback)]*

A: How does the AR compare?

Trainee 6: The AR system builds from a low-fidelity box trainer but adds realism around the operative field. The potential is in adding AI that tracks instruments, measuring force and movement. If the system could track pressure on tissue, tension, and instrument economy of motion, it would be brilliant. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: realistic feedback)]*

A: Does frequency of use matter?

Trainee 6: Definitely. Frequent training on a box trainer correlates with better intraoperative skills. I started intracorporeal suturing on humans last year but had practised since 2016 on boxes. The translation was clear – it improved my confidence and performance. There's a learning curve- rapid early improvement then gradual gains- but no true plateau. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: frequency and motivation)]*

A: What about structured programmes?

Trainee 6: Structured training is definitely better, but you must target by skill level, not training year. Baseline tests could tailor learning plans like language courses- measure ability first, then assign appropriate exercises. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: individualised targets)]*

A: What would an ideal integrated programme look like?

Trainee 6: Start at CT1 learning steps (e.g., appendicectomy) on simulation. Then move into theatre, with feedback that combines simulation metrics and live performance. Simulators should be located in theatres for warm-up practice between cases. Having easy access "plug in and go" makes it part of everyday work. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: access and workflow integration)][Theme 2- Early introduction of simulation in surgical training (subtheme: simulation combined with real-life training)]*

Trainee 7

A: Describe your experience with the VR simulator and how it compares with the AR simulator.

Trainee 7: One advantage of the AR simulator is the haptic feedback and the ability to approach procedures in multiple ways. It doesn't penalise you for taking a safe alternative route. The VR simulator was fun and game-like for tasks, but the procedural modules (like appendicectomy) were rigid- it marked you down if you deviated from its set order. As surgeons, we want to score well, so that rigidity can be frustrating. Simulation should be tailored to the trainee's level- if you've already logged your appendicectomy numbers, you shouldn't be doing that module again; move to colectomy instead. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: gamification and tailored progression)]*

A: Does frequency of use impact results?

Trainee 7: Yes- the more frequently you use it, the more you progress. If your firm isn't doing many laparoscopic cases, simulation is essential to maintain your skills. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: emphasis for limited opportunities)]*

A: What do you think about structured use?

Trainee 7: I like the robotic simulator model – you must reach 90% on an exercise before moving on. Everyone learns at different rates. Some achieve 90% in five attempts, others in thirty. The key is performance, not repetition count. Have a set of baseline tasks everyone completes to 90%, then tailor advanced modules to what each person needs. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: performance-gated progression)]*

A: Has simulation helped you in real life?

Trainee 7: Yes. When I used virtual and robotic simulators earlier, it helped me learn steps and techniques. When I later did live surgery, I already had confidence and familiarity. With robotics, simulation is vital before using the real system because it lacks haptic feedback. The AR simulator's tactile realism helps bridge that gap for laparoscopic training. *[Theme 2- Early introduction of simulation in surgical training (subtheme: teaching before live operating)]*

A: What would ideal integration look like?

Trainee 7: There should be regular protected time- a half-day weekly or fortnightly in the timetable, like teaching sessions. During that time, trainees should work on meeting their individual simulation goals, such as maintaining scores above 90%. Simulators should be near theatres, quick to start, and available for short practice before cases. I'd also like to upload videos for ergonomic feedback and include video evidence of skills in training portfolios. *[Theme 1- Varied motivators encourage engagement with simulation (subtheme: accountability and ARCP oversight)][Theme 2- Early introduction of simulation in surgical training (subtheme: structured protected practice)]*

Trainee number	Training grade at the time of the VirtaMed study	Baseline score	Final score
Tr 1	ST5	631	7071
Tr 2	ST5	373	444
Tr 3	ST5	937	16832
Tr 4	ST4	379	5469
Tr 5	ST3	359	359
Tr 6	ST4	377	1979
Tr 7	ST6	382	973
Tr 8	ST3	368	1621
Tr 9	ST4	287	7145
Tr 10	ST5	340	1288
Tr 11	ST6	362	1687
Tr 12	ST7	395	1896
Tr 13	ST4	386	2807
Tr 14	ST6	367	367

Tr 15	ST7	317	453
Tr 16	ST7	391	606
Tr 17	ST5	391	1098
Tr 18	ST6	383	3017
Tr 19	ST3	387	7116
Tr 20	ST5	136	1542
Tr 21	ST3	385	9858
Tr 22	ST4	376	3417

Table 30 The baseline and final scores generated by the VirtaMed™ VR laparoscopic simulator for each trainee participant (Trainee 1 to 22). Scores represent the simulator's proprietary composite performance metric, calculated from multiple parameters including time taken, instrument economy of movement, accuracy, and error rate. The "Baseline score" reflects the participant's initial performance during the introductory session, and the "Final score" represents the final assessment recorded score at the end of the structured training period. These data are included for completeness and transparency but were not used for inferential statistical analysis in this study; rather, they provide contextual information to complement the qualitative findings presented in Chapter Seven

Trainee No	Hand eye coordination	Economy of movement	Learning/practising steps of the operation	Anticipating complications	Managing complications	Any other skills	Any other skills improvement score
Tr 1	8	8	3	3	3	8	Very good for training juniors on 30degree scope Excellent in familiarising students on different types of instruments
Tr 2	7	8	7	7	8	No	No
Tr 3	8	8	3	8	7	No	No
Tr 4	4	4	7	4	5	No	No
Tr 5	8	8	5	7	8	No	No
Tr 6	2	2	2	2	5	No	No
Tr 7	8	9	7	5	8	No	No
Tr 8	8	8	9	7	7	No	No
Tr 9	7	8	8	7	7	No	No
Tr 10	3	3	8	6	1	No	No
Tr 11	5	4	6	4	4	No	No
Tr 12	7	7	6	4	4	No	No
Tr 13	4	8	8	6	8	No	No
Tr 14	10	8	9	7	9	No	No

Tr 15	5	3	6	3	5	No	No
Tr 16	6	6	6	6	5	6	Helps build awareness of operative steps
Tr 17	8	8	6	6	8	No	No
Tr 18	8	7	7	6	9	No	No
Tr 19	7	8	4	2	2	7	Adopting comfortable operative position
Tr 20	2	2	1	1	1	No	No
Tr 21	6	6	8	3	4	No	No
Tr 22	6	6	4	2	4	No	No

Table 31 Trainees (Tr 1 to Tr 22) rated the perceived usefulness of the VR simulator for selected technical domains on a scale from 1 to 10 (1 = not useful at all; 10 = extremely useful). Any other skills are the free-text responses from the follow-up questionnaire relevant to additional perceived benefits; only quotes provided in this section of the questionnaire are included

Trainee number	Laparoscopic appendicectomy (confidence 0–10; 0 = none, 10 = fully confident)	Laparoscopic cholecystectomy (confidence 0–10)	Managing intra-operative complications (confidence 0–10)	Managing the on-call as registrar (confidence 0–10)	Running an elective theatre list (confidence 0–10)	Reported impact of COVID-19 on confidence	Expected confidence at CCT (0–10 / narrative)	Anticipated effect of simulation training on confidence
Tr 1	8	8	7	8	8	None	9	No, not at this stage of my training
Tr 2	8	7	5	8	6	Specific cases has been affected as less operating	9	Yes
Tr 3	9	8	7	9	8	None	10	Yes
Tr 4	7	5	4	9	4	Some	9	Yes
Tr 5	7	5	4	5	3	None	10	Yes, indirectly
Tr 6	10	9	7	7	10	None	10	Yes
Tr 7	9	8	4	8	8	None	9	No
Tr 8	8	3	1	9	2	Reduced operating, not confidence	9	Yes

