Early patient-reported outcomes following primary hip and knee replacement have improved over the past seven years - Analysis of the NHS PROMs dataset

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Competing interests statement

There are no conflicts of interest related to this work. AA and AJP have received speaker bureau fees from Zimmer-Biomet and DePuy Synthes outside of the submitted work.

Data statement

All data for this study is available within the public domain on the NHS Digital PROMS website and is regularly updated. Statistical code is available on request.

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Abstract

Introduction.

Routinely-collected patient-reported outcome measures (PROMs) have been useful to quantify and quality-assess provision of total hip replacement (THR) and total knee replacement (TKR) in the UK for the past decade. This study aimed to explore whether the outcome following primary THR and TKR has improved over the past seven years.

Methods.

Secondary data analysis of 277,430 primary THR and 308,007 primary TKR from the NHS PROMs programme. Outcome measures were: (i) post-operative Oxford hip/knee score (OHS/OKS); (ii) proportion of patients achieving a clinically important improvement in joint function (responders); (iii) quality of life; (iv) patient satisfaction; (v) perceived success; and (vi) complication rates. Outcomes were compared based on year of surgery.

Results

For primary THR, more recent year of surgery was associated with higher post-operative OHS (0.15 points, 95% confidence interval (CI) 0.14-0.17; $p<0.001$) and higher EQ-5D utility (0.002, 95% CI 0.001-0.002; $p<0.001$). The odds of being a responder (OR 1.02, 95% CI 1.01-1.03; $p<0.001$) and patient satisfaction (OR 1.02, 95% CI 1.01-1.03; $p<0.001$) increased with year of surgery, whilst the odds of any complication reduced (OR 0.97, 95% CI 0.97-0.98; $p<0.001$). No trend was found for perceived success ($p=0.56$). For primary TKR, more recent year of surgery was associated with higher post-operative OKS (0.21 points, 95% CI 0.19-0.22; $p<0.001$) and higher EQ-5D utility (0.002, 95% CI 0.002-0.003; $p<0.001$). The odds of being a responder (OR 1.04, 95% CI 1.03-1.04; $p<0.001$), perceived success (OR 1.02, 95% CI 1.01-1.02; $p<0.001$) and patient satisfaction (OR 1.02, 95% CI 1.01-1.02; $p<0.001$) all increased with year of surgery, whilst the odds of any complication reduced (OR 0.97, 95% CI 0.97-0.97; $p<0.001$).

Conclusion

Nearly all patient-reported outcomes following primary THR/TKR improved by a small amount over the past seven years. Due to the high proportion of patients achieving good outcomes, PROMs following THR/TKR may need to focus on better discrimination of patients achieving high scores to be able to continue to measure improvement in outcomes.

Keywords

total hip replacement; total knee replacement, patient-reported outcome measures; complications

Introduction

Over the past decade, a number of national initiatives have been launched to try to improve clinical outcomes for patients following primary total hip replacement (THR) and total knee replacement (TKR). Enhanced recovery after surgery (ERAS) [1] pathways aim to optimise procedures for pre-operative assessment, surgical and anaesthetic technique [2,3]) and post-operative patient mobilisation. There are national audits to examine and report clinical outcomes following joint replacement at a surgical unit and consultant level. New implants receive greater scrutiny through initiatives such as the Orthopaedic Data Evaluation Panel (ODEP) and Beyond Compliance [4]. These quality improvement initiatives have been associated with lower revision rates following primary hip and knee joint replacement, shorter length of hospital stay and cost-efficiencies [5,6]. However, a key question that remains unanswered is whether the clinical outcomes following primary hip and knee replacement surgery are noticeably improved over time from the perspective of the patient.

Indeed, whilst clinicians can recognise impairment and disability, only patients can report symptoms and quality of life [7]. Over the past decade, prioritising patients' views has become an essential component of delivering patient-centred surgery [8]. Patient-reported outcome measures (PROMs) are increasingly used to capture this perspective. PROMs measure patients' perceptions on the impact of a condition or a treatment on their health [9]. The recent Cumberlege report [10] examined how we respond to harmful side effects from medical devices and made recommendations to promote quicker and more effective responses in the future. One of their key recommendations was the wider utilisation of PROMs.

For primary hip and knee replacement procedures in England, PROMs have been included in a national audit framework since April 2009 [11]. Patients are routinely asked to comment on their joint function and quality of life before surgery and at six months post-surgery. Both procedures have consistently been found to be highly clinically effective [12], but few studies have analysed trends in PROMs over time. One early study, based on the first three years of the PROMs

dataset, found little effect of the NHS PROMs programme on patient selection for surgery or post-operative results [13] Two subsequent studies suggested a trend towards improvement over time in post-operative outcomes, including PROMs [1,12]. The aim of this study was to address the research question: Have early (6 months post-surgery) patient-reported outcomes from primary hip and knee replacement improved over the past seven years?

Patients and Methods

This study used de-identified patient-level data available from the NHS PROMs website [11]. Ethical approval was not required since the data was de-identified and available in the public domain. This study is reported following the RECORD checklist [14] and a checklist for transparent reporting of patient-reported outcome measures from arthroplasty registries developed by Bohm et al [15].

Study dataset

The NHS PROMs dataset included patients undergoing NHS-funded primary hip and knee replacement procedures in England from 1st April 2009 to 31st March 2020. PROM questionnaires were administered in paper or electronic form prior to surgery (Q1) and at six months post-surgery (Q2) [16]. Data were collected on baseline patient demographics, joint function, quality of life and complications. Joint replacement procedures performed prior to 1st April 2013 were excluded from our analysis due to changes in NHS Digital methodology for data collection and processing of PROM data, which limited comparability to later years. Prior to 1st April 2012, primary and revision joint replacement procedures in the PROM dataset were not differentiated by cross-referencing to Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures (OPCS-4) codes in the Hospital Episodes Statistics (HES) dataset. Supplementary questions to the PROMs on pre-operative comorbidities, perceived disability and living arrangements were not available in datasets prior to 1st April 2013.

Statistical analysis

Hip and knee replacement procedures were analysed separately throughout. The de-identified NHS PROMs dataset used for analysis does not allow for simultaneous or staged bilateral procedures to be linked to the patient's first procedure. As such, we assumed that all observations were independent.

PROM return rate

The PROM return rate was defined as the number of patients who returned both Q1 and Q2 questionnaires divided by the number of eligible primary hip or knee joint replacement procedures from HES. This was calculated from aggregate data presented in annual *Participation and Linkage* datasets [11]. The return rate was calculated from 2016/7 onwards, as earlier *Participation and Linkage* datasets did not differentiate primary and revision procedures and therefore did not provide a suitable denominator.

Trends over time in baseline characteristics of patients undergoing hip and knee replacement

Patient demographic data were summarised overall and by year of operation (2013/4 to 2019/20). Continuous variables were described using means and standard deviations (SD) or medians and interquartile ranges (IQR) as appropriate, after visual inspection of data distributions. Binary and categorical data were described using counts with percentages. The burden of comorbidity at baseline was analysed using comorbidity count (0/1/2/3+) and presented visually over time as a stacked bar plot.

Trends over time for patient-reported outcomes following hip and knee replacement

Outcome measures of interest.

- *Post-operative joint function*: This was recorded using the Oxford Hip Score (OHS) or Oxford Knee Score (OKS) as appropriate [17–19]. Both instruments have been validated for the measurement of pain and function during activities of daily living [20,21]. The best score for each instrument is 48 points, whilst the worst score is zero points.
- *Responder analysis*: The change in joint function was calculated as the difference in OHS/ OKS score between Q1 and Q2. Individual patients were classified as a *responder* (if their change in score was equal to or greater than the minimal important change (MIC)) or a non-responder.

We used MICadjusted estimates of 8 points for THR and 7 points for TKR, based on a recent study from our group [22].

- *Post-operative quality of life (QoL)*: This was measured using the EQ-5D-3L [23]. A health profile was created for each patient based on their responses across five dimensions (mobility, self-care, usual activities, pain/discomfort and anxiety/depression). Each dimension was rated from 1 (no problems) to 3 (severe problems) to create a health profile. Each profile was converted to a utility scaled for the UK population from -0.594 (worst) to 1 (best) with utility zero considered to be equivalent to death.
- *Patient satisfaction*: This was evaluated from responses to the question: *"How would you describe the results of your operation?"* Patients who responded 'Excellent', 'Very good' or 'Good' were defined as 'satisfied', whilst those who responded 'Fair' or 'Poor' were 'dissatisfied'.
- *Perceived success of surgery*: This was evaluated from responses to the question: *"Overall, how are the problems now in the hip/knee on which you had surgery, compared to before your operation?"* Patients who responded 'Much better' or 'A little better' were defined as having had a successful outcome, whilst those who responded 'About the same', 'A little worse' or 'Much worse' did not have a successful outcome.
- *Patient-reported complications*: Complications were recorded for the following outcomes: further surgery, hospital readmission, wound healing problems, urinary tract infection, drug reaction and bleeding problems. Patients were dichotomised into those who did not experience a complication in any of the domains versus those who experienced at least one complication in at least one of the domains.

The outcome measures of interest were summarised overall and by year of operation (2013/4 to 2019/20). For continuous data (OHS/OKS and EQ-5D utility), box-plots depicting median scores with IQRs were created using the *ggplot2* package in R. Binary data (responders, satisfaction and success), were presented as bar plots with 95% binomial confidence intervals (Wilson's method)

using the epitools package in R [24]. The number of complications reported per patient was presented as a stacked bar plot.

Multiple linear regression models were used to model the relationship between continuous variables (OHS/OKS and EQ-5D utility) and year of surgery, which was also treated as continuous. These models were adjusted for the following variables in order to account for differences in patient factors at baseline: (i) age ($<$60/ 60-69/ 70-79/ $\geq$ 80); (ii) gender (male/ female); (iii) symptom period ($<$1 year/ 1-5 years/ 6-10 years/ $>$10 years); (iv) living arrangements (with partner, spouse, family or friends/ alone/ nursing home or facility/ other); (v) perceived disability (yes/ no); (vi) self-reported comorbidities - arthritis, cancer, circulation, depression, diabetes, heart disease, high blood pressure, kidney disease, liver disease, lung disease, nervous system disorder, stroke (yes/ no, for each comorbidity); (vii) total number of comorbidities (0/1/2/3+); and (viii) baseline OHS/ OKS or EQ-5D as appropriate. Effect estimates were reported along with 95% confidence intervals (CIs) and associated p-values. Analogous logistic regression models were used to model the relationship between binary variables (responders, patient satisfaction, perceived success from surgery and patient-reported complications) and year of surgery. Odds ratios with 95% CIs and associated p-values were reported. Assumptions of the fitted models were checked including assessment of the distributions of residuals.

Missing data

Complete case analysis was used throughout as the missingness mechanism could not be inferred.

Software

Statistical analyses were performed using Stata (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC.) and R version 3.6.2.

