National Joint Registry
www.njrcentre.org.uk
Working for patients, driving forward quality

HIPS
KNEES
ANKLES
ELBOWS
SHOULDERS

Click here to go to Contents page, with links to navigate all parts of the report

16th Annual Report 2019

National Joint Registry for England, Wales, Northern Ireland and the Isle of Man

Surgical data to 31 December 2018

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This document is available in PDF format for download from the NJR Reports website at **www.njrreports.org.uk**.
Additional data and information can also be found as outlined on pages 20-23.

Chairman's Foreword

Laurel Powers-Freeling, National Joint Registry Steering Committee, Chairman

The National Joint Registry Steering Committee (NJRSC) oversees the strategic and operational work programme of the registry and I am delighted to have performed the role of Chairman of the Committee over the past seven years. It's always a pleasure at this time of year to take a step back to look back on our work over the last year and compose this foreword for our annual report, which is now showing the output of NJR's work in our 16th edition.

Key work and development

National Musculoskeletal Registry (NMR): This year a major work stream for the NJR has been leading a study to consider the feasibility of developing an operating model that would facilitate a closer working relationship between the NJR and the seven orthopaedic registries forming the BOA Trauma and Orthopaedic Registries Unifying Structure (TORUS). The ambitious vision that has emerged is to develop a NMR that collects and analyses high quality data for the benefit of patients, surgeons and society. This has the support of the NJR, TORUS registries and the BOA, and we are working with NHS leadership to secure their support as well.

The NMR will initially bring the seven registries together with the NJR, under a single governance body, sharing practical aspects and also be capable of aligning with NHS key strategic objectives, such as supporting the delivery of national programmes including Getting it Right First Time (GIRFT) and the National Clinical Improvement Programme (NCIP), aligning to national data strategy around single integrated datasets, encouraging a focus on economies of scale and supporting clinicians with self-appraisal and driving best practice. We will continue the development of this exciting proposal in the coming year to consider in more detail associated implementation, operational and resource arrangements.

Minimum Data Set (MDS) Version 7: The implementation of MDSv7 this year has enabled a refinement of the data that is now being collected for all joint replacement. The improvements enhance the ability of the NJR to analyse and report on the data and enable us to more appropriately reflect clinical practice and enhance reporting for clinician level feedback.

Data Quality Audit: Activity has continued to remain high on the NJR agenda, with an increased number of units that are now more experienced with the audit process, achieving high levels of compliance. We are also delighted to currently be piloting an automated data quality system for hips and knees with very positive feedback so far. Automation expands the validation work timeline, enabling units to submit and check data at any time and therefore maintain a high quality compliance figure throughout the year. As a patient safety benefit, there is an early alarm for low/non-compliance, enabling timely action to address this. The advancement of the pilot is being further developed to include shoulders with a roll-out of the full NJR automated data quality system early next year.

Data Access Portal: Another significant NJR development is our Data Access Portal which has been completed to streamline the process of researchers accessing NJR data once applications have been approved by the NJR Research Committee. Research is very important to the NJR and with over 2.8 million records on our database, we remain the largest arthroplasty register in the world and are able to support research across the range of orthopaedic practice to provide greater understanding and outcomes to benefit and inform patients. The new data access portal will facilitate streamlining and simplifying our associated processes and governance arrangements for this purpose and is scheduled to go live this autumn. Further detail of research projects that have used NJR data appear in our In-depth studies within this year's report.

Patient Decision Support Tool: NJR data has also been used by the Universities of Sheffield and Bristol to develop the patient decision support tool. This will be of significant benefit to patients considering or due to undergo joint replacement surgery, as the tool will be able to produce calculations based on real patient outcome data that will enable shared decision-making between health professionals, patients and their families. The tool is now available on the NJR website, but will be formally launched on the refreshed NJR website patient area later in the year.

Future plans for the coming year 2019/20

As always, the NJR has ambitious plans for continued development which enable us to maintain our reputation as a world class, innovative registry. These plans are reflected in both our Strategic Plan 2018-21 and Annual Plan 2019/20. However, two major areas of focus and resource I would like to mention will be continuing with the Phase 2 development of the proposed implementation of a National Musculoskeletal Registry and development of the new NJR Cloud-based IT Platform. This is an exciting project to amalgamate our currently separate reporting portals to a single NJR securely encrypted cloud-based platform, which would provide the NJR with increased flexibility for all future change, enhance user and public interrogation of the data including PROMs, and have the capacity to extend to any additional TORUS registry alignment.