Tr 9	7	6	6	8	7	The pandemic has resulted in several elective non cancer procedures to be cancelled which have subsequently impacted on training	I believe upon CCT, a trainee should be able to manage the acute surgical take efficiently and be able to practice independently within their own speciality of interest	Yes
Tr 10	10	7	8	10	9	None	Not sure	Yes
Tr 11	10	8	8	9	7	None	10	Yes

Tr 12	9	9	8	9	8	None	10	Yes
Tr 13	9	7	4	9	8	None	9	Yes
Tr 14	9	8	7	9	9	None	9	Yes
Tr 15	9	9	8	9	7	None	9	Perhaps. It depends on the quality of the simulation. Dealing with complication in a simulator doesn't compare to a real-life situation unless you have the added pressures of non-technical skills, unstable patient etc.
Tr 16	9	7	7	7	7	None	9	Unsure, happy to try
Tr 17	10	10	8	10	8	None	10	No
Tr 18	8	5	5	9	7	Some, slow return to operating post pandemic	Not sure	Yes

Tr 19	7	6	1	8	2	Some, low case numbers	9	Yes
Tr 20	9	9	7	8	2	None	Not sure	Doubtful, but worth a try.
Tr 21	8	4	4	7	5	None	9	Unsure
Tr 22	9	6	3	8	6	Some	9	It does have the potential to, particularly if expanded to deal with both technical and non-technical skills.

Table 32 Data were derived from the baseline questionnaire, completed before starting the virtual reality (VR) simulation programme. Trainees rated their confidence (0–10 scale; 0 = no confidence, 10 = fully confident) across key surgical and management domains, including performing laparoscopic appendicectomy and cholecystectomy, managing intra-operative complications, taking surgical on-call, and running an elective theatre list. Additional responses describe the reported impact of the coronavirus disease 2019 (COVID-19) pandemic on confidence, the expected confidence level at Certificate of Completion of Training (CCT), and whether trainees anticipated that simulation training would improve confidence. All ratings and statements reflect self-reported perceptions rather than objectively assessed performance

Appendix Four- Documents related to the Ethnographic study in Chapter Eight

Details submitted to CTRG

Title:

Understanding the feasibility of teaching technical skills in a simulated obstetric on-call setting

Team:

Miss Aditi Siddharth: Registrar in Obstetrics and Gynaecology, University of Oxford

Miss Flora Wong: Consultant in Obstetrics and Gynaecology, Stoke Mandeville Hospital

Miss Nadia Muspratt Tucker: Registrar in Obstetrics and Gynaecology, OUH

Miss Ruth Houlden: Consultant in Obstetrics and Gynaecology, OUH

Dr. Debbie Aitken: Lecturer in Medical Education, University of Oxford

Dr. Helen Higham: Associate Professor in Nuffield Department of Clinical Neurosciences and OxSTaR

Aims:

To explore trainees' perspective on learning and performing technical skills in tandem with non-technical skills in a simulated obstetric on call setting

Purpose:

Background:

Obstetric training in the United Kingdom is a 7-year programme during which time trainees are required to master a range of technical skills like performing caesarean sections and instrumental births [1]. There is a simultaneous emphasis on non-technical skills as a vital skill set of an effective obstetrician is to work cohesively within a multidisciplinary team. Non-technical skill (NTS) training with team-based drills is now a routine part of regular teaching in Obstetrics as it has been shown to improve patient safety and effective team working [2]. The Oxford trainees from the Thames Valley

deanery have regular sessions as part of their regional teaching days in addition to mandatory multidisciplinary team (MDT) simulations at their hospitals.

Technical skills for obstetric trainees are traditionally acquired using two methods: isolated simulation training and learning in a clinical context [3]. There are benefits to simulation training for technical skill which focuses on repetition and practice of a particular task including improving muscle memory and automatisation. However, this approach reduces technical skill acquisition to a one-dimensional model without considering the context of its application where affective skills are required to be applied like communicating with the patient and theatre team [3, 4].

Obstetric trainees routinely participate in team based NTS training as part of the regional teaching. This quality improvement project focuses on the incorporation of technical skills training into a team-based simulation of an obstetric on call. This helps increase the fidelity of the simulation by mimicking a real on call scenario. It also helps provide an environment where technical skills can be practiced along with the necessary affective skills. Qualitative methods will be used to collect data on trainee perception of this simulation. We aim to understand if it is feasible to incorporate technical skill training into the routine team-based simulations we deliver as part of regional training to enhance the learning opportunities for trainees from attending a single training session.

Design/method:

This project has been registered as a quality improvement project with the OUH trust- 8153.
All Obstetric specialist year 1 and 2 (ST1-2) trainees from the Thames Valley deanery have been invited to attend the regional training obstetric simulation day at the John Radcliffe Hospital (JRH) in February 2023. As part of the full day simulation training, one session is dedicated to team-based training simulating an obstetric on call to provide training for NTS, namely situational awareness, communication, and leadership skills. This session will be conducted in the training rooms on level 5 at the John Radcliffe hospital. The simulation training uses a bank of scenarios designed by context specific experts (consultant and registrars in Obstetrics who will also act as faculty on the day).

These scenarios are recognised diagnoses and emergencies in Obstetrics which occur routinely during an obstetric on call.

The objectives are:

1. Experience higher level of responsibility in the simulation than current training grade
2. Understand the demands of each clinical role (empathy for team members)
3. Learning technical skills (namely rotational delivery, conducting a ward round, managing maternity assessment unit) whilst practicing NTS

Description of the training:

All ST1-2 trainees will arrive at the level 5 training room at JRH. After faculty introductions, there will be a 5-minute discussion about the learning objectives for the session including discussing the ethnographic method (one faculty member will act as observer participant within the simulation, all faculty members will maintain an observation diary and audio recording) that will be used for data collection. Written consent will be taken from the participants (Section A). The group (14 trainees are anticipated to attend) will be divided into two groups- one group will participate in the simulation, whilst the other group will attend a session on ultrasound use in obstetrics. The two groups will swap over after the coffee break. The simulation will run over 45 mins with debrief to follow for 30 mins. There will be a 15-minute coffee break (refreshments provided) after which the groups will swap over.

The layout for the simulation is shown below (Figure 24):



Figure 24 Layout for the simulation (training room on level 5 of John Radcliffe Hospital)

The layout of the simulation will be shown to the trainees to familiarise them with the set up. There will be a faculty member in each zone. The zones include the labour ward board, the theatre, maternity assessment unit and the antenatal ward (which is outside the main training room, in an office nearby).

Roles in the scenario (Section B):

Trainees will be allocated the following roles within the scenario:

Consultant, Specialist year 5 (ST5) registrar, Specialist year 3 (ST3) registrar, 2 senior house officers (SHOs), patient and observer. The brief they will be provided is included in the sections below.

Faculty instructions (Section C):

Each faculty member will be in charge of a zone in the simulation. They will have specific instructions with a timeline of the activity that is required to be completed as trainees will move through the zones simultaneously. The faculty instructions are in sections below.

Participants will sit down for a 30-minute structured de-brief at the end of the simulation to talk through their learning, feelings that arose during the simulation, difficulties faced and how they handled it and actions they will implement if faced with a similar situation in real life. There will be an emphasis on sharing the learning with others especially with regards to technical skills they have performed for the first time during the simulation (e.g., conducting a ward round) to enhance shared learning.