Results

PROM return rate

PROM data were available for 277,430 primary hip replacements and 308,007 primary knee replacements. The PROM return rate was 51.4% for primary THR and 49.8% for primary TKR (based on data from 2016/7 onwards).

Trends over time in baseline characteristics of patients undergoing hip and knee replacement

(a) Hips

Over the seven years of this study, there was little change in the age or gender distribution of patients undergoing primary hip replacement, their duration of symptoms, or number of comorbidities (Table 1). Around 86% of patients reported one or more comorbidities prior to surgery. In more recent years, fewer patients reported themselves to be 'disabled' prior to surgery (48% in 2019/20 compared to 55% in 2013/4). The pattern of patient comorbidities at baseline for each year of the dataset is demonstrated in Figure 1.

(b) Knees

Over the seven years of this study, there was little change in the age or gender distribution of patients undergoing primary knee replacement, their duration of symptoms, or number of comorbidities (Table 2). Around 90% of patients reported one or more comorbidities prior to surgery. In more recent years, fewer patients reported themselves to be 'disabled' prior to surgery (45% in 2019/20 compared to 55% in 2013/4). The pattern of patient comorbidities at baseline for each year of the dataset is demonstrated in Figure 2.

Trends over time for patient-reported outcomes following hip and knee replacement

(a) Hips

The outcomes following primary THR are provided in Table 1. Over the entire study period, the mean pre-operative OHS was 17.8 points and post-operative OHS 39.9 points. The proportion of patients achieving a meaningful change in

joint function was 89.8%, whilst 92.0% were satisfied with surgery and 95.0% perceived surgery to be a success. We have provided graphs for unadjusted trends over time as supplementary material (joint function [Appendix Figure 1]; quality of life [Appendix Figure 3]; success [Appendix Figure 5]; satisfaction [Appendix Figure 7]; and complications [Appendix Figures 9 and 11].

Each of the outcome measures of interest displayed a statistically significant, but small improvement with more recent year of surgery, except for perceived success where no trend was evident (p=0.56) (Table 3). More recent year of surgery was associated with higher post-operative OHS (0.15 points, 95% confidence interval (CI) 0.14-0.17; p<0.001) and higher EQ-5D utility (0.002, 95% CI 0.001-0.002; p<0.001). The odds of being a responder (OR 1.02, 95% CI 1.01-1.03; p<0.001) and patient satisfaction (OR 1.02, 95% CI 1.01-1.03; p<0.001) increased with year of surgery, whilst the odds of any complication reduced (OR 0.97, 95% CI 0.97-0.98; p<0.001). These estimates have been framed in terms of absolute risk difference in Appendix Table 1.

(b) Knees

The outcomes following primary TKR are provided in Table 2. Over the entire study period, the mean pre-operative OKS was 19.1 points and post-operative OKS 35.9 points. The proportion of patients achieving a meaningful change in joint function was 83.0%, whilst 86.0% were satisfied with surgery and 89.0% perceived surgery to be a success. We have provided graphs for unadjusted trends over time as supplementary material (joint function [Appendix Figure 2]; quality of life [Appendix Figure 4]; success [Appendix Figure 5]; satisfaction [Appendix Figure 7]; and complications [Appendix Figures 10 and 12]. Each of the outcome measures of interest displayed statistically significant, but small improvement with more recent year of surgery (Table 4). More recent year of surgery was associated with higher post-operative OKS (0.21 points, 95% CI 0.19-0.22; p<0.001) and higher EQ-5D utility (0.002, 95% CI 0.002-0.003; p<0.001). The odds of being a responder (OR 1.04, 95% CI 1.03-1.04; p<0.001), perceived success (OR 1.02, 95% CI 1.01-1.02; p<0.001) and patient satisfaction (OR 1.02, 95% CI 1.01-1.02; p<0.001) all increased with year of surgery, whilst

the odds of any complication reduced (OR 0.97, 95% CI 0.97-0.97; p<0.001). These estimates have been framed in terms of absolute risk difference in Appendix Table 2.

Discussion

This study has investigated trends on a population-level for early patient-reported outcomes following primary hip and knee replacement surgery in England over the past seven years. We found that nearly all outcomes measured by the NHS PROMs programme improved by a small, but statistically significant amount over the study period. After adjusting for differences in the patient case-mix, the post-operative OHS/OKS improved by ~0.2 points per year and quality of life by an EQ-5D utility of ~0.002 per year. We found that the odds of being a responder improved by ~2% per year for THR and ~4% per year for TKR. For both procedures, the odds of patient satisfaction improved by ~2% per year, whilst the odds of experiencing a complication decreased by ~3% per year and fewer patients reported multiple complications. The odds of perceived success increased by ~2% per year for TKR, but there was no trend for THR.

The trends we have observed are unlikely to be recognised as a meaningful difference by the average patient undergoing surgery today, compared to their counterpart who underwent surgery in 2013/4 [22]. However, it is important to recognise that the average patient already achieved a very good outcome following surgery at the start of the study period, with a post-operative OHS ~39 points and OKS ~35 points. Indeed, in 2013/4, 89% of patients undergoing primary THR and 82% of patients undergoing primary TKR experienced a clinically important improvement in joint function. Our findings suggest that the minority of patients experiencing a poor outcome following primary THR and TKR has become even smaller.

Garriga et al [1] recently investigated clinical outcomes following primary knee replacement as part of their evaluation of the impact of pathways for enhanced recovery after surgery (ERAS). They identified a trend where the change in Oxford Knee Score from baseline to six months improved by 2-3 points more on average in 2016 compared to 2008. They also found a decrease in hospital length of stay over the past decade and fewer complications presenting to secondary care [1]. An important contrast to highlight with the current study

is the difference in complication rates between patient reports and estimates from routine secondary care datasets. For example, in 2016/7 Garriga et al found that around 1.7% of procedures were associated with a complication at six-months based on data from Hospital Episode Statistics (HES). In the current study, the rate of patient-reported complications was around twenty times greater (30.5% for primary hip replacement, 35.3% for primary knee replacement based on 2016/7 data). This suggests that a large proportion of patients who experience a complication do not need to return to secondary care for treatment, but whether they are treated in primary care or do not require any treatment is not clear from this study.

Our study has used a large, prospectively gathered dataset of patient-reported outcome measures following primary hip and knee joint replacement. An important strength is the use of validated PROMs [17–19] and the focus on outcome reporting from the perspective of the patient. For the identification of complications from surgery, this has the potential advantage of capturing adverse events across both primary and secondary care. Whilst two recent studies have shown that patient-reported comorbidity and complication rates have good agreement to administrative coding [25,26], our study has highlighted that large differences in rates may be observed between these two different methods for data capture. There are further limitations that should also be acknowledged. Perhaps most importantly, whilst this study has focused on PROM outcomes, other domains of outcome (such as revision rate and mortality) are also important to patients [27]. As such, our findings must be interpreted in the context of trends in these other domains. One must also recognise that our findings represent only an early assessment of patient-reported outcomes (at six months post-operation), when the expected horizon for these devices is far longer [28–30]. The de-identified NHS PROMs dataset used for analysis does not allow for simultaneous or staged bilateral procedures to be linked to the patient's first procedure. Whilst these cases violate the principle of independence of observations upon which our analyses are based, the effect of this on the reported results (if any) is not clear. Due to changes in the reporting of PROM returns by NHS Digital over the

study period, we were not able to explore the potential effect of differences in PROM return rates over time on the observed patient-reported outcomes. Both the RECORD checklist [14] and a bespoke checklist for transparent reporting of patient-reported outcome measures from registry studies [15] are included with this study. It is of note that the de-identified PROM dataset contains only a limited selection of control variables. Further variables for covariate adjustment (such as body mass index or implant type) may be obtained through linkage to other datasets (such as Hospital Episode Statistics or the National Joint Registry). However, a cost to external database linkages is the attrition of PROM data.

The observed trends in patient-reported outcomes can be interpreted as 'marginal gains' [31] over time. Whilst the average patient may not recognise these improvements as a clinically important difference [22,32], they do represent an increase in the transfer of health to the population as a whole. This may be important from a health economic perspective (for example, through fewer complications requiring treatment or fewer dissatisfied patients needing to be followed-up). This study has not investigated the reasons behind this improvement in outcomes. However, possible causal associations include the introduction of enhanced recovery after surgery (ERAS) programmes [1] and quality improvement initiatives (such as the NHS PROMS audit itself [11], *Getting It Right First Time* (GIRFT) [6] and consultant outcomes reporting from the National Joint Registry [5]).

In conclusion, we found that nearly all domains of patient-reported outcome evaluated by the NHS PROMs programme following primary hip and knee replacement demonstrated a small improvement over the past seven years. Due to the high proportion of patients achieving good outcomes, to be able to continue to measure improvement in outcomes, PROMs following THR/TKR may need to focus on better discrimination of patients achieving high scores. However, this must first be shown to be relevant and important to patients.

References

[1] Garriga C, Murphy J, Leal J, Price A, Prieto-Alhambra D, Carr A, et al. Impact of a national enhanced recovery after surgery programme on patient outcomes of primary total knee replacement: An interrupted time series analysis from "The National Joint Registry of England, Wales, Northern Ireland and the Isle of Man." Osteoarthritis and Cartilage 2019:1–4. doi:10.1016/j.joca.2019.05.001.

[2] Wall PD, Ahmed I, Metcalfe A, Price AJ, Seers K, Hutchinson CE, et al. Safety and feasibility evaluation of tourniquets for total knee replacement (SAFE-TKR): Study protocol. BMJ Open 2018;8:1–7. doi:10.1136/bmjopen-2018-022067.

[3] Lloyd TD, Neal-Smith G, Fennelly J, Claireaux H, Bretherton C, Carr AJ, et al. Peri-operative administration of tranexamic acid in lower limb arthroplasty: A multicentre, prospective cohort study. Anaesthesia 2020;75:1050–8.

[4] ODEP. Orthopaedic Data Evaluation Panel (ODEP) 2021.

[5] National Joint Registry for England Wales Northern Ireland and the Isle of Man. NJR 17th Annual Report 2020.

[6] Briggs T. A national review of adult elective orthopaedic services in England: Getting It Right First Time. British Orthopaedic Association 2015:68. doi:10.2514/1.15824.

[7] Black N, Jenkinson C. Measuring patients' experiences and outcomes. BMJ 2009;339:b2495. doi:10.1136/bmj.b2495.

[8] Department of Health and Social Care. High quality care for all: NHS Next Stage Review final report. GOVUK 2008.

[9] Greenhalgh J, Dalkin S, Gibbons E, Wright J, Valderas JM, Meads D, et al. How do aggregated patient-reported outcome measures data stimulate health care improvement? A realist synthesis. Journal of Health Services Research & Policy 2018;23:57–65. doi:10.1177/1355819617740925.

[10] Cumberlege J. First Do No Harm - The report of the Independent Medicines and Medical Devices Safety Review. 2020.

[11] NHS Digital. Patient Reported Outcome Measures (PROMs) n.d.