Acknowledgments

This year there have been further changes to the membership of the NJRSC. I would like to give a special mention to Martyn Porter, NJR Medical Director and Vice Chairman, who at the end of 12 years of dedicated service to the NJR, came to the end of his final term in December 2018. I would like to offer my sincere thanks and appreciation to Martyn for the significant role he has played in the overall development of the NJR and specifically for his valuable advice, expertise and clinical leadership of the NJR Medical Advisory Committee, which has been instrumental in forging the strong working relationships between the NJR and the BOA and professional orthopaedic societies, that we benefit from today. At a personal level, I have learned a great deal from Martyn and valued his wise counsel and creative thinking; he will be missed.

New member appointments have included Mr Tim Wilton who succeeded Martyn as NJR Medical Director and Vice Chairman from 1 January 2019. Tim was previously a co-opted member of the NJRSC in his role as BOA President and brings considerable clinical and leadership expertise to the NJR. Robin Brittain also commenced on 1 January 2019 as the second patient representative, joining Gillian Coward who has provided excellent service and advice

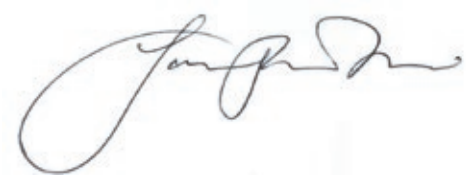
pending Robin's appointment. Patient involvement is of considerable importance to the NJR and I greatly value this second patient member appointment to the NJRSC. I would like to take the opportunity to welcome both new members to the Committee and I look forward to working with them in the future.

I would also like to thank Professor Philip Turner for his considerable contribution this year as a co-opted member of the NJRSC in his capacity as BOA President, which has been of significant value to the NJR in continuing our valued relationship with the orthopaedic profession. I look forward to welcoming his successor who takes up post from September.

I would like to end by thanking all members of the NJR Steering Committee and sub-committees, for their continued enthusiastic and valuable contribution to our work and specifically to the Chairs of each of the NJR sub-committees: Tim Wilton, Peter Howard, Mark Wilkinson, Mike Reed and Matthew Porteous, for their hard work and extraordinary effort which maintains the NJR's international reputation and influence as a leading arthroplasty register. I would encourage you to read and review the reports from each committee chairman at www.njrreports.org.uk where they provide an insightful overview in our key work areas.

I would also like to extend my grateful thanks to our contract partners Northgate Public Services (UK) Ltd, University of Bristol and University of Oxford, for their excellent work throughout the year in supporting the NJR to deliver its work agenda and objectives.

Finally, the NJR Management team has this year once again brought all this work together to deliver a genuinely world-class registry under the leadership of Elaine Young, Director of Operations. We ask more from them each year, and each year they delight us with their energy and enthusiasm for the tasks at hand; thank you.



Laurel Powers-Freeling

Chairman, National Joint Registry Steering Committee

Contents

Part 3 tables

Part 3 figures

Executive Summary

Professor Mike Reed, Chairman of the Editorial Board

This year our annual report is based on 2,835,101 records and we maintain our position as the largest registry in the world. We are presenting joint replacement up to 15 years of follow-up, with data on hips, knees, shoulders, elbows and ankle replacements. A further quarter of a million records were added this year.

Progress and achievements

In order to provide high-quality registry data and feedback to the orthopaedic community, patients and other stakeholders, the NJR has made great progress in improving data quality. The data quality process works by matching information held in the NJR with information held on hospital systems in order to accurately capture every relevant procedure, and make sure it is recorded and used for analysis. This process has been running successfully since 2015 in the NHS and from 2016 in the private sector, and this has been a key component in our strategy in recent years. This year saw the launch of the pilot of an automated data quality system which will directly compare a hospital's reported activity and NJR activity, and produce queries so that any discrepancies can be reviewed. This automation will allow the NJR to perform the audit in a more efficient and streamlined way, and will reduce some of the burden placed upon both Trust and NJR staff in manually checking data. Automation also includes an early alarm for low/non-compliance, enabling timely action to address this. Looking forward, we will extend the quality audit into shoulders, elbows and ankles, and work to bring these joints on board has already commenced.