Data will be collected during the simulation using an ethnographic approach: Dr Aditi Siddharth will act as observer-participant during the study keeping a diary where anonymised field notes will be documented. Observations will be made regarding how the participants behave during the simulation with regards to body language, observed action (e.g., with uncertainty, confidence, anxiety etc), professionalism (e.g., technical, communication etc.). Timings and decisions made etc will be noted as well. Body language during the debrief will be noted. All the observations will be supplemented using quotes from the transcriptions of the audio recordings (which will be stored securely on a password protected computer) and from anonymised field notes made by the other faculty members.

Outcomes:

The qualitative data collected (as detailed above) will be coded into themes using an iterative process of data analysis. The thematic output of the analysis will be discussed with the other faculty members who were present to ensure it was representative of the observations. Similar themes will be grouped together to synthesise higher order concepts which will be contrasted with social theory [5].

Dissemination/plans:

This study forms part of the lead investigator's DPhil and we would hope to publish the work in a peer reviewed journal and present at conferences.

Do you think your proposal falls into the category of:

Research □ Audit □ Service evaluation Yes

Please add more information supporting your view below:

We have reflected carefully on the question of whether the analysis of this simulation is research or service evaluation and feel that it falls into the service evaluation domain because:

- The simulation training is a routine part of regional training and is accessible to all trainees.
- There will be no impact on service delivery as this is part of mandatory training and the ST1-2s are released from their clinical duties to attend the training day. This simulation is a component of the agenda for the obstetric simulation training day.
- No new techniques are being used for this training. Obstetric trainees are familiar with using mannequins and role play. The novelty is only with the simultaneous use of simulation techniques for technical and non-technical skill training and the anonymised written observations captured by faculty which will inform both the post scenario debrief and the study.

References:

1. Jones, O. and W. Reid, The development of a new speciality training programme in obstetrics and gynaecology in the UK. Best Practice & Research Clinical Obstetrics & Gynaecology, 2010. 24(6): p. 685-701.

2. Lavelle, M., et al., MBRRACE in simulation: an evaluation of a multi-disciplinary simulation training for medical emergencies in obstetrics (MEmO). Journal of Obstetrics and Gynaecology, 2018. 38(6): p. 781-788.

3. Reznick, R.K., Teaching and testing technical skills. The American journal of surgery, 1993. 165(3): p. 358-361.

4. Kopta, J.A., An approach to the evaluation of operative skills. Surgery, 1971. 70(2): p. 297-303.

5. Jowsey, T., Watering down ethnography. BMJ Quality & Safety, 2016. 25(7): p. 554-555.

Section A: Information sheet and consent form

This is a team-based simulation designed to combine both technical and non-technical skills training, in order to mimic real life as well as enhance learning of non-technical skills.

The learning objectives are:

1. To get a first-hand feel for running labour ward/ the unit

2. To gain a clearer understanding of the demands on different members of the team and how to support each other more effectively

3. An opportunity to practise technical skills such as performing a rotational delivery/trial in theatre, running a labour ward shift, conducting an antenatal ward round whilst learning non-technical skills.

Consent form:

Please circle the answers, provide your name, and contact details and your signature

Please read the statements below: Please initial each box

1. I confirm that I have read and understand the information sheet provided. 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, and without any adverse consequences or penalty.

3. I agree to take part in the study. Taking part in the project will include being interviewed and recorded (audio only) and I am happy to be contacted for the same.

4. I understand that this research is likely to be written up, presented at conferences and published.

5. I understand that my personal details such as name and contact details will be anonymised in any data collection, publications or funding applications.

6. I give permission to be quoted directly (only if fully anonymised) in research output.

Name:

Training grade:

Preferred contact details (email address/mobile number):

Signature:

Section B: Instructions to the participants

The scenario takes place on the delivery suite of a busy tertiary centre, with 7000 deliveries/year. There are 10 labour rooms. The situation begins, after handover, at 08:30. You have access to delivery suite, theatre, MAU, and antenatal ward

Consultant

You are the Consultant covering delivery suite today. You have not worked with the ST1 before. You have worked with the ST5 many times over the last few months, they were in an academic placement for 2 years, but you would be happy for them to run labour ward with remote supervision. The ST3 is a trainee who you are familiar with (they worked as ST2 in the unit the year before). You feel they can be a little overconfident and not call for help appropriately sometimes but so far they have not had any bad outcomes.

You covered the on-call shift last night and were in the hospital until 01:00. You returned to take handover at 08:00. You are glad to have 3 trainees working on delivery suite today. You are looking forward to going home this evening.

The Consultant for the levels ward round is sick, and the Antenatal ward round has to be completed now by the on-call team as well as cover the delivery suite.

The unit was very busy overnight, and you are aware that a number of the inductions are backed up. You need to prioritise the inductions to avoid undue delay and coordinate with the midwife in charge to bring these patients down.

ST5 Registrar

You are an experienced ST5 who has returned to delivery suite after an academic 2-year out of programme experience, 4 months ago. The fellowship was linked to a London hospital providing 3000 deliveries/year and you covered a few on calls as a locum but feel a little anxious about your operative deliveries.

You have an ARCP in 3 weeks, this is a waypoint for moving into ST6. You have returned to work LTFT, working clinically part time, and completing a PHD in your academic time. You have only had delivery suite sessions every other week as part of your working pattern, next session in 2 weeks. You have to complete an OSAT for rotational delivery prior to your ARCP otherwise you will not have completed your matrix requirements for ST5.

ST3

You are an ST3, who has worked as an ST2 in this unit. You have always been an overachiever and have always been commended in your ARCP for an excellent e-portfolio. You are a few months into your ST3 and would like to be more independent on labour ward, especially with decision making. You are usually with a senior registrar who you feel is very controlling and expects every decision to be run by them. You were looking forward to this shift as it's with a registrar you have not worked with before. You plan on speaking to them to tell them you would like to run labour ward this morning. You do not have any e-portfolio requirements to complete per-se but want to use this time for a Non-Technical Skills for Surgeons (NOTSS) form to assess how you are managing labour ward.

SHO

You are an ST1. Although this is your first year as in Obstetrics and Gynaecology trainee you have had a lot of experience previously. You took a sabbatical after medical school and travelled to Uganda where they let you assist with lots of caesarean sections. You also spent 12 months in as a staff grade SHO and have completed 20 caesarean sections independently and have also done a few kiwi deliveries.

The previous unit you worked in was even busier, delivering 10,000 women each year. You have seen women with a full range of obstetric complications: obstetric cholestasis, pre-eclampsia, Haemolysis, Elevated Liver enzymes, Low Platelet count (HELLP) etc. You have been coupled with an ST3 for you on calls and you have watched them do a number of forceps deliveries. You are 6 months into your training year and have discussed with your educational supervisor that your training goal should be to get a formative OSAT for forceps delivery within the next month.

SHO

You are an ST1.This is your first year as in Obstetrics and Gynaecology trainee and you have only had a 4-month stint as an FY2 in a much smaller unit. You are nervous about this job and want to make a good impression.

Patient

You are the patient in room 1. You are in your first pregnancy, a week and a half past your due date, and you are fed up with being pregnant. You have been contracting on and off for days and are finally in labour. The midwife from the night shift examined you and said you were fully dilated 3 hours ago, and you expected to have had your baby by now. You have had a straightforward pregnancy so far and cannot understand what the delay is with having your baby. You have been pushing for an hour, and you are exhausted.