[12] NHS Digital. Time-series Analysis: PROMs from 2009-10 to 2014-15 2015.

[13] Varagunam M, Hutchings A, Neuburger J, Black N. Impact on hospital performance of introducing routine patient reported outcome measures in surgery. Journal of Health Services Research & Policy 2014;19:77–84. doi:10.1177/1355819613506187.

[14] Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, et al. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. PLOS Medicine 2015;12:e1001885. doi:10.1371/journal.pmed.1001885.

[15] Bohm ER, Kirby S, Trepman E, Hallstrom BR, Rolfson O, Wilkinson JM, et al. Collection and reporting of patient-reported outcome measures in arthroplasty registries: Multinational survey and recommendations. Clinical Orthopaedics and Related Research®2021;479:2151–66.

[16] NHS Digital. Patient Reported Outcome Measures (PROMs) in England - A guide to PROMS methodology. 2017.

[17] Dawson J, Fitzpatrick R, Carr A, Murray D. Questionnaire on the perceptions of patients about total hip replacement. Journal of Bone and Joint Surgery Br 1996;78:185–90. doi:10.1302/0301-620x.78b2.0780185.

[18] Dawson J, Fitzpatrick R, Murray D, Carr A. Questionnaire on the perceptions of patients about total knee replacement. Journal of Bone and Joint Surgery Br 1998;80:63–9. doi:10.1302/0301-620X.80B1.7859.

[19] Murray DW, Fitzpatrick R, Rogers K, Pandit H, Beard DJ, Carr AJ, et al. The use of the Oxford hip and knee scores. The Journal of Bone and Joint Surgery British Volume 2007;89-B:1010–4. doi:10.1302/0301-620X.89B8.19424.

[20] Harris K, Beard D, Dawson J, Price A. An exploratory and confirmatory analysis of the oxford hip score: Generation of subscales assessing self-reported function and pain. Trials 2013;14:1–1. doi:10.1186/1745-6215-14-s1-p74.

[21] Harris K, Dawson J, Doll H, Field RE, Murray DW, Fitzpatrick R, et al. Can pain and function be distinguished in the Oxford Knee Score in a meaningful way? An exploratory and confirmatory factor analysis. Quality of Life Research 2013;22:2561–8. doi:10.1007/s11136-013-0393-x.

[22] Sabah SA, Alvand A, Beard DJ, Price AJ. Minimal important changes and differences were estimated for Oxford hip and knee scores following primary and revision arthroplasty. Journal of Clinical Epidemiology 2022;143:159–68. doi:10.1016/j.jclinepi.2021.12.016.

[23] EuroQol - a new facility for the measurement of health-related quality of life. Health Policy 1990;16:199–208. doi:10.1016/0168-8510(90)90421-9.

[24] Aragon TJ, Fay MP, Wollschlaeger D, Omidpanah A. Epitools: Epidemiology Tools 2020.

[25] Podmore B, Hutchings A, Konan S, van der Meulen J. The agreement between chronic diseases reported by patients and derived from administrative data in patients undergoing joint arthroplasty. BMC Medical Research Methodology 2019;19:87. doi:10.1186/s12874-019-0729-5.

[26] Dang KLT, Badge H, Harris IA. Validity of patient-reported complications after total hip and knee arthroplasty. Journal of Orthopaedic Surgery 2018;26:2309499018802493. doi:https://dx.doi.org/10.1177/2309499018802493.

[27] Wilson HA, Middleton R, Abram SGF, Smith S, Alvand A, Jackson WF, et al. Patient relevant outcomes of unicompartmental versus total knee replacement: Systematic review and meta-analysis. BMJ 2019;364:l352. doi:https://dx.doi.org/10.1136/bmj.l352.

[28] Bayliss LE, Culliford D, Monk AP, Glyn-Jones S, Prieto-Alhambra D, Judge A, et al. The effect of patient age at intervention on risk of implant revision after total replacement of the hip or knee: A population-based cohort study. The Lancet 2017;389:1424–30. doi:10.1016/S0140-6736(17)30059-4.

[29] Evans JT, Walker RW, Evans JP, Blom AW, Sayers A, Whitehouse MR. How long does a knee replacement last? A systematic review and meta-analysis of case series and national registry reports with more than 15 years of follow-up. Lancet 2019;393:655–63. doi:https://dx.doi.org/10.1016/S0140-6736(18)32531-5.

[30] Evans JT, Evans JP, Walker RW, Blom AW, Whitehouse MR, Sayers A. How long does a hip replacement last? A systematic review and meta-analysis of case series and national registry reports with more than 15 years of follow-up. Lancet (London, England) 2019;393:647–54. doi:10.1016/S0140-6736(18)31665-9.

[31] Slater M. Marginal gains underpin GB cycling dominance. BBC Sport 2012.

[32] Beard DJ, Harris K, Dawson J, Doll H, Murray DW, Carr AJ, et al. Meaningful changes for the Oxford hip and knee scores after joint replacement surgery. Journal of Clinical Epidemiology 2015;68:73–9. doi:10.1016/j.jclinepi.2014.08.009.

Tables

Table 1: Baseline patient characteristics and patient-reported outcomes following primary hip replacement

Characteristic	Overall, N = 277,430[1]	2013/14, N = 41,530	2014/15, N = 42,775	2015/16, N = 40,079	2016/17, N = 41,066	2017/18, N = 36,524	2018/19, N = 38,467	2019/20, N = 36,989
Age (years)								
<60	36,739 (13%)	5,371 (13%)	5,632 (13%)	5,346 (13%)	5,441 (13%)	4,877 (13%)	5,106 (13%)	4,966 (13%)
60-69	85,797 (31%)	13,265 (32%)	13,483 (32%)	12,713 (32%)	12,977 (32%)	11,139 (30%)	11,333 (29%)	10,887 (29%)
70-79	102,425 (37%)	14,792 (36%)	15,437 (36%)	14,541 (36%)	15,148 (37%)	13,716 (38%)	14,786 (38%)	14,005 (38%)
80+	36,020 (13%)	5,077 (12%)	5,102 (12%)	5,299 (13%)	5,430 (13%)	4,801 (13%)	5,244 (14%)	5,067 (14%)
(Missing)	16,449 (5.9%)	3,025 (7.3%)	3,121 (7.3%)	2,180 (5.4%)	2,070 (5.0%)	1,991 (5.5%)	1,998 (5.2%)	2,064 (5.6%)
Gender								
Female	159,190 (57%)	23,582 (57%)	24,165 (56%)	23,043 (57%)	23,798 (58%)	21,103 (58%)	22,169 (58%)	21,330 (58%)
Male	101,900 (37%)	14,932 (36%)	15,545 (36%)	14,870 (37%)	15,198 (37%)	13,437 (37%)	14,315 (37%)	13,603 (37%)
(Missing)	16,340 (5.9%)	3,016 (7.3%)	3,065 (7.2%)	2,166 (5.4%)	2,070 (5.0%)	1,984 (5.4%)	1,983 (5.2%)	2,056 (5.6%)

[1]n (%); c("Mean (SD)", "N missing (% missing)")

Characteristic	Overall, N = 277,430[1]	2013/14, N = 41,530	2014/15, N = 42,775	2015/16, N = 40,079	2016/17, N = 41,066	2017/18, N = 36,524	2018/19, N = 38,467	2019/20, N = 36,989
Duration of symptoms								
Less than 1 year	34,525 (12%)	5,712 (14%)	5,670 (13%)	5,292 (13%)	5,222 (13%)	4,260 (12%)	4,362 (11%)	4,007 (11%)
1 - 5 years	190,857 (69%)	28,145 (68%)	28,933 (68%)	27,402 (68%)	28,290 (69%)	25,368 (69%)	26,866 (70%)	25,853 (70%)
6 - 10 years	31,958 (12%)	4,555 (11%)	4,867 (11%)	4,549 (11%)	4,734 (12%)	4,334 (12%)	4,557 (12%)	4,362 (12%)
10 years +	16,980 (6.1%)	2,562 (6.2%)	2,574 (6.0%)	2,369 (5.9%)	2,507 (6.1%)	2,306 (6.3%)	2,338 (6.1%)	2,324 (6.3%)
(Missing)	3,110 (1.1%)	556 (1.3%)	731 (1.7%)	467 (1.2%)	313 (0.8%)	256 (0.7%)	344 (0.9%)	443 (1.2%)
Self-reported disability								
Yes	141,544 (51%)	22,641 (55%)	22,435 (52%)	20,469 (51%)	20,716 (50%)	18,607 (51%)	18,935 (49%)	17,741 (48%)
No	119,900 (43%)	16,776 (40%)	17,643 (41%)	16,895 (42%)	17,837 (43%)	15,800 (43%)	17,355 (45%)	17,594 (48%)
(Missing)	15,986 (5.8%)	2,113 (5.1%)	2,697 (6.3%)	2,715 (6.8%)	2,513 (6.1%)	2,117 (5.8%)	2,177 (5.7%)	1,654 (4.5%)
Number of comorbidities								

[1]n (%); c("Mean (SD)", "N missing (% missing)")

Characteristic	Overall, N = 277,430[1]	2013/14, N = 41,530	2014/15, N = 42,775	2015/16, N = 40,079	2016/17, N = 41,066	2017/18, N = 36,524	2018/19, N = 38,467	2019/20, N = 36,989
0	39,572 (14%)	5,849 (14%)	6,376 (15%)	6,013 (15%)	6,057 (15%)	5,125 (14%)	5,207 (14%)	4,945 (13%)
1	105,052 (38%)	15,415 (37%)	16,027 (37%)	15,080 (38%)	15,528 (38%)	13,819 (38%)	14,750 (38%)	14,433 (39%)
2	82,090 (30%)	12,591 (30%)	12,576 (29%)	11,754 (29%)	11,987 (29%)	10,821 (30%)	11,384 (30%)	10,977 (30%)
3+	50,716 (18%)	7,675 (18%)	7,796 (18%)	7,232 (18%)	7,494 (18%)	6,759 (19%)	7,126 (19%)	6,634 (18%)
Pre-operative OHS								
Mean (SD)	18 (8)	18 (8)	18 (8)	18 (8)	18 (8)	17 (8)	17 (8)	18 (8)
N missing (% missing)	3,073 (1.1%)	550 (1.3%)	460 (1.1%)	408 (1.0%)	464 (1.1%)	376 (1.0%)	472 (1.2%)	343 (0.9%)
Post-operative OHS								
Mean (SD)	40 (9)	39 (9)	40 (9)	40 (8)	40 (9)	40 (8)	40 (8)	40 (8)
N missing (% missing)	3,188 (1.1%)	550 (1.3%)	493 (1.2%)	470 (1.2%)	461 (1.1%)	472 (1.3%)	356 (0.9%)	386 (1.0%)
Change in OHS								
Mean (SD)	22 (10)	21 (10)	21 (10)	22 (10)	22 (10)	23 (10)	23 (10)	23 (10)

[1]n (%); c("Mean (SD)", "N missing (% missing)")