With improvements in registry-wide data quality we can now offer better information to patients considering surgery about their own particular risks and benefits. For hip and knee replacements, a

Patient Decision Support Tool has been developed using NJR data, for use by patients and also clinical staff so that they can input details of their own personal circumstances to estimate their individual patient outcome, benefits of surgery and risks regarding mortality and revision surgery, based on a number of relevant metrics. This is an exciting development and I recommend that you go online and see how the tool works. It is likely that as traction gains, patients will be interacting with this and no doubt will come to consultations better equipped to share in their treatment plans with this information. The Patient Decision Support Tool can be found at **www.njrcentre.org.uk/njrcentre/Patients/Patient-Decision-Support-Tool**.

For the first time, this year surgeon and hospital performance data will be produced over a rolling 10-year period, rather than the whole life of the registry. Thus, historical data will now no longer be used and a more up-to-date assessment of contemporary practice will be presented in surgeon and hospital level data.

In order to allow wider participation in research using NJR data, a research Data Access Portal has been developed. More detailed information on this is provided in Part 1 of this report.

It has been a busy year for research outputs with this year's NJR Research Fellows producing high quality and prize winning work in journals such as The Lancet. NJR data have been used across a wide range of topics and some of these are detailed in Part 4 of this report. Many more of the publications can be found in Appendix 4 in the downloads section of **www.njrreports.org.uk**.

As always, the NJR and its committees have been visible at both national and international meetings with a presence at the specialist society conferences including BOA Congress, EFORT, BESS, BHS, BASK, EHS, EORS and ISAR and other societies' events being planned for later this year.

Main headlines from the data

For hip replacement we now have well over one million procedures, some with over 15 years of follow-up. Hip surgeons are performing an average of 60 joint replacements per year. This year's report confirms the increasing trend for hybrid hip replacement over the last five years. Three and five year revision rates have reduced over the last ten years, after the peak of metal-on-metal, and the introduction of NJR clinician feedback since 2008. The data is structured to show the effect of patient and implant factors on revision estimates. For example, patient factors include gender and age at time of surgery, while implant factors include type of fixation, brand, bearing and head size. Ceramic-on-polyethylene looks encouraging with longer follow-up, and as a bearing choice this is increasing. Young women form the group that are most likely to be revised. Reassuringly the numbers of revisions performed each year has decreased since 2012 despite higher numbers of primaries. For those joints that are revised, the longer the primary lasts, the lower the chance of re-revision.

There are over one million knee replacement procedures contributing to the registry and we add to it with over 100,000 new cases per year. Surgeons are performing around 40 cases per year on average. Although the patient groups are not necessarily comparable, the results show the lowest revision rates for cemented unconstrained fixed bearing TKR and cemented TKR with monobloc polyethylene tibias. The revision rates in cemented TKRs that are posterior-stabilised and those that have mobile bearings remain higher. The revision rates for UKRs remain substantially higher than for TKR, this is most marked in the patellofemoral replacement group.

This year's report showcases an increasing dataset in both the shoulder and elbow registries with both revision and perioperative mortality being included. Data shows that reverse polarity shoulder replacement has increased further and now dominates practice at 57% while proximal humeral hemiarthroplasty continues to diminish. Usefully, PROMs data is provided and can be interpreted alongside revision rates. More elective humeral hemiarthoplasties are being revised earlier and while it can be argued this revision is an easier operation to perform, the PROMs data in this report does suggest lower change scores are being achieved in the specific patient groups that receive a hemiarthoplasty.

We now have over 5,000 ankle operations recorded on the registry, the majority of which are uncemented implants. There is a cumulative percentage of revision at seven years following a primary ankle replacement of 8.51%, but there is a belief that not all revisions are being entered, and both the British Orthopaedic Foot and Ankle Society (BOFAS) and the NJR encourage surgeons to complete forms for all revisions, conversion of an ankle replacement to an arthrodesis, and amputations, which are mandatory requirements.