Observer

There is the delivery suite handover room, delivery room, theatre, MAU, and antenatal ward in this simulation. As the observer/s, you are free to walk around to the various locations without interfering in the simulation itself. Please make a note of your observations in the domains of

communication with staff, communication with patients, staff allocation/situational awareness and team working. You can share your observations during the debrief at the end of the simulation.

From the NOTSS for labour ward guidance-

Situation Awareness:

1. Gathering information (seeking information on the labour ward from the hospital notes, CTG, Partogram, observation charts and multidisciplinary team)
2. Understanding information (updating one's mental picture by interpreting the information gathered, and comparing it with existing knowledge to identify the match or mismatch between the situation and the expected state)
3. Projecting and anticipating future state (predicting what may happen in the near future as a result of possible actions, interventions, or non-intervention)

Communication and Teamwork:

1. Exchanging information (giving and receiving knowledge and information in a timely manner to aid establishment of a shared understanding among team members)
2. Establishing a shared understanding (ensuring that the team not only has the necessary relevant information to carry out the plan, but that they understand it and that an acceptable shared 'big picture' of the case is held by team members)
3. Co-ordinating team activities (working together with other team members to carry out cognitive and physical activities in a simultaneous, collaborative manner)

Section C: Faculty instructions

Overall timeline

The simulation starts at 0830, after the morning handover has taken place on labour ward.

First 10 mins of the simulation:

The team should have gathered, looked over the labour ward board, assigned members of the team for labour ward round, assessment of the woman in room 1, antenatal ward round and Maternity Assessment Unit (MAU) reviews. If no one has been assigned to perform antenatal ward round by

10 mins, there will be an emergency buzzer on the antenatal ward that should prompt one member of staff to go there.

10 min – 25 mins:

Antenatal ward round should be completed in this time.

In the main room:

1. Assessment of room 1 and decision for trial of instrumental delivery in theatre, including transfer of patient to the operating theatre and performing the procedure.
2. Labour ward round, including checking the patient investigations
3. MAU patient being assessed

25 mins- 35 mins:

1. Trial of instrumental delivery in theatre should be ending
2. MAU patient should have a management plan in place after identifying the correct diagnosis. If this has not happened at 25 mins, there should be an emergency buzzer in MAU to draw the attention of the team
3. Team should re-group including checking labour ward board as it has changed.

35- 40 mins:

1. Review list of new patients on labour ward to prioritise.

Room No	Patient details
1	Primigravida, term pregnancy, fully dilated with passive second stage for 2 hours followed by active second stage for 1 hour. She has an epidural for analgesia
2	Para 3, term pregnancy, with spontaneous onset of labour, Vaginal examination (VE) findings at 07:30: 5 cm dilated. Foetal heart monitered by Intermittent Auscultation (IA)
3	Primigravida, Gestational Diabetes Mellitus (GDM) on diet control, term pregnancy, for Induction of Labour (IOL), the baby has macrosomia. VE: 02:30: Artificial Rupture of Membranes (ARM) at 2 cm dilated, 04:30: oxytocin infusion started.
4	Para 1, 35 weeks pregnant , positive foetal Fibronectin (fFN), has started to contract. Last speculum 04:00: cervical os closed
5	Empty room
6	Empty room
7	Empty room
8	Para 3 had a category 1 Lower Segment Caesarean Section (LSCS) overnight. Major Obstetric Haemorrhage (MOH) of 2.4 litres
9	Postnatal readmission. Admitted with temperature of 38 degrees Celsius, Maternity Early Warning Score (MEOWS) 4. Sepsis screening tests have been completed, and she is on iv antibiotics. Diagnosis: Possible Endometritis
10	Para 4 now. Had Neville Barnes Forceps Delivery (NBFD) at midnight. Estimated Blood Loss (EBL) is 600 ml.

Room No	Patient details
Maternity Assessment Unit (MAU)	Exam room 1: Postcoital spotting, 35 weeks of pregnancy, Primigravida Exam room 2: Para 2, 38 weeks of pregnancy, has come into hospital contracting Waiting room: 1. Primigravida, 36 weeks pregnant, complains of epigastric discomfort, possible gastritis. Also has reduced foetal movements 2. Patient is waiting for review of pre-eclampsia blood test results. She may be ready for discharge afterwards. 3. Para 1, GDM, 37 weeks pregnant, 3rd episode of reduced foetal movements

Table 33 1st Labour ward board at 08:30am (at the start of the simulation). Abbreviations: ARM- Artificial Rupture of Membranes, EBL- Estimated Blood Loss, fFN- foetal Fibronectin, GDM- Gestational Diabetes Mellitus, IA- Intermittent Auscultation, IOL- Induction of Labour, LSCS- Lower Segment Caesarean Section, MEOWS- Maternity Early Warning Score, MOH- Major Obstetric Haemorrhage, NBFD- Neville Barnes Forceps Delivery VE- Vaginal Examination

Room No	Patient details
1	The patient is in the operating theatre
2	Para 3, term pregnancy, spontaneous onset of labour, VE at 07:30: 5 cm dilated, at 08:40: Spontaneous Rupture of Membranes with meconium-stained liquor
3	Primigravida, GDM on diet control, term pregnancy, for IOL, baby has macrosomia.VE 02:30: ARM 2 cm dilated, at 04:30 oxytocin was started. Next vaginal examination due at 10:30
4	Para 1, 35 weeks pregnant, positive fFN, contracting. Last speculum at 04:00: cervical os closed was closed
5	Para 3, 26+3 weeks pregnant, came to hospital by ambulance , feels pressure vaginally. Needs an urgent doctor's review.
6	Empty room
7	Empty room
8	Empty room
9	Postnatal readmission. Admitted with temperature of 38 degree Celsius, MEOWS 4. Sepsis screen done, on iv antibiotics. Diagnosis: Possible Endometritis. At 08:45: Venous blood gas showed a Lactate of 2, Ultrasound pelvis showed retained pregnancy tissue.
10	Empty room

Room No	Patient details
MAU	Exam room 1: postcoital spotting, 35 weeks pregnant, Primigravida Exam room 2: Para 2 at 38 weeks of pregnancy is contracting Waiting room: 1. Primigravida at 36 weeks of pregnancy with epigastric discomfort and reduced movements. 2. Waiting for blood test reports to be reviewed and can go home after if normal 3. Para 1, GDM, 37 weeks pregnant with 3rd episode reduced movements

Table 34 2nd Labour ward board at 10:00 am (around the mid-point of the simulation). Abbreviations: ARM- Artificial Rupture of Membranes, fFN- foetal Fibronectin, GDM- Gestational Diabetes Mellitus, IOL- Induction of Labour, MAU- Maternity Assessment Unit, MEOWS- Maternity Early Warning Score, VE- Vaginal Examination

Clinical details for the ward round on labour ward at start of the simulation (estimated time at around 08:30)

ROOM 1 (examination to be performed on mannequin):

Primigravida, 41+5 weeks pregnant, IOL: Prolonged latent phase for 48 hours

VE:

21:30 3 cm

02:45 6cm ARM

05:30 fully dilated

Reduced urine output in labour. No urine seen in catheter for the last 5 hours

Renal function tests at the start of labour was normal. A repeat renal function test was performed half an hour ago and the results are awaited.

Contracting 4 in every 10 minutes

Cardiotocography (CTG) was normal throughout labour

Epidural insitu for pain relief in labour

No medical or surgical past history of note

No allergies

Observations : normal

36 weeks foetal growth scan: normal growth. All other scans in pregnancy were normal

Expected action: Recognise prolonged second stage and vaginally assess patient to decide on trial of instrumental delivery in theatre.