Characteristic	Overall, N = 277,430[1]	2013/14, N = 41,530	2014/15, N = 42,775	2015/16, N = 40,079	2016/17, N = 41,066	2017/18, N = 36,524	2018/19, N = 38,467	2019/20, N = 36,989
N missing (% missing)	6,170 (2.2%)	1,083 (2.6%)	937 (2.2%)	866 (2.2%)	915 (2.2%)	834 (2.3%)	815 (2.1%)	720 (1.9%)
Responder								
Yes	249,254 (90%)	36,859 (89%)	38,129 (89%)	35,928 (90%)	36,853 (90%)	33,143 (91%)	34,879 (91%)	33,463 (90%)
No	22,006 (7.9%)	3,588 (8.6%)	3,709 (8.7%)	3,285 (8.2%)	3,298 (8.0%)	2,547 (7.0%)	2,773 (7.2%)	2,806 (7.6%)
(Missing)	6,170 (2.2%)	1,083 (2.6%)	937 (2.2%)	866 (2.2%)	915 (2.2%)	834 (2.3%)	815 (2.1%)	720 (1.9%)
Pre-operative EQ-5D utility								
Mean (SD)	0.35 (0.32)	0.35 (0.32)	0.36 (0.32)	0.36 (0.32)	0.35 (0.32)	0.33 (0.32)	0.34 (0.32)	0.34 (0.32)
N missing (% missing)	15,144 (5.5%)	2,140 (5.2%)	2,323 (5.4%)	2,254 (5.6%)	2,281 (5.6%)	1,862 (5.1%)	2,364 (6.1%)	1,920 (5.2%)
Post-operative EQ-5D utility								
Mean (SD)	0.80 (0.24)	0.79 (0.24)	0.80 (0.24)	0.80 (0.24)	0.80 (0.24)	0.80 (0.24)	0.80 (0.24)	0.80 (0.24)
N missing (% missing)	11,738 (4.2%)	1,776 (4.3%)	1,926 (4.5%)	1,725 (4.3%)	1,738 (4.2%)	1,713 (4.7%)	1,471 (3.8%)	1,389 (3.8%)

[1]n (%); c("Mean (SD)", "N missing (% missing)")

Characteristic	Overall, N = 277,430[1]	2013/14, N = 41,530	2014/15, N = 42,775	2015/16, N = 40,079	2016/17, N = 41,066	2017/18, N = 36,524	2018/19, N = 38,467	2019/20, N = 36,989
Change in EQ-5D utility								
Mean (SD)	0.45 (0.34)	0.44 (0.34)	0.44 (0.34)	0.44 (0.34)	0.45 (0.34)	0.47 (0.34)	0.47 (0.34)	0.46 (0.34)
N missing (% missing)	25,756 (9.3%)	3,752 (9.0%)	4,066 (9.5%)	3,801 (9.5%)	3,849 (9.4%)	3,426 (9.4%)	3,671 (9.5%)	3,191 (8.6%)
Patient satisfied								
Yes	255,413 (92%)	37,994 (91%)	39,474 (92%)	37,044 (92%)	37,942 (92%)	33,352 (91%)	35,495 (92%)	34,112 (92%)
No	18,344 (6.6%)	3,000 (7.2%)	2,896 (6.8%)	2,631 (6.6%)	2,743 (6.7%)	2,290 (6.3%)	2,411 (6.3%)	2,373 (6.4%)
(Missing)	3,673 (1.3%)	536 (1.3%)	405 (0.9%)	404 (1.0%)	381 (0.9%)	882 (2.4%)	561 (1.5%)	504 (1.4%)
Perceived success								
Yes	262,394 (95%)	39,215 (94%)	40,649 (95%)	38,109 (95%)	38,988 (95%)	34,218 (94%)	36,300 (94%)	34,915 (94%)
No	11,753 (4.2%)	1,849 (4.5%)	1,770 (4.1%)	1,625 (4.1%)	1,748 (4.3%)	1,494 (4.1%)	1,646 (4.3%)	1,621 (4.4%)
(Missing)	3,283 (1.2%)	466 (1.1%)	356 (0.8%)	345 (0.9%)	330 (0.8%)	812 (2.2%)	521 (1.4%)	453 (1.2%)
Number of complications								

[1]n (%); c("Mean (SD)", "N missing (% missing)")

Characteristic	Overall, N = 277,430[1]	2013/14, N = 41,530	2014/15, N = 42,775	2015/16, N = 40,079	2016/17, N = 41,066	2017/18, N = 36,524	2018/19, N = 38,467	2019/20, N = 36,989
0	191,513 (69%)	27,986 (67%)	29,232 (68%)	27,552 (69%)	28,293 (69%)	25,250 (69%)	26,895 (70%)	26,305 (71%)
1	62,476 (23%)	9,670 (23%)	9,832 (23%)	9,284 (23%)	9,475 (23%)	7,893 (22%)	8,401 (22%)	7,921 (21%)
2	16,039 (5.8%)	2,698 (6.5%)	2,683 (6.3%)	2,302 (5.7%)	2,322 (5.7%)	2,057 (5.6%)	2,161 (5.6%)	1,816 (4.9%)
3+	4,908 (1.8%)	835 (2.0%)	810 (1.9%)	722 (1.8%)	761 (1.9%)	617 (1.7%)	581 (1.5%)	582 (1.6%)
(Missing)	2,494 (0.9%)	341 (0.8%)	218 (0.5%)	219 (0.5%)	215 (0.5%)	707 (1.9%)	429 (1.1%)	365 (1.0%)

[1]n (%); c("Mean (SD)", "N missing (% missing)")

Table 2: Baseline patient characteristics and patient-reported outcomes following primary knee replacement

Characteristic	Overall, N = 308,007[1]	2013/14, N = 43,699	2014/15, N = 45,884	2015/16, N = 44,263	2016/17, N = 44,815	2017/18, N = 43,402	2018/19, N = 43,102	2019/20, N = 42,842
Age (years)								
<60	30,610 (9.9%)	4,109 (9.4%)	4,167 (9.1%)	4,163 (9.4%)	4,264 (9.5%)	4,741 (11%)	4,608 (11%)	4,558 (11%)
60-69	103,257 (34%)	15,055 (34%)	15,622 (34%)	15,404 (35%)	15,205 (34%)	14,386 (33%)	13,848 (32%)	13,737 (32%)
70-79	121,967 (40%)	16,662 (38%)	17,800 (39%)	17,451 (39%)	17,671 (39%)	17,192 (40%)	17,642 (41%)	17,549 (41%)
80+	36,367 (12%)	5,014 (11%)	5,353 (12%)	5,253 (12%)	5,638 (13%)	5,044 (12%)	5,078 (12%)	4,987 (12%)
(Missing)	15,806 (5.1%)	2,859 (6.5%)	2,942 (6.4%)	1,992 (4.5%)	2,037 (4.5%)	2,039 (4.7%)	1,926 (4.5%)	2,011 (4.7%)
Gender								
Female	167,591 (54%)	23,642 (54%)	25,052 (55%)	24,349 (55%)	24,753 (55%)	23,466 (54%)	23,380 (54%)	22,949 (54%)
Male	124,585 (40%)	17,173 (39%)	17,890 (39%)	17,922 (40%)	18,025 (40%)	17,897 (41%)	17,796 (41%)	17,882 (42%)
(Missing)	15,831 (5.1%)	2,884 (6.6%)	2,942 (6.4%)	1,992 (4.5%)	2,037 (4.5%)	2,039 (4.7%)	1,926 (4.5%)	2,011 (4.7%)
Duration of symptoms								

[1]n (%); c("Mean (SD)", "N missing (% missing)")

Characteristic	Overall, N = 308,007[1]	2013/14, N = 43,699	2014/15, N = 45,884	2015/16, N = 44,263	2016/17, N = 44,815	2017/18, N = 43,402	2018/19, N = 43,102	2019/20, N = 42,842
Less than 1 year	14,148 (4.6%)	2,131 (4.9%)	2,301 (5.0%)	2,179 (4.9%)	2,081 (4.6%)	1,968 (4.5%)	1,782 (4.1%)	1,706 (4.0%)
1 - 5 years	159,532 (52%)	22,663 (52%)	23,751 (52%)	22,864 (52%)	23,122 (52%)	22,536 (52%)	22,377 (52%)	22,219 (52%)
6 - 10 years	67,349 (22%)	9,540 (22%)	9,851 (21%)	9,687 (22%)	9,924 (22%)	9,585 (22%)	9,454 (22%)	9,308 (22%)
10 years +	63,562 (21%)	8,839 (20%)	9,248 (20%)	8,963 (20%)	9,353 (21%)	8,996 (21%)	9,049 (21%)	9,114 (21%)
(Missing)	3,416 (1.1%)	526 (1.2%)	733 (1.6%)	570 (1.3%)	335 (0.7%)	317 (0.7%)	440 (1.0%)	495 (1.2%)
Self-reported disability								
Yes	152,567 (50%)	24,051 (55%)	23,957 (52%)	22,325 (50%)	22,098 (49%)	20,860 (48%)	19,890 (46%)	19,386 (45%)
No	141,686 (46%)	17,577 (40%)	19,455 (42%)	19,884 (45%)	20,736 (46%)	20,718 (48%)	21,486 (50%)	21,830 (51%)
(Missing)	13,754 (4.5%)	2,071 (4.7%)	2,472 (5.4%)	2,054 (4.6%)	1,981 (4.4%)	1,824 (4.2%)	1,726 (4.0%)	1,626 (3.8%)
Number of comorbidities								
0	31,928 (10%)	4,274 (9.8%)	4,912 (11%)	4,736 (11%)	4,552 (10%)	4,606 (11%)	4,444 (10%)	4,404 (10%)

[1]n (%); c("Mean (SD)", "N missing (% missing)")

Characteristic	Overall, N = 308,007[1]	2013/14, N = 43,699	2014/15, N = 45,884	2015/16, N = 44,263	2016/17, N = 44,815	2017/18, N = 43,402	2018/19, N = 43,102	2019/20, N = 42,842
1	103,332 (34%)	14,261 (33%)	14,917 (33%)	14,673 (33%)	15,137 (34%)	14,693 (34%)	14,802 (34%)	14,849 (35%)
2	101,488 (33%)	14,528 (33%)	15,306 (33%)	14,665 (33%)	14,639 (33%)	14,261 (33%)	14,185 (33%)	13,904 (32%)
3+	71,259 (23%)	10,636 (24%)	10,749 (23%)	10,189 (23%)	10,487 (23%)	9,842 (23%)	9,671 (22%)	9,685 (23%)
Pre-operative OKS								
Mean (SD)	19 (8)	19 (8)	19 (8)	19 (8)	19 (8)	19 (8)	19 (8)	19 (8)
N missing (% missing)	3,592 (1.2%)	517 (1.2%)	596 (1.3%)	505 (1.1%)	503 (1.1%)	509 (1.2%)	544 (1.3%)	418 (1.0%)
Post-operative OKS								
Mean (SD)	36 (9)	35 (10)	35 (10)	36 (9)	36 (9)	36 (9)	36 (9)	37 (9)
N missing (% missing)	4,873 (1.6%)	640 (1.5%)	596 (1.3%)	585 (1.3%)	606 (1.4%)	1,080 (2.5%)	736 (1.7%)	630 (1.5%)
Change in OKS								
Mean (SD)	17 (10)	16 (10)	16 (10)	16 (10)	17 (10)	17 (10)	17 (10)	17 (10)
N missing (% missing)	8,353 (2.7%)	1,142 (2.6%)	1,176 (2.6%)	1,079 (2.4%)	1,090 (2.4%)	1,568 (3.6%)	1,265 (2.9%)	1,033 (2.4%)
Responder								