Concluding acknowledgements

There is considerable additional information available online and I would encourage you to explore the NJR's dedicated annual report website at **www.njrreports.org.uk**. The website offers a helpful interactive platform for Part Two of the report, which is the descriptive NJR data; supporting appendices; and, when published, the latest NJR Patient and Public Guides to the annual report.

The NJR continues to work with many stakeholders; the most important, of course, are the patients, who I would like thank for allowing the NJR to use their data.

The NJR is a huge team effort. Many thanks also to the following without which the NJR could not function:

All members of the NJR Steering Committee

Members of the NJR sub-committees:

- Executive
- Data Quality
- Editorial Board
- Implant Scrutiny
- Medical Advisory
- Regional Clinical Coordinators
- Research
- Surgical Performance

Members of Data Access Review Group

Members of the NJR Patient Network

Other organisations:

- Medicines and Healthcare products Regulatory Agency (MHRA)
- Care Quality Commission (CQC)
- NHS England
- NHS Digital
- NHS Improvement
- British Orthopaedic Association (BOA)
- British Hip Society (BHS)
- British Association for Surgery of the Knee (BASK)
- British Elbow and Shoulder Society (BESS)
- British Orthopaedic Foot and Ankle Society (BOFAS)
- European Orthopaedic Research Society (EORS)
- Healthcare Quality Improvement Partnership (HQIP)
- Northgate Public Services (UK) Ltd
- University of Bristol
- University of Oxford
- Confidentiality Advisory Group
- Association of British HealthTech Industries (ABHI)

On a personal note I would particularly like to thank Laurel Powers-Freeling, Chairman of the NJR and Elaine Young, NJR Director of Operations.

Northgate Public Services, University of Bristol and University of Oxford teams have done a first class job, as always.

Particular personal thanks to Vicky McCormack and Deirdra Taylor for getting the final report into shape.

Martyn Porter stepped down this year having served for over 15 years on the steering committee and led a huge variety of projects to support the NJR. We are hugely indebted to him, and he is greatly missed across the breadth of the NJR's activities.

Professor Mike Reed

Chairman of the NJR Editorial Board

Part 1

Annual progress

1.1 Annual Report introduction

The 16th Annual Report of the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man (NJR) is the formal public report for the period 1 April 2018 to 31 March 2019. The report consists of a number of parts which are outlined in the summary table on page 23.

As part of the continued approach to sharing information about NJR progress, clinical activity and hospital and implant activity, the NJR has updated the data on its dedicated annual report website, 'NJR Reports', to showcase annual report data and information.

Some of these data can also be found in this printed report – in particular, the summaries and the full detailed, statistical analysis of outcomes following joint replacement surgery.

A short summary of the NJR's progress over 2018/19 is included below and in both the Chairman's Foreword and Annual Report Executive Summary.

Additional information and reports are available online via 'NJR Reports' at: **www.njrreports.org.uk**.

1.2 Annual progress

As at 31 March 2019, the total number of procedures submitted to the NJR was approximately 2.8 million. In the financial year 2018/19, a total of 259,859 records were submitted, which is an increase of 7,608 over the previous year. This increase in submissions may correlate with the NJR's data quality audit and the subsequent creation of new records and re-submission of corrected records.

Overall key performance indicators demonstrated:

- Informed patient consent (to allow or reject the recording of their personal details in the NJR) was recorded as 93.8%, a slight decrease from informed consent in the previous year (2017/18 94.4%). England, Wales and the Isle of Man maintained the same consent rates as last financial year (92.3%) and Northern Ireland had a slight drop from 96.1% to 95.7%.
- Linkability (the ability to link a patient's primary procedure to a revision procedure) was recorded as 95.9%, an increase of 1.9% on the previous year.

Whilst a comparison of successive years will show variation in the rates of the key indicators of consent and linkability, these may be attributable to the outcomes of the data quality audits that have taken place in recent years. This has resulted in the retrospective submission of missing procedures for which some will not have had patient consent recorded. Linkability is dependent on the submission or tracing (via PDS) of NHS and, in Northern Ireland, HCN numbers. Please see the data completeness and quality indicators section on **www.njrreports.org.uk** for further detail.