On examination:

Per abdomen: Cephalic $0/5^{th}$ palpable

Vaginal examination: Fully dilated, LOT at +1, minimal descent with pushing, small caput, moulding+

Expected action: Decision for trial of instrumental delivery in theatre, inform consultant on call, discuss options with patient and consent patient appropriately.

Instructions for faculty in theatre

1. World Health Organisation (WHO) check: PPH risk and plan for management of third stage
2. ST5 not signed off as competent for performing rotational delivery independently- so if ST5 is performing the procedure, must request consultant presence.
3. Assess steps of rotational delivery and technique for forceps. Facilitate a straightforward manual rotation and NBFD with episiotomy
4. EBL 800 ml. Was Tranexamic acid considered as part of management of blood loss?
5. WHO Sign out and patient debrief.

ROOM 2:

Para 3- 3 previous normal vaginal deliveries

40 weeks pregnant

Midwifery led care in pregnancy

Spontaneous onset of labour

VE:

07:30 5 cm, intact membranes

On IA: normal

No medical or surgical past history of note

Expected action: Next VE at 11:30. If no progress, offer ARM.

ROOM 3:

Primigravida

39+2 weeks pregnant

GDM on diet control- diagnosed 2 weeks ago

Ultrasound of foetal growth at 37 weeks: Abdominal circumference was over the 95th centile, estimated foetal weight was on the 90th centile and was 4.0 kg, normal umbilical artery doppler

Progress:

IOL- 2 prostaglandin gels were used

02:30: ARM 2 cm, clear liquor

04:30: oxytocin started.

CTG normal

No medical or surgical past history of note

Last blood sugar at 08:00 was 8.0

Expected action: Next VE at 1030. Hourly fresh eyes review of CTG. Continue blood sugar monitoring as per GDM guideline. Counsel regarding risk of shoulder dystocia at delivery.

ROOM 4:

Para 1 (Previous delivery was by LSCS for failure to progress at 10 cm)

35 weeks pregnant

Came to hospital at 22:30 last night contracting. Speculum on admission: cervical os was closed, no evidence of ruptured membranes, fFN was positive. CTG was normal on admission. CTG was repeated at 0400: normal. Recorded contractions were 3-4 every 10 minutes

Last speculum 04:00: os closed

Ultrasound by the night team confirmed cephalic presentation

Admission blood tests: White Blood Cell count (WBC) 12.6/ microlitre, C Reactive Protein (CRP) 50 mg/dL

Expected action: Since the patient has continued to contract regularly, offer repeat of speculum on the ward round to check for cervical changes since the last speculum. Repeat CTG as she is regularly contracting and has had a previous LSCS.

ROOM 8:

Para 3

Delivered by category 1 LSCS overnight at 0100 for abruption where 500 gm of retroplacental clots were found. Baby was normal and doing well.

MOH of 2.4 L from bilateral extensions of the uterine incision and atonicity of the uterus after delivery. Bleeding was managed using Oxytocin, Ergometrine, Tranexamic acid, Haemabate 1 dose and Misoprostol 800 mcg.1 unit transfused in theatre. Post operative blood tests are awaited.

MEOWS now 2- HR 120/min. Lochia is normal.

Expected action: Chase the awaited blood tests to decide if further blood transfusion or oral iron is required. Debrief the patient regarding the blood loss.

ROOM 9:

Postnatal readmission. Para 1, delivered by NBFD 3 days ago. EBL at delivery 700 ml. Some difficulty with delivering the placenta was reported but it was delivered by registrar in the room. Ultrasound of the uterus after delivery of the placenta by the registrar did not show any retained pregnancy tissue. Afebrile at discharge a day later.

Readmitted with temperature of 38 deg C, MEOWS 4 (temp 38 deg C, HR 120, RR 22). Sepsis screen done and started on broad spectrum iv antibiotics with a working diagnosis of endometritis. Night team was very busy and could not see patient but prescribed antibiotics and asked for sepsis screen to be completed. FBC- WBC 18/ microlitre CRP 280 mg/dL. Lactate 2.0 mmol/L, lochia is normal.

Expected action: Review of patient and head to toe evaluation for source of sepsis. Review of fluid balance and ordering an ultrasound pelvis to rule out retained pregnancy tissue.

ROOM 10:

Para 4 now. Had NBFD at midnight. EBL 600 ml. MEOWS 0, lochia normal

Expected action: Review, debrief and move to the ward from labour ward.

Clinical details for the 2nd ward round on labour ward at 10:00 am

ROOM 2:

Same patient as in the previous ward round

Progress:

VE:

07:30: 5 cm dilated, intact membranes

08:40: Spontaneous Rupture of Membranes (SROM), Significant Meconium staining of liquor, 6 cm dilated

Contracting 2 every 10 minutes

CTG connected –normal

Expected action: Counsel the patient regarding the issues with meconium staining of liquor. Discuss option of starting oxytocin to increase contractions either straightaway (as contractions are 2 every

10 minutes) or waiting another two hours, checking progress with a VE and if slow progress to consider oxytocin.

ROOM 3: (no change)

Same patient as in the previous ward round

Progress:

02:30: ARM 2 cm, clear liquor

04:30: oxytocin started.

Expected action: Next VE at 10:30. Check blood sugars are in the normal range. If not, consider starting a sliding scale. Check frequency of contractions and titration of oxytocin. Check CTG.

ROOM 4 (no change)

Same patient as in the previous ward round

Recorded contractions 3-4 every 10 minutes

Speculum examination 04:00: os closed

08:30: 3 cm dilated

Expected action: Inform neonatal team, start iv antibiotics for preterm labour, offer pain relief, await events. No steroids or Magnesium Sulphate required as beyond the gestational age when it is indicated.

ROOM 5

Para 3- 3 previous normal deliveries

26+3 (normal 20-week scan, placenta not low)

Came by ambulance and feels pressure in the vagina.

Foetal heart is normal and CTG connected

On examination: contracting 3 every 10 minutes

Cephalic presentation on ultrasound

Speculum examination: 4 cm dilated, intact membranes

Expected action: Inform neonatal team and senior members of obstetric team, administer steroid 1st dose and magnesium sulphate, commence antibiotics.

ROOM 9:

Same patient as in the previous ward round

Ultrasound pelvis: Retained pregnancy tissue measuring 2.5 X 3X 2 cm

Lochia normal

Expected action: Continue iv antibiotics for 24 hours, observe lochia. If no improvement in observations, consider evaluation of retained tissue in theatre. Counsel patient regarding ultrasound report and plan.

Location	History	Expected action
Exam room 1	Primigravida, 35 weeks pregnant, presented with postcoital spotting. No abdominal pain. 20-week ultrasound scan did not show a low-lying placenta. CTG met Dawes Redman criteria. Blood group is Rhesus negative	Doctor to review symptoms including pain, previous smear test history, foetal movements. CTG to be performed. Abdominal examination to check resting tone of uterus. Speculum examination to check cervix, dilatation, and quantity of bleeding. To admit if bleeding is seen on speculum. To decide on administration of Anti D antibodies.
Exam room 2	Para 2, 38 weeks pregnant, MLC, presented with contractions	Midwife to examine patient to diagnose labour and move to labour ward.