[1]n (%); c("Mean (SD)", "N missing (% missing)")

Characteristic	Overall, N = 308,007[1]	2013/14, N = 43,699	2014/15, N = 45,884	2015/16, N = 44,263	2016/17, N = 44,815	2017/18, N = 43,402	2018/19, N = 43,102	2019/20, N = 42,842
Yes	254,553 (83%)	35,667 (82%)	37,352 (81%)	36,349 (82%)	36,929 (82%)	36,039 (83%)	36,061 (84%)	36,156 (84%)
No	45,101 (15%)	6,890 (16%)	7,356 (16%)	6,835 (15%)	6,796 (15%)	5,795 (13%)	5,776 (13%)	5,653 (13%)
(Missing)	8,353 (2.7%)	1,142 (2.6%)	1,176 (2.6%)	1,079 (2.4%)	1,090 (2.4%)	1,568 (3.6%)	1,265 (2.9%)	1,033 (2.4%)
Pre-operative EQ-5D utility								
Mean (SD)	0.42 (0.31)	0.41 (0.31)	0.42 (0.31)	0.42 (0.31)	0.42 (0.31)	0.41 (0.31)	0.42 (0.31)	0.42 (0.31)
N missing (% missing)	16,651 (5.4%)	2,384 (5.5%)	2,446 (5.3%)	2,616 (5.9%)	2,511 (5.6%)	2,131 (4.9%)	2,387 (5.5%)	2,176 (5.1%)
Post-operative EQ-5D utility								
Mean (SD)	0.75 (0.25)	0.73 (0.25)	0.74 (0.25)	0.74 (0.25)	0.74 (0.25)	0.75 (0.25)	0.76 (0.24)	0.76 (0.25)
N missing (% missing)	13,554 (4.4%)	2,027 (4.6%)	2,217 (4.8%)	1,905 (4.3%)	2,002 (4.5%)	2,140 (4.9%)	1,717 (4.0%)	1,546 (3.6%)
Change in EQ-5D utility								
Mean (SD)	0.33 (0.33)	0.32 (0.33)	0.32 (0.33)	0.32 (0.33)	0.32 (0.33)	0.34 (0.33)	0.34 (0.33)	0.34 (0.33)

[1]n (%); c("Mean (SD)", "N missing (% missing)")

Characteristic	Overall, N = 308,007[1]	2013/14, N = 43,699	2014/15, N = 45,884	2015/16, N = 44,263	2016/17, N = 44,815	2017/18, N = 43,402	2018/19, N = 43,102	2019/20, N = 42,842
N missing (% missing)	28,902 (9.4%)	4,215 (9.6%)	4,440 (9.7%)	4,316 (9.8%)	4,347 (9.7%)	4,086 (9.4%)	3,929 (9.1%)	3,569 (8.3%)
Patient satisfied								
Yes	263,410 (86%)	36,972 (85%)	39,019 (85%)	37,890 (86%)	38,411 (86%)	37,089 (85%)	37,137 (86%)	36,892 (86%)
No	40,858 (13%)	6,256 (14%)	6,420 (14%)	5,967 (13%)	5,997 (13%)	5,488 (13%)	5,295 (12%)	5,435 (13%)
(Missing)	3,739 (1.2%)	471 (1.1%)	445 (1.0%)	406 (0.9%)	407 (0.9%)	825 (1.9%)	670 (1.6%)	515 (1.2%)
Perceived success								
Yes	275,021 (89%)	38,798 (89%)	40,880 (89%)	39,556 (89%)	40,113 (90%)	38,702 (89%)	38,568 (89%)	38,404 (90%)
No	29,841 (9.7%)	4,514 (10%)	4,651 (10%)	4,388 (9.9%)	4,402 (9.8%)	3,959 (9.1%)	3,934 (9.1%)	3,993 (9.3%)
(Missing)	3,145 (1.0%)	387 (0.9%)	353 (0.8%)	319 (0.7%)	300 (0.7%)	741 (1.7%)	600 (1.4%)	445 (1.0%)
Number of complications								
0	198,958 (65%)	27,373 (63%)	29,078 (63%)	28,400 (64%)	28,855 (64%)	28,181 (65%)	28,307 (66%)	28,764 (67%)
1	74,585 (24%)	11,100 (25%)	11,455 (25%)	10,775 (24%)	10,966 (24%)	10,320 (24%)	10,106 (23%)	9,863 (23%)

[1]n (%); c("Mean (SD)", "N missing (% missing)")

Characteristic	Overall, N = 308,007[1]	2013/14, N = 43,699	2014/15, N = 45,884	2015/16, N = 44,263	2016/17, N = 44,815	2017/18, N = 43,402	2018/19, N = 43,102	2019/20, N = 42,842
2	24,242 (7.9%)	3,667 (8.4%)	3,814 (8.3%)	3,698 (8.4%)	3,610 (8.1%)	3,257 (7.5%)	3,213 (7.5%)	2,983 (7.0%)
3+	8,208 (2.7%)	1,334 (3.1%)	1,348 (2.9%)	1,241 (2.8%)	1,237 (2.8%)	1,137 (2.6%)	1,010 (2.3%)	901 (2.1%)
(Missing)	2,014 (0.7%)	225 (0.5%)	189 (0.4%)	149 (0.3%)	147 (0.3%)	507 (1.2%)	466 (1.1%)	331 (0.8%)

[1]n (%); c("Mean (SD)", "N missing (% missing)")

Table 3: Changes over time in patient-reported outcomes following primary hip replacement

	Post-operative OHS	Post-operative EQ-5D	Responder	Satisfaction	Success	Complication
Year of surgery	0.152 [a]	0.002 [a]	1.020 [b]	1.020 [b]	0.997 [b]	0.973 [b]
	[0.136,0.167]	[0.001,0.002]	[1.012,1.028]	[1.012,1.028]	[0.987,1.007]	[0.969,0.977]
	(0.000)	(0.000)	(0.000)	(0.000)	(0.555)	(0.000)
Observations	237332	221191	237332	239330	239672	240339
Adjusted R-squared	0.15	0.16				

[a] Coefficient represents the change in the dependent variable as year of surgery is increased by one unit

[b] Odds ratio represents the change in odds of the response 'Yes' in the dependent variable as year of surgery is increased by one unit

Note: 95 percent confidence intervals in brackets; p-values in parentheses

Table 4: Changes over time in patient-reported outcomes following primary knee replacement

	Post-operative OKS	Post-operative EQ-5D	Responder	Satisfaction	Success	Complication
Year of surgery	0.207 [a]	0.002 [a]	1.038 [b]	1.018 [b]	1.018 [b]	0.970 [b]
	[0.190,0.223]	[0.002,0.003]	[1.033,1.044]	[1.013,1.024]	[1.012,1.025]	[0.966,0.973]
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	267300	250189	267300	271201	271703	272678
Adjusted R-squared	0.17	0.18				

[a] Coefficient represents the change in the dependent variable as year of surgery is increased by one unit

[b] Odds ratio represents the change in odds of the response 'Yes' in the dependent variable as year of surgery is increased by one unit

Note: 95 percent confidence intervals in brackets; p-values in parentheses

Figures

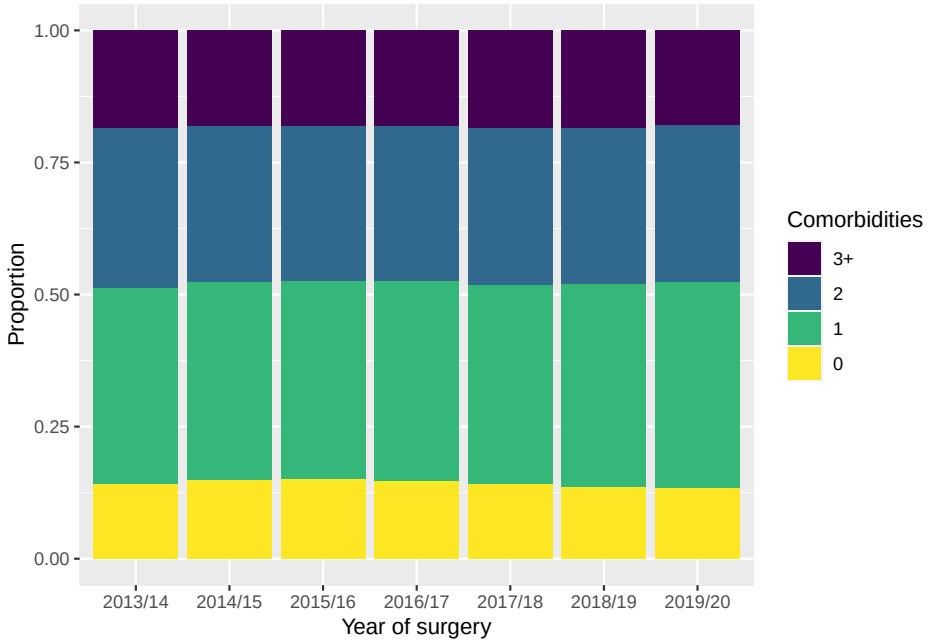

Figure 1: Stacked bar chart demonstrating trends over time in the number of patient comorbidities at baseline for primary hip replacement

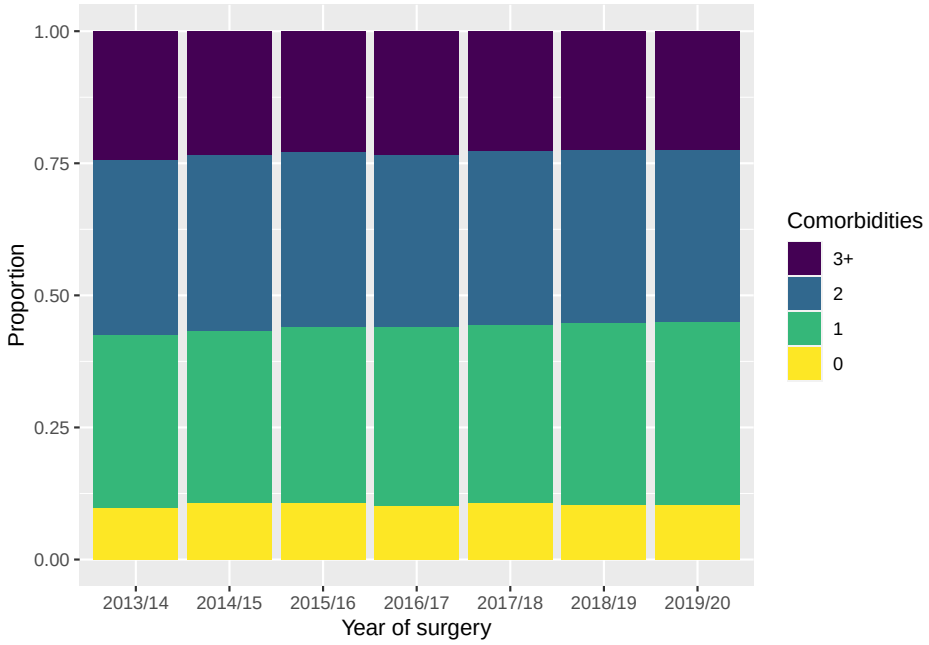

Figure 2: Stacked bar chart demonstrating trends over time in the number of patient comorbidities at baseline for primary knee replacement