Data quality was still the primary focus in 2018/19 as we continued our data quality audit across NHS and independent sector units. The NJR data quality audits began in 2015 and were slow to be embraced by units, but there has been a steady improvement in response and in the audit covering the 2017/18 financial year, 42% of units had completed their audits within six months. The completion report provided to each Trust or independent organisation provides valuable feedback on compliance and recommends improvements in local processes.

This year saw the development of an automated data quality audit process to further improve the submission of data. Units will be able to upload a local Patient Administration System data file directly to the NJR and view the audit results. This reduces the burden on hospital staff and gives units greater control of their data. The pilot of this system launched in April 2019.

Surgeons already have access to the NJR's Clinician Feedback system, allowing them to review and validate their data. This has been further enhanced in 2019 with the introduction of an email notification when procedures are revised or a patient death is recorded. This allows surgeons to check their data on a more regular and timely basis as well as compare performance with their peers on a local and national level.

Consultant Level Reports can be downloaded in pdf format in Clinician Feedback. Surgeons can record the download within the website and that this has been reviewed and will be used as part of their annual appraisal and revalidation cycle. This also supports the GMC's commitment to members' participation in quality improvement activities.

Further progress and updates will be available at **www.njrreports.org.uk** and also via the main NJR website at **www.njrcentre.org.uk**.

1.3 Patient Decision Support Tool

We were delighted to launch the NJR Patient Decision Support Tool (PDST) in 2019, available at **www.njrcentre.org.uk/njrcentre/Patients/Patient-Decision-Support-Tool**. Developed by the University of Sheffield and the University of Bristol with funding from Arthritis Research UK grant 20894, this is a web-enabled personalised tool for patients considering hip or knee replacement and has been a core development strategy for the NJR to increase the public use of the dataset.

This simple tool enables patients to enter their personal demographic information and the type of operation they are considering, in order to understand their personalised risks and benefits of proceeding with surgery.

The clinician-assisted version of the tool allows the additional input of surgical variables into the algorithm. The algorithm then uses the linked data from the NJR and national PROMs data to calculate the most likely PROMs score at six months post-operatively, a 1-year mortality profile and an eight to ten year revision risk estimate. The algorithms behind the tool have been validated internally and also externally in collaboration with the Norwegian Arthroplasty Register.

Decision aids fill the gap between population level data and its application to a patient's individual circumstances. This better informs patients making choices about healthcare interventions, enhances patient participation in the process, reduces decisional conflict and subsequently benefits healthcare economies through improved clinical outcomes and better resource utilisation.

The NJR Patient Decision Support Tool helps patients considering joint replacement make evidence-based choices about their treatment and share decision-making with their clinicians when considering the benefits and risks of undergoing joint replacement. The tool underscores the NJR's recognition that patients wish to receive information that is tailored to their own circumstances and is consistent with the recent Montgomery ruling[1] on the personalisation of informed consent. This project represents a substantial initiative on the part of the NJR to meet one of our core objectives to improve accessibility of the NJR resources to patients and promote shared, informed and value-based decision-making.

Having now launched this tool, we are continuing our work to further develop it. Further algorithms are being developed by the Universities of Sheffield and Bristol that will enable the most up-to-date NJR data to be used to calculate projected risks and benefits of joint replacement surgery. We are also working towards updates of the algorithm and website that will enable an automatic refresh of the system as new outcomes data comes online.

[1] Montgomery v Lanarkshire Health Board [2015] SC 11 [2015] 1 AC 1430.

1.4 Data Access Portal and research applications

Another key aim this year has been the creation and development of a secure means of sharing NJR data with researchers.

The NJR Research committee is responsible for delivering the NJR research agenda and its objective is to enhance the understanding of the science of arthroplasty, improve clinical practice and benefit public health. The committee aims to maximise the value of the NJR to research by making NJR data widely available through an impartial and objective application process.

The NJR is working to make the process of applying for and working on NJR data more straightforward for researchers through our new Data Access Portal. The aims of the portal are to provide secure access by approved researchers to specified sub-sets of the NJR dataset. This new approach will enable the NJR to maximise safe access to the data whilst meeting our information governance legal obligations. It will also allow the NJR to reduce the analysis burden on researchers by providing a single data source. Finally, it will enable the NJR to service a larger number of research requests whilst giving greater protection to the data.