Chair 1	Primigravida, 36 weeks pregnant, presented with epigastric discomfort and reduced foetal movements. BP is 133/88. Blood tests for pre-eclampsia (full blood count, renal and liver function tests) and urine for PCR taken at 07:30 The patient starts to feel unwell, dizzy, and nearly faints after 10 minutes of the simulation starting. Her observations at that time: BP 130/90, Pulse Rate (PR) 90, Temperature 37.4 deg C, Respiratory Rate (RR) 20/min. Her blood test results: (normal values) Haemoglobin (Hb) 116 g/dL (110-140 g/dL) White blood cell count (WBC) 22 X 10^9/L (6-16 X 10^9/L) Platelets 238 X 10^9/L (150-400 X 10^9/L) Sodium 135 mmol/L (130-140 mmol/L) Potassium 3.5 mmol/L (3.3-4.1 mmol/L) Urea 4.0 mmol/L (<4.5 mmol/L) Creatinine 70 micromol/L (<75 micro mol/L) Bilirubin 20 micro mol/L (<16 micro mol/L) Aspartate Aminotransferase (AST) 250 IU/L (10-30 IU/L) Alanine Transaminase (ALT) 400 IU/L (6-32 IU/L) If the doctor asks for a blood sugar, it is 2.0 mmol/L (low). No proteinuria	Patient requires a CTG, review blood tests and a blood sugar assessment as soon as possible. The diagnosis of AFLP should be made and escalated to the consultant and coordinator midwife. Stabilising the patient and urgent transfer of patient to labour ward with involvement with ITU and rapid response are the next steps.

Location	History	Expected action
Chair 2	Para 1 30 weeks pregnant presented with a headache, which settled after receiving paracetamol. The junior doctor on the night team had reviewed and requested for blood tests to rule out pre-eclampsia, which were sent. Urine dipstick showed protein 1+. BP is 128/80	If blood test results are normal, she could be discharged home with plan for MAU midwives to follow up on the PCR test result.
Chair 3	Para 1, GDM, 37 weeks pregnant, 3rd episode of reduced foetal movements	CTG. Discuss with consultant regarding Ultrasound for growth or IOL as patient has GDM.

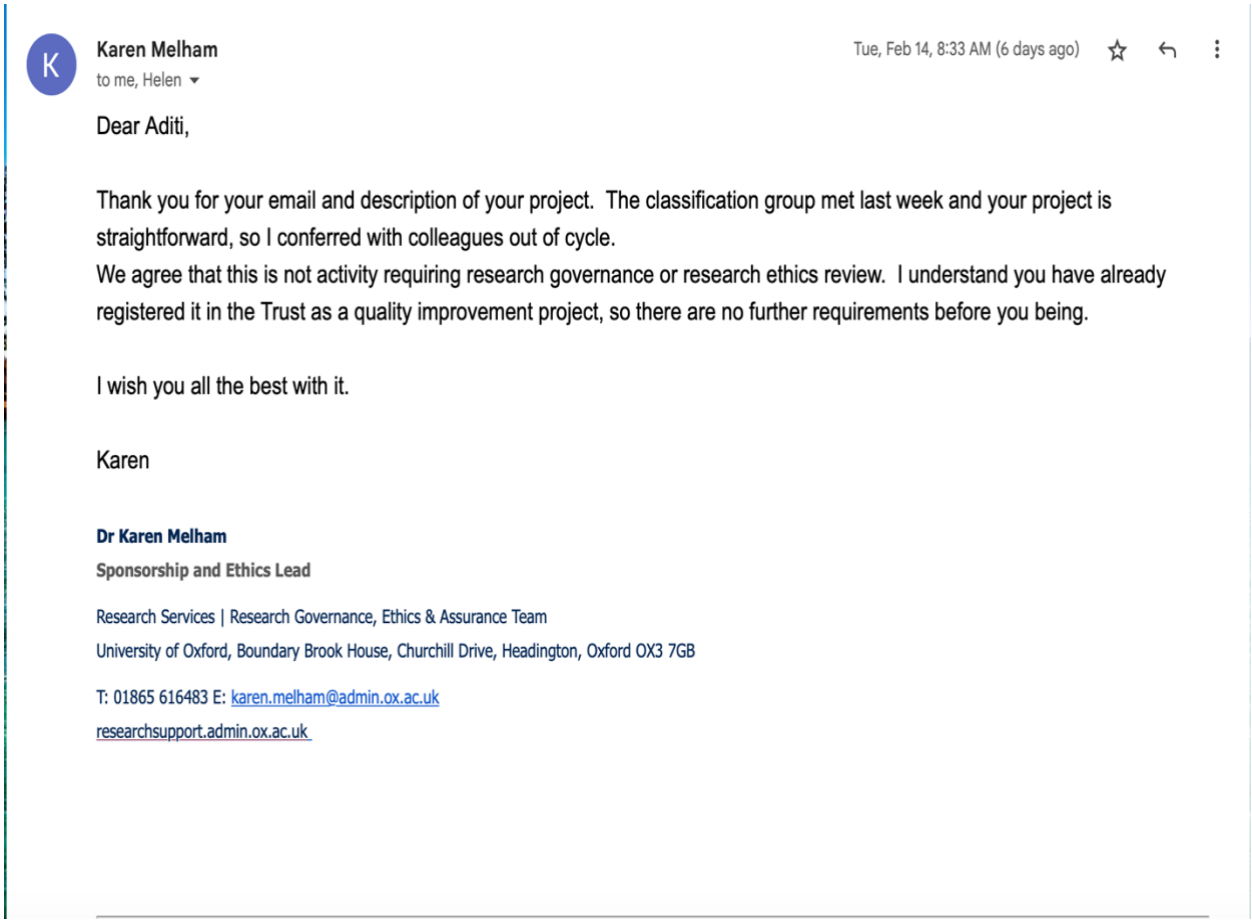
Table 35 Patients in Maternity Assessment Unit (MAU). The patient information for the faculty acting as midwife in charge. Abbreviations: AFLP- Acute Fatty Liver of Pregnancy, ALT- Alanine Transaminase, AST- Aspartate Aminotransferase, BP- Blood Pressure, CTG- Cardiotocography, GDM- Gestational Diabetes Mellitus, Hb- Haemoglobin, IOL- Induction of Labour, ITU- Intensive Therapy Unit, MLC- Midwifery Led Care, PCR- Protein Creatinine Ratio, PR- Pulse Rate, RR- Respiratory Rate, WBC- White Blood Cells

Patient	Age	History	Expected action
1.	23	Primigravida, 29 weeks, Small for gestational age (SGA) 8th centile, admitted overnight with reduced foetal movements, CTG met Dawes Redman criteria	If feeling movements now can be discharged with foetal medicine follow-up.
2.	41	Primigravida, 39 weeks, CTG not met Dawes Redman criteria. She has started contracting spontaneously 6 times every 10 minutes and had a prolonged deceleration on the CTG that recovers spontaneously.	Recognise CTG concerns are due to hyperstimulation (contracting 5 or more times in a 10-minute period). Request midwife to administer Terbutaline to reduce contractions and vaginally assess the patient for progress.
3.	33	Para 1, 35 weeks, placenta praevia major, spotting vaginally, Hb 112 g/dL	Ensure patient has iv access and a valid group and save. Keep in hospital for observation until 24 hours without bleeding.
4.	24	Primigravida, 32 weeks, severe pre-eclampsia on 3 oral medication to control blood pressure. The creatinine was elevated (100 mg/dL) on the blood tests taken at 0700 before the ward round. The Estimated Foetal Weight (EFW) 7th centile	Escalate to consultant to consider urgent delivery by induction of labour, monitoring of urine output, administering magnesium sulphate and corticosteroids. Discussion with the coordinator midwife on labour ward to move patient from antenatal ward to labour ward.
5.	22	Para 1, 29 weeks, pyelonephritis, on iv antibiotics	Plan ultrasound of renal tract. Continue iv antibiotics. Plan discharge if pain is better and afebrile for 24 hours. Chase urine culture results.
6.	39	Para 2, 32 weeks, confirmed Preterm Premature Rupture of Membranes (PPROM)	Check WBC and CRP. Check if patient has received 2 doses of corticosteroids. Discharge after 72 hours of PPROM
7.	35	Para 4, 29 weeks, possible pulmonary embolism, awaiting CTPA	Ensure patient is on treatment dose of low molecular weight heparin