Appendix

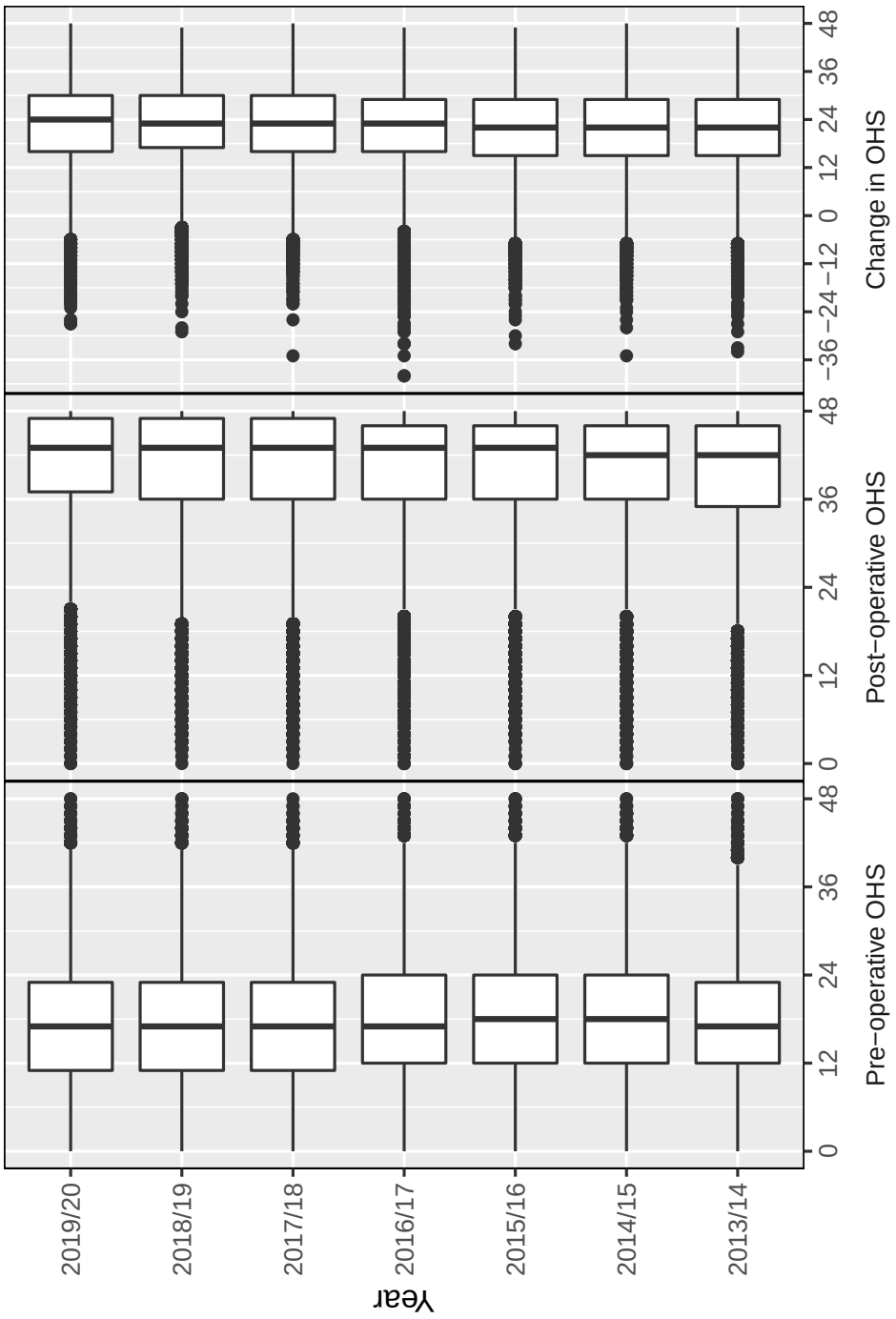

Figure 3: Box-plots demonstrating trends over time for pre-operative, post-operative and change in OHS

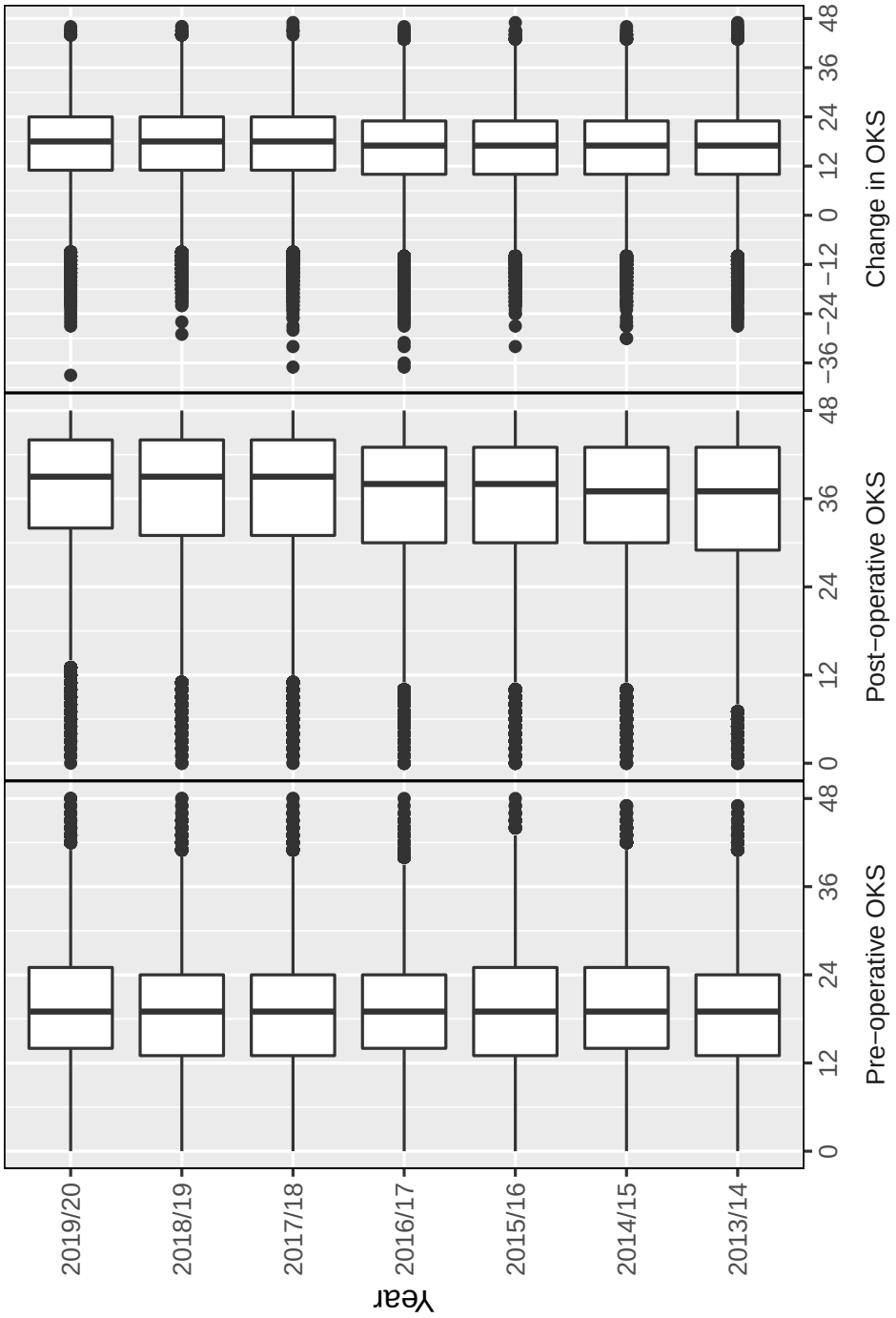

Figure 4: Box-plots demonstrating trends over time for pre-operative, post-operative and change in OKS