The Data Access Portal will also incorporate pre-specified linkage with other national datasets, including Hospital Episode Statistics, mortality data and National Patient Reported Outcomes through a sub-licensing agreement with NHS Digital. This pre-linkage of the datasets will allow the NJR to act as the single source of access to further reduce the burden of the application process for external researchers.

With the redesign of the NJR website, we will be introducing a fully online process for managing research data access requests, with end-to-end management of the application process from initial expression of interest through to final project report download. Several licensed end-user analysis tools will be available to support interaction with the data, including STATA and Microsoft Office, as well as open source tools Python and R. All of the data extraction and analysis will take place within this secure research environment without data ever leaving the NJR servers. Users will be able to save files/outputs from their analysis to a secure area within the Data Access Portal for subsequent download.

Underpinning the Data Access Portal is a “research-ready” dataset. Taken together, these initiatives will improve the utility of the NJR dataset for external researchers, whilst protecting the confidentiality of identifiable data.

1.5 Summary of content for the NJR Annual Report

Section	Summary	Content	Full information can be found
Part One	Executive summaries, annual progress and FY2018/19 highlights	News and information in executive summaries, committee reports and highlights about the progress of the NJR to 31 March 2019	www.njrreports.org.uk
Part Two	Clinical activity 2018	Statistics on joint replacement activity for hip, knee, ankle, elbow and shoulder activity for the period 1 January to 31 December 2018	www.njrreports.org.uk through interactive reporting
Part Three	Outcomes after joint replacement surgery 2003-2018	Detailed statistical analyses on hip and knee replacement surgery using data from 1 April 2003 to 31 December 2018. Updated analyses of primary ankles and shoulders representing data collected since 1 April 2010 and 1 April 2012 respectively. Analyses on provisional data for elbows using data collected since 1 April 2012	In this printed report and via www.njrreports.org.uk
Part Four	Implant and unit-level activity and outcomes	Indicators for hip and knee joint replacement procedures by Trust, Local Health Board and unit. Plus commentary on implant performance and those that have higher than expected rates of revision and were reported to the MHRA	In this printed report and via www.njrreports.org.uk
Prostheses	Use of prostheses by brand (implants)	Prostheses used in joint replacement surgery in 2018 for hip, knee, ankle, elbow and shoulder	www.njrreports.org.uk
Appendices	Information relating to the NJR's governance and operational structure	Composition, attendance, declarations of interest for the NJR Steering Committee, sub-committees and terms of reference	www.njrreports.org.uk
	Research	Published and approved research papers using NJR data	

Part 2

Clinical activity 2018 and using the dedicated NJR Reports website

2.1 Clinical activity 2018 overview

Part Two of the NJR's 16th Annual Report can now be found online via the registry's dedicated NJR Reports website at: www.njrreports.org.uk.

Part Two presents data on clinical activity during the 2018 calendar year. This includes information on the volumes and surgical techniques in relation to procedures submitted to the NJR, with the most recent data being for the period 1 January 2018 to 31 December 2018. To be included in Part Two all procedures must have been entered into the NJR by 28 February 2019.

The double page infographic spread at the end of this report offers a visual summary of key facts relating to clinical activity during the 2018 calendar year. This can also be downloaded as a waiting room poster via **www.njrreports.org.uk/downloads**.

The information in Part Two now includes historical data, going back to 2005 in most cases. Using the dedicated website, readers are able to use interactive, filterable graphs to identify the key information and trends associated with the following reports for hip, knee, ankle, elbow and shoulder data (where sufficient data are available):

- Total number of hospitals and treatment centres in England, Wales and Northern Ireland able to participate in the NJR and the proportion actually participating
- Number of participating hospitals and the number and type of procedures performed
- Number of procedures undertaken as a proportion of all procedures submitted annually
- Procedure details by type of provider
- Primary procedure details by type of provider
- Types of primary replacements undertaken
- Patient characteristics for primary replacement procedures, according to procedure type
- Age and gender for primary replacement patients
- Patients' physical status classification (ASA grades) for primary replacement procedures
- Body Mass Index (BMI) for primary replacement patients
- Indications for primary procedure based on age groups
- Age of patients undergoing primary joint replacement
- Surgical technique for primary replacement patients
- Thromboprophylaxis regime for primary replacement patients, prescribed at time of operation
- Reported untoward intra-operative events for primary replacement patients, according to procedure type
- Patient characteristics for revision procedures, according to procedure type
- Indication for surgery for revision procedures
- Trends in use of the most commonly used brands

For hips specifically

- Components removed during hip revision procedures
- Components used during single-stage hip revision procedures
- Trends in femoral head size and hip articulation

For knees specifically

- Implant constraint for primary procedures
- Bearing type for primary procedures

2.2 Navigating the NJR Reports online facility

What can you find at NJR Reports online?