Patient	Age	History	Expected action
8.	19	Primigravida, 32+2 weeks, Antepartum Haemorrhage of 100mls	Review CTG and bleeding, consider corticosteroids if ongoing, check if patient is in pain, review previous ultrasound to check placental location. Patient to stay in till bleed free for at least 24 hours.
		Induction of labour (IOL)	
9.	42	Para 2, 39/40, IOL mat age	Can have prostaglandin for IOL. Priority 4
10.	32	Para 0, 37+1, SGA, raised dopplers	Can have prostaglandin for IOL. Priority 1
11.	37	Para 1, 42, IOL for postdates	Can have prostaglandin for IOL. Priority 3
12.	28	Para 1, 40+1, GDM metformin	Can have prostaglandin for IOL. Priority 2

Table 36 Patient details for the antenatal ward round. Abbreviations: AFLP- Acute Fatty Liver of Pregnancy, ALT- Alanine Transaminase, AST- Aspartate Aminotransferase, BP- Blood Pressure, CTG- Cardiotocography, CTPA- CT Pulmonary Angiogram, EFW- Estimated Foetal Weight, GDM- Gestational Diabetes Mellitus, Hb- Haemoglobin, IOL- Induction of Labour, ITU- Intensive Therapy Unit, IV- Intravenous, MLC- Midwifery Led Care, PCR- Protein Creatinine Ratio, PPROM- Preterm Premature Rupture of Membranes, SGA- Small for Gestational Age

Section D: Response from ethics lead



Karen Melham
to me, Helen
Tue, Feb 14, 8:33 AM (6 days ago)

Dear Aditi,

Thank you for your email and description of your project. The classification group met last week and your project is straightforward, so I conferred with colleagues out of cycle.
We agree that this is not activity requiring research governance or research ethics review. I understand you have already registered it in the Trust as a quality improvement project, so there are no further requirements before you being.

I wish you all the best with it.

Karen

Dr Karen Melham
Sponsorship and Ethics Lead

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Figure 25 Response from ethics lead

Appendix Five- Feedback from training sessions conducted using adaptations of the simulation described in chapter eight

Regional training for obstetric trainees, Thames Valley Deanery

I have presented the participant feedback from each adaption of the simulation conducted since the study in chapter eight took place.

ST3-5 regional simulation teaching, October 2023

What did you enjoy the most about the simulation morning	What is the learning from this morning that you will be implementing into your daily practice?	What would you change about today's morning simulation session?	Was there something that stood out about the morning simulation that you would like more of?	Any other thoughts about the day?
Simulation labour ward	Good, closed loop communication	PPH simulation could have 2 rounds so more participation	Non-technical skills	It was a well organised programme and very innovative. So much to learn from it
The management of impacted foetal head session	Patwardhan maneuverer	More technical skill sessions	The way the PPH session was held	Very well organised and useful for ST3-5 trainees
Genuinely, reflects real situations on labour ward	Non-technical skills	Nothing	Real case labour ward scenarios	Thanks
Difficult delivery simulation - Debrief after simulations	Very clear communication - watch more videos on Patwardhan technique	Nothing - all was very good	I really liked the labour ward simulation and the debrief afterwards	It was really well organised and very useful - many thanks

What did you enjoy the most about the simulation morning	**What is the learning from this morning that you will be implementing into your daily practice?**	**What would you change about today's morning simulation session?**	**Was there something that stood out about the morning simulation that you would like more of?**	**Any other thoughts about the day?**
Interactive simulation scenarios	Appreciative enquiry	Nothing	Good mix of complex obstetrics scenarios	Excellent teaching day - very well organised
Practical skills	Keep the team informed about what you're doing	If possible, one more group in order to have smaller groups	More time on the simulation model	Very nice teaching, it was very useful and interesting
Debrief and feedback session	How to break task focused habit and relying on your teammates	More prompt with observations and amount of bleeding, staff involved in organising simulation to be involved and do basic duties	Very well organised. Prioritisation station was excellent and realistic. Highlighted the importance of communication and proactivity	Excellent and highly stimulating
Labour ward Prioritising	Appreciative inquiries	Nothing, it was a really interesting day	Passionate staff	
Interactive nature with hands on experience	Feel more confident about calling upon non-resident consultant to attend	Nothing	More scenarios in Sim lab	More frequent Sim sessions, please

What did you enjoy the most about the simulation morning	**What is the learning from this morning that you will be implementing into your daily practice?**	**What would you change about today's morning simulation session?**	**Was there something that stood out about the morning simulation that you would like more of?**	**Any other thoughts about the day?**
Well organised and covered the important aspects of working as a registrar	Improve communication skills	Nil	Good prioritisation stations and labour ward simulation	
PPH scenario and importance of clear escalation	Effective communication	Nothing	Videos showing breech extraction technique in case of impacted foetal head	
Friendly, non-intimidating environment to learn	Reminder to use closed-loop communication in emergency scenarios	Nothing specific - there was a great mix of traditional simulation, simulated busy labour ward and hand on practise with impacted foetal head	I really enjoyed the simulated busy labour ward - as an ST5 I found it really useful practise for stepping up to senior registrar in the near future. I've never done a similar simulation (just talked through boards for exam practise) but would love more similar scenarios	Thank you! I've really enjoyed the day and found it very useful

What did you enjoy the most about the simulation morning	**What is the learning from this morning that you will be implementing into your daily practice?**	**What would you change about today's morning simulation session?**	**Was there something that stood out about the morning simulation that you would like more of?**	**Any other thoughts about the day?**
Practical learning on impacted foetal head	Approach to impacted foetal head	More scenarios in the sim lab with shorter debrief	The labour ward simulation with different evolving scenarios was great	
Labour ward prioritisation station with team working elements	Effective closed loop communication	Session in sim lab felt very critical of one person (person allocated ST3 role) without much positive feedback	Practical advice sessions like impacted foetal head	Thank you
All stations were real simulations - useful for clinical application on labour ward	Human factors - Escalation for patient safety , close loop of communication , delegation of work, prioritisation of workload , gentle delivery of impacted head and reverse breech extraction	None , session was well structured, well planned and organized with clear instructions and roles for role players	All parts of NOTSS were covered and practically demonstrated	Reflected situational awareness in scenarios, decisions making and team working. Thank you. Best simulation and well organized

Table 37 Feedback from the participants from the ST3-5 regional simulation teaching conducted in October 2023. Abbreviations: NOTSS- Non-Technical Skills for Surgeons, PPH- Postpartum Haemorrhage, ST- Specialist Training Year

ST3-5 regional simulation teaching, March 2024

What were your expectations for this simulation? How did your experience compare?	**What did you find most challenging?**	**What was your take aways from this simulation?**	**Was this team-based simulation with technical skill tasks useful? Reflect on your overall experience today.**	**Any other comments that will help us plan future simulations?**
Observe	-	Good	Yes	Good
Very positive experience. However, I think some fairly poor actions in the group could have been called out more in the debrief	Good to have challenge of moving between rooms	Great learning!	Yes definitely	Very positive experience
High quality-I had done a simulation with Aditi before, and it was excellent	Speaking up	Speak up!	Yes found the impacted foetal head scenario really helpful	Keep up the good work-this is the best sim I've ever attended (and I've done a lot)
Build on confidence	Being a consultant and standing back/not being involved	Communicate and escalate early. Closed loop communication	Yes, regular simulations of different scenarios keep your knowledge refreshed	Thank you