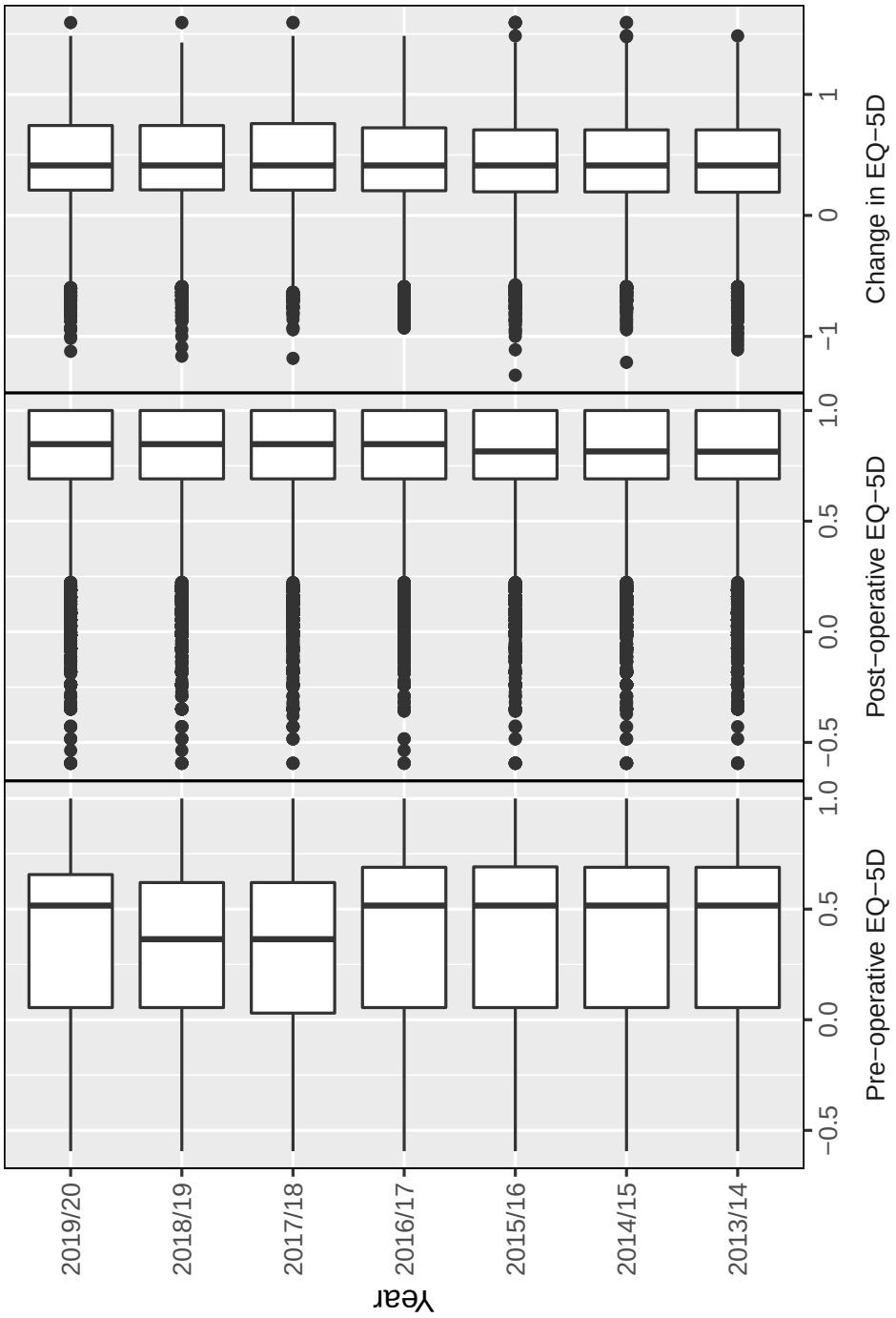

Figure 5: Box-plots demonstrating trends over time for pre-operative, post-operative and change in EQ-5D after primary hip replacement

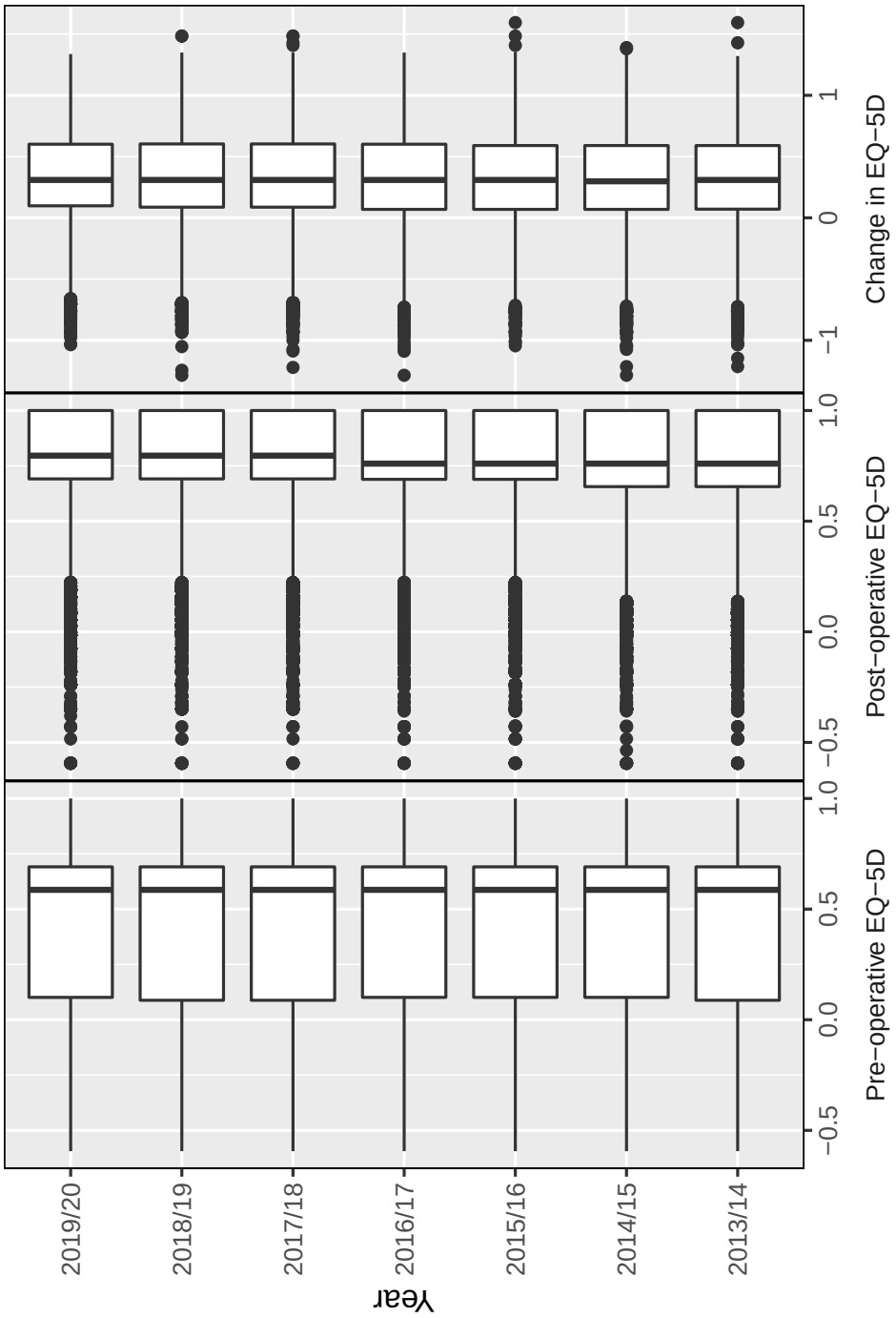

Figure 6: Box-plots demonstrating trends over time for pre-operative, post-operative and change in EQ-5D after primary knee replacement

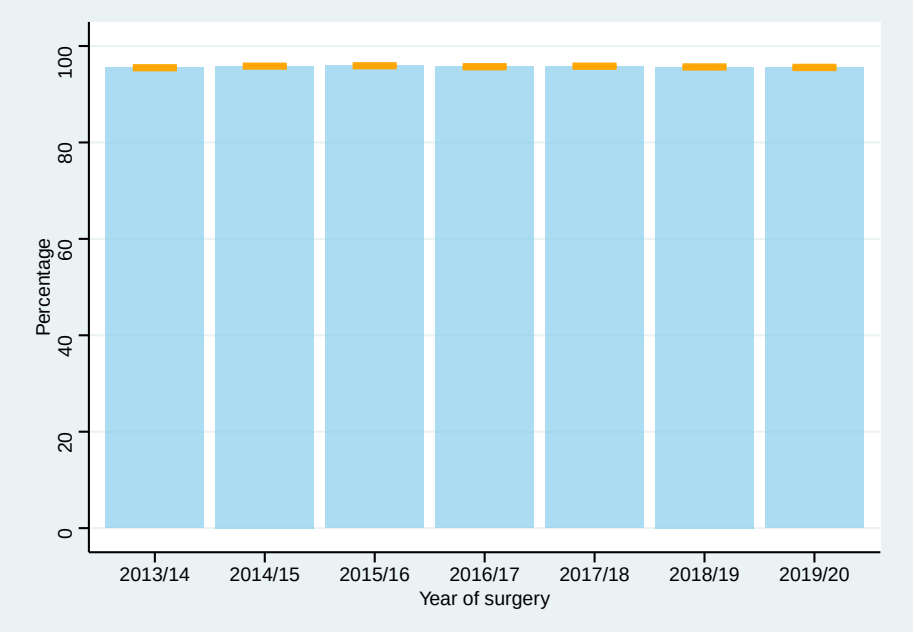

Figure 7: Bar chart demonstrating trends over time in the proportion of patients reporting that primary hip replacement surgery was perceived to be a success

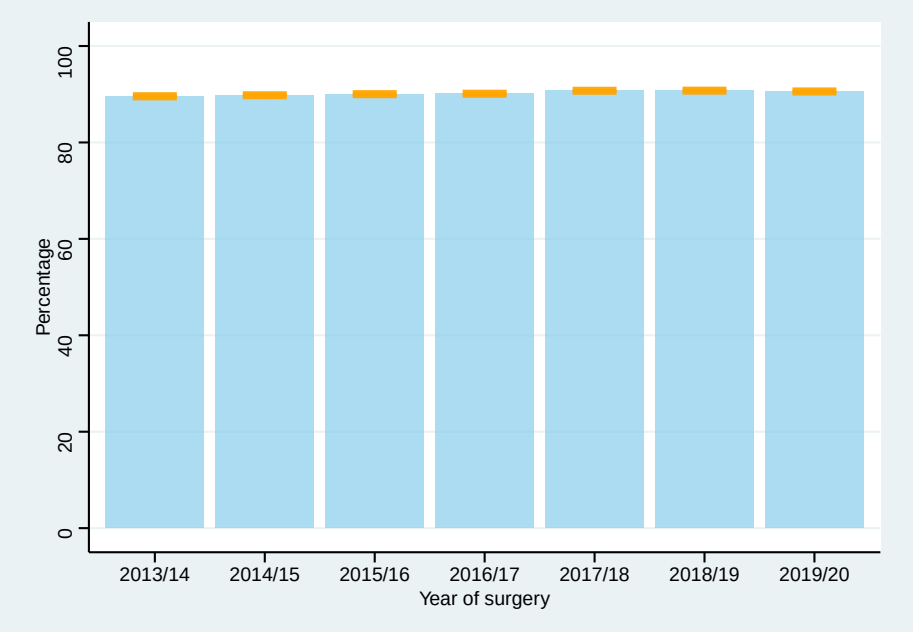

Figure 8: Bar chart demonstrating trends over time in the proportion of patients reporting that primary knee replacement surgery was perceived to be a success

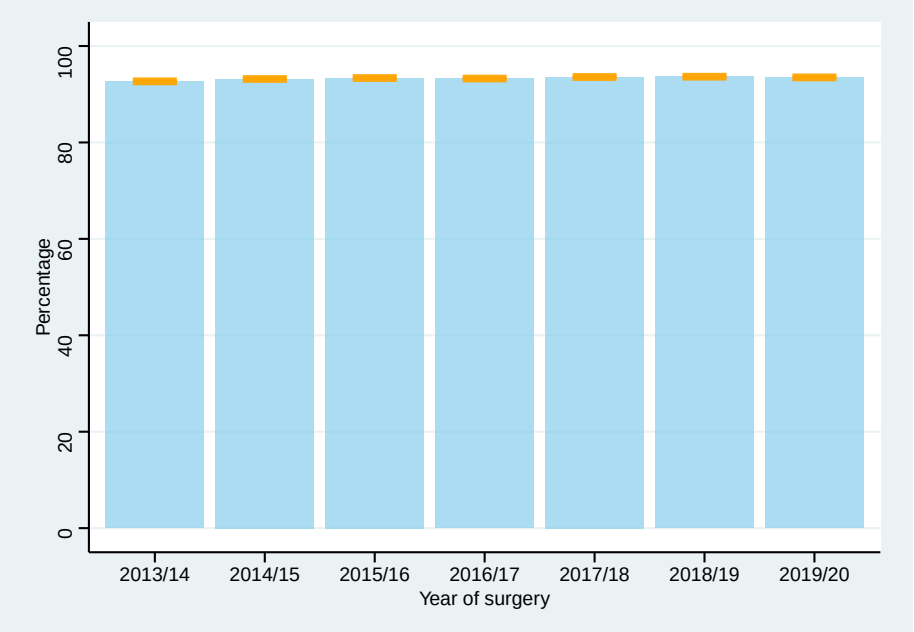

Figure 9: Bar chart demonstrating trends over time in the proportion of patients reporting satisfaction with the result of primary hip replacement