What were your expectations for this simulation? How did your experience compare?	**What did you find most challenging?**	**What was your take aways from this simulation?**	**Was this team-based simulation with technical skill tasks useful? Reflect on your overall experience today.**	**Any other comments that will help us plan future simulations?**
Expectations aligned with experience. Expected to be allocated different roles for each member of the team, go through labour ward board, and undertake dynamic simulation of labour ward and break off into different groups	Remembering the steps for particular emergencies for example impacted foetal head	Good revision of stepwise management of impacted foetal head at Caesarean section	This was a reasonably accurate simulation of a real-life labour ward so was useful to practise as a group	Thanks
Excellent sim, stressful as expected, but very useful in terms of preparing to be a senior registrar	Being responsible with no one more senior on site	Communicate emergencies clearly, delegate according to skills, get consultant in if needed	Yes, very useful	This was excellent, more like this please
Thought it was going to be like a part 3 OSCE station. But it's completely different and very well organized with hard work	Acting in artificial environment	Importance of communication	It's important as focused on both technical and non-technical parts	Well done

What were your expectations for this simulation? How did your experience compare?	**What did you find most challenging?**	**What was your take aways from this simulation?**	**Was this team-based simulation with technical skill tasks useful? Reflect on your overall experience today.**	**Any other comments that will help us plan future simulations?**
I didn't expect it to be so realistic. This was so useful and multi layered. I also enjoyed that there was both clinical and prioritisation	The knowledge that there were simultaneous situations occurring at the same time - but this is good because that's what real life is like. The best simulation I've participated in	The delegation skills	I found the facilitators to be extremely encouraging, and it felt like a safe space to try and learn	Please could we have a full day session of this
This was the most practical and pragmatic simulation training I've done. I enjoyed it and wasn't expecting to	N/A	Prem 7! The importance of declaring of an emergency	Yes, it really highlighted areas that I need to work on, and the group discussion really helps to highlight best practice and useful clinical tips	This was very enjoyable; thank you

What were your expectations for this simulation? How did your experience compare?	**What did you find most challenging?**	**What was your take aways from this simulation?**	**Was this team-based simulation with technical skill tasks useful? Reflect on your overall experience today.**	**Any other comments that will help us plan future simulations?**
Experience of managing labour ward and emergencies occurring. It was a good opportunity to experience this in a safe space with no judgement	Initially being observed and feeling judged, but then this improved	Lessons from others management, including systematic management and decision making	Very useful! Really enjoyed the experience and found it helpful, constructive and will help my development	Please can this be done more! And longer sessions if at all possible, to get into the scenarios more and get the most from
My expectations of prioritisation of labour ward board completely met	Found challenging to go home in the simulation as the "consultant", leaving patients with 1 senior registrar and 1 new registrar	Team working and delegation will help in managing different cases by helicopter view	It was a good experience for part 3 exam , highlighted and help focus on team working , delegation and prioritisation	None

Table 38 Feedback from the participants from the ST3-5 regional simulation teaching conducted in March 2024. Abbreviations: OSCE- Observed Structured Clinical Examination

Supported Return to Training (SuppoRTT) for obstetric trainees, Thames Valley Deanery, June 2023

The organisers of SuppoRTT in Thames Valley had attended one of the simulation training sessions I had organised for the deanery and requested to adapt and use my simulation framework for their training sessions. Trainees who have been away from clinical work for any period of time due to a variety of reasons including maternity leave, parental leave, out of programme experience, out of programme for research or career break attended these sessions before coming back to work.

I have presented the feedback collected by the SuppoRTT team and shared with me with permission to include in this thesis.

"Implementing a labour ward simulation programme on our Supported Return to Training Programme has proven to be immensely valuable for trainees. It has helped them to improve their confidence by practising complex situations in a risk-free setting. The simulations emphasise the importance of clear communication and effective teamwork, which are crucial in high-pressure environments like the labour ward. By simulating real-life scenarios, staff can practise and improve their decision-making skills, learning how to quickly assess situations and choose the best course of action."
S.C, organiser of SuppoRTT simulation for O&G in Thames Valley

Before joining the program, I felt well prepared to return to work	**Was there anything specific about the course that will help you in your return?**	**After completing the programme, I felt well prepared to return to work**	**I would recommend this programme to colleagues**	**How do you think we could improve the programme?**
Disagree	The simulation activities really increased my confidence and showed me I hadn't forgotten everything! I also found the update on changes to practice really useful	Agree	Strong agree	I really enjoyed the day and came away feeling much more positive about my return - thank you. I feel the day was comprehensive and worked much better than the virtual return to training
Agree	Loved all the practical tips and revision of the guidelines. This was so useful	Agree	Agree	I'm most worried about instrumental deliveries - it would have been nice to do a short practise. Also, I'm nit-picking, but I think the assumption is that most people have time off for maternity leave- returning after sick leave or research can feel very different
Disagree	Update on guideline changes	Agree	Strong agree	

Before joining the program, I felt well prepared to return to work	**Was there anything specific about the course that will help you in your return?**	**After completing the programme, I felt well prepared to return to work**	**I would recommend this programme to colleagues**	**How do you think we could improve the programme?**
Agree	Updating me on guidelines that have changed	Strongly agree	Strong agree	None. I really enjoyed the informal but well-organized nature of the course
Neutral	Meeting other people in the same position and sharing problems/concerns/strategies	Agree	Strong agree	It was brilliant - especially the simulation. Thank you so much
Disagree	Brilliant simulation - original format, designed to practise real time decision making and team co-ordination. This is just what is needed prior to returning	Agree	Strong agree	

Before joining the program, I felt well prepared to return to work	**Was there anything specific about the course that will help you in your return?**	**After completing the programme, I felt well prepared to return to work**	**I would recommend this programme to colleagues**	**How do you think we could improve the programme?**
Agree	The simulation session was excellent. It was a fantastic opportunity for all to participate and realise they haven't forgotten everything. I attended this RTT day last year following a period of OOPR, and the simulation really boosted my confidence	Strongly agree	Strong agree	Move the information heavy sessions to the morning and the group discussion sessions after lunch. It was harder to focus post lunch, especially for those who have been away on maternity leave
Disagree		Strongly agree	Strong agree	

Before joining the program, I felt well prepared to return to work	**Was there anything specific about the course that will help you in your return?**	**After completing the programme, I felt well prepared to return to work**	**I would recommend this programme to colleagues**	**How do you think we could improve the programme?**
Disagree	Yes - I found the station about impacted foetal head very useful and definitely feel better equipped to deal with this emergency on my return to work. The talk giving an overview on obstetrics management was a useful refresher	Agree	Strong agree	I really can't think of anything specific. I thought the day had an excellent balance of clinical skills/knowledge and pastoral support focussing on the challenges of returning to work after maternity leave. I had taken part in the obstetrics simulation before during ST3-5 teaching so was familiar with most of the vignettes. I perhaps would have found that particular part of the day more useful if it was new cases. Thank you so much for organising such a useful day. The environment felt really supportive and safe

Table 39 Feedback from the participants who attended one SuppoRTT training session. Abbreviation: OOPR- Out of Programme for Research, RTT- Return to training, ST- Specialist Training Year, SuppoRTT- Supported Return to Training