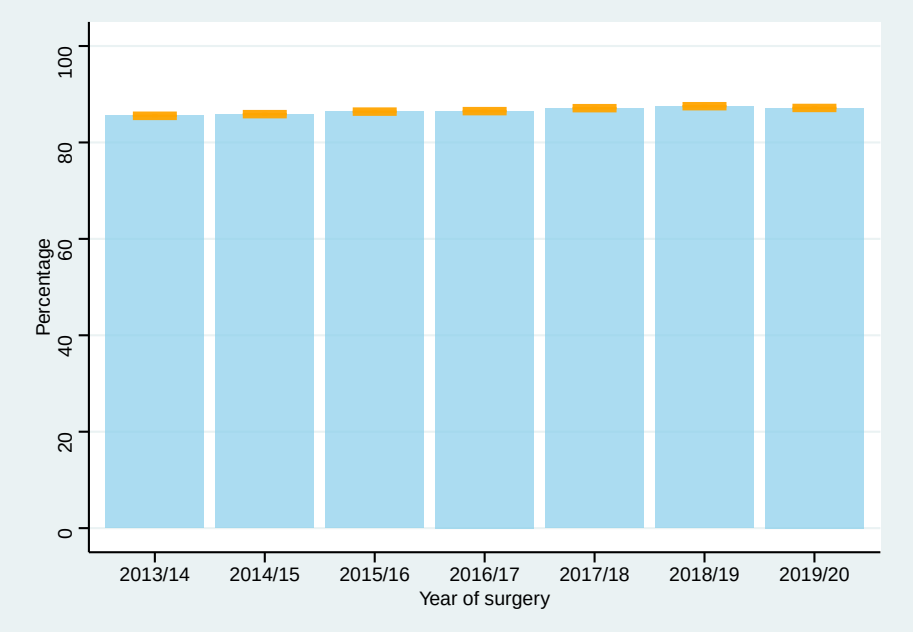

Figure 10: Bar chart demonstrating trends over time in the proportion of patients reporting satisfaction with the result of primary knee replacement

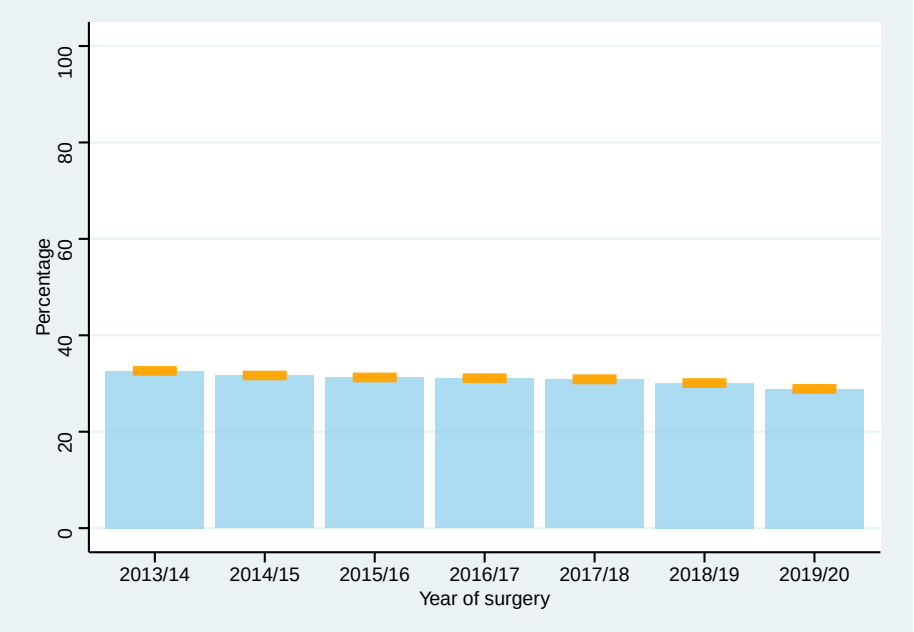

Figure 11: Bar chart demonstrating trends over time in the proportion of patients reporting one or more complications following primary hip replacement

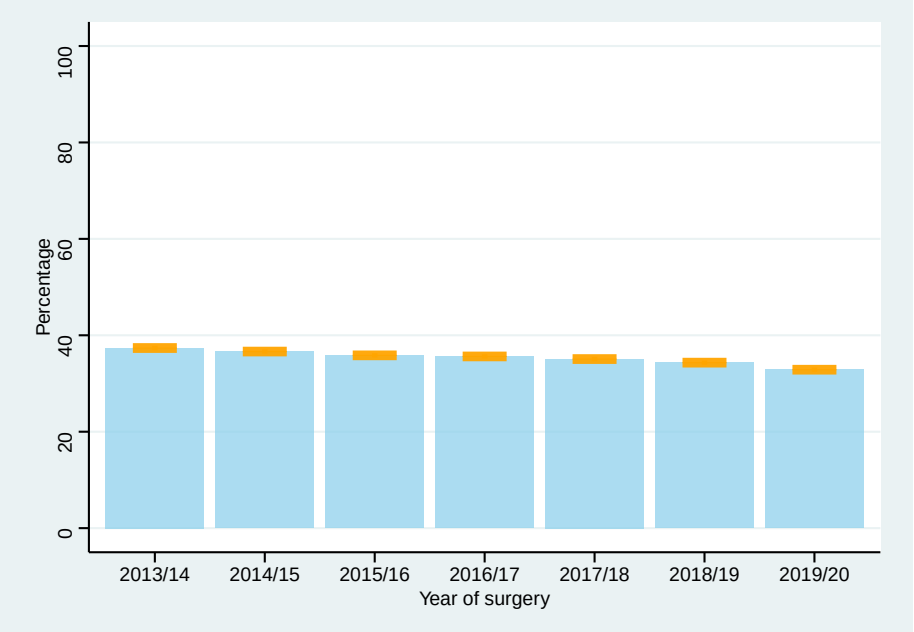

Figure 12: Bar chart demonstrating trends over time in the proportion of patients reporting one or more complications following primary knee replacement

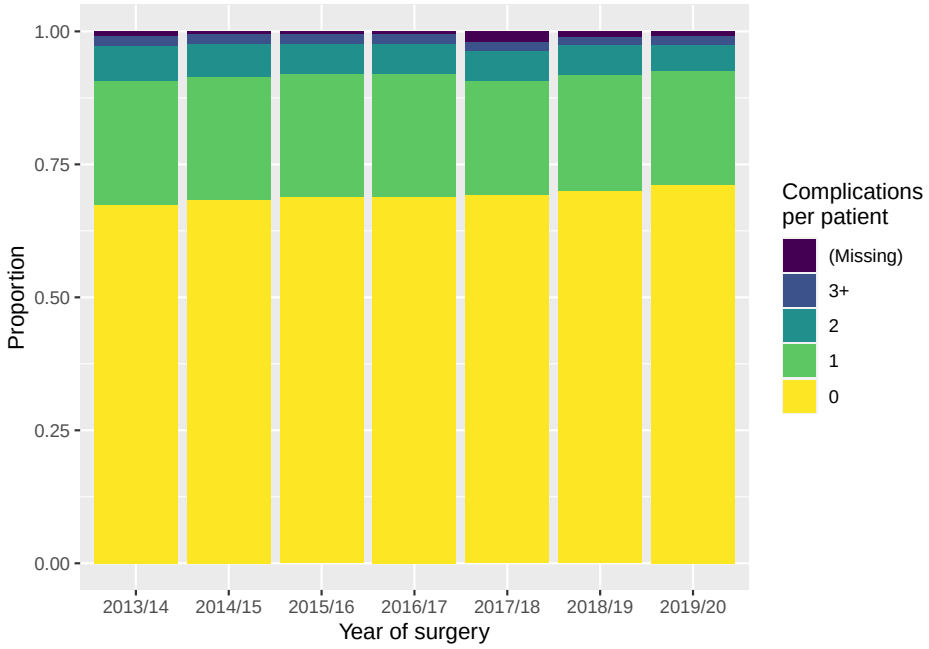

Figure 13: Stacked bar chart demonstrating trends over time in the number of complications reported by each patient following primary hip replacement

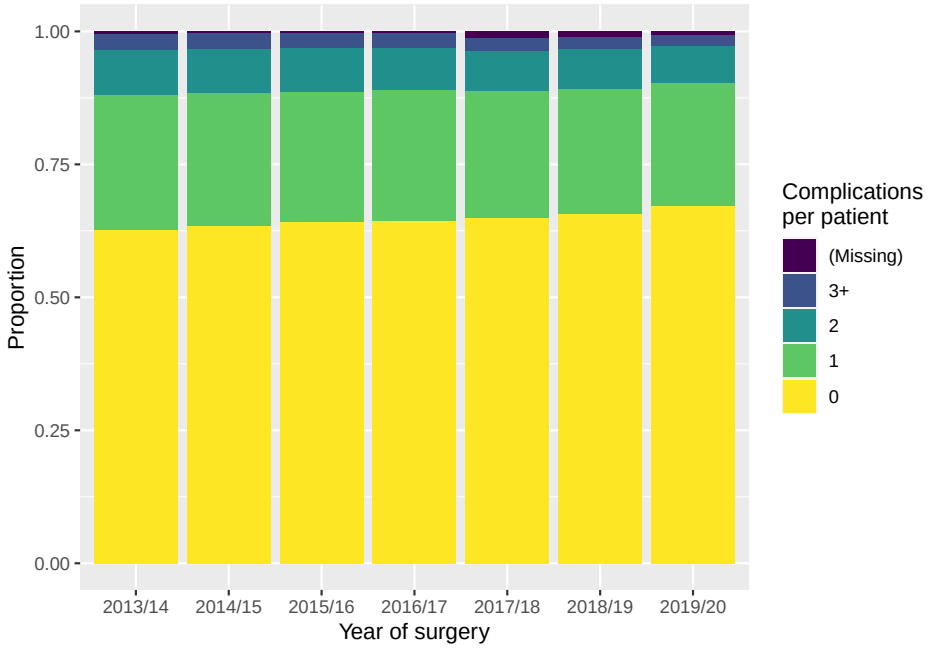

Figure 14: Stacked bar chart demonstrating trends over time in the number of complications reported by each patient following primary knee replacement