The total number of procedures recorded in the NJR is now over 2.8 million (at 31 March 2019).

The NJR has refreshed its dedicated online annual report website – NJR Reports – to showcase annual report data and help users easily navigate the growing wealth of information collected about joint replacement procedures.

Part Two of the NJR's 16th Annual Report presents data on clinical activity during the 2018 calendar year. Simply navigate the left hand tabs to view information on the volumes and surgical techniques in relation to procedures submitted to the NJR.

Left hand tabs: Here, the information is segregated by report and information type. A wealth of updates are available, from Executive Reports including from the NJR's Steering Committee Chairman, to Executive Summaries on clinical activity and outcomes data, and highlights from the year.

Top tabs: If you require information about specific procedures, go straight to the data by clicking on the joint type most relevant to you.

There is also implant and hospital specific information available, a **glossary** and downloadable **patient guides** to make all the information as accessible as possible to all of our visitors.

Visit the NJR Reports website at: www.njrreports.org.uk

Part 3

Outcomes after joint replacement 2003 to 2018

3.1 Executive summary

Part Three of the 16th Annual Report provides outcome data in relation to hip, knee, ankle, shoulder and elbow replacements. It describes activity between 1 April 2003 and 31 December 2018.

There were 2,766,764 procedures entered into the NJR across all joint types, performed up to 31 December 2018. After removing procedures without linkage identifiers and those procedures where the linkage was not sufficiently clear to allow their use, there remained 2,332,798 primary cases and 66,248 linked revisions. This represents over a quarter of a million new cases being registered during the year.

There were 1,091,892 primary total hip replacements, 1,193,830 knee replacements, 5,587 ankle replacements, 37,916 shoulder replacements and 3,573 elbow replacements available for analysis, and these form the basis of the ensuing section concerning clinical outcomes, including revision rates, mortality data and other clinical outcomes where these are collected.

As previously, some figures in the latest year may not yet fully represent the final figures. There may be late data entry by units and further correction after the data quality audit and for this reason, readers should be wary of drawing conclusions about apparent sudden increases or decreases in a particular procedure in the latest year compared to previous years.

Hip replacement procedures

The number of hip replacement procedures recorded in the NJR continues to grow at a few percent per year continuing the pattern over the last decade since data entry became consistent at around 95% after the initial few years of “start-up”.

The steady gentle decline in cemented and uncemented hips since 2012 continues in favour of hybrid fixation. Few cemented hips have anything other than metal-on-polyethylene (MoP) or ceramic-on-polyethylene (CoP) bearings and the steady decline of MoP in favour of CoP continues. Likewise, those using hybrid hips appear to be increasingly favouring CoP. The consistent and dramatic decline (since 2011) in the use of ceramic-on-ceramic (CoC) bearings in favour of CoP bearings for uncemented hips continues. These combinations are used more in younger patients and this change to CoP is likely related to the excellent survivorship of this bearing surface combination as highlighted in previous years’ reports.

> Metal-on-metal (MoM) bearings have declined to a trickle, and the brief burst of interest in ceramic-on-metal (CoM) bearings several years ago appears to have lapsed almost completely.

As with knee replacement, primary hip revision rates have declined steadily but progressively since about 2008, with this change being even more obvious for hips than for knees. In hips, this has often been attributed to the rapid decline in MoM usage and this has no doubt been a significant factor. However, the fact that we see a similar decrease in revision rates for knee replacements indicates that we need to look for alternative explanations for this improvement. It seems that the progressive decline in revision rates does coincide closely with the time at which the NJR began to provide personal revision rate feedback to surgeons. It is therefore likely that at least some element of the improvement in revision rates has come about due to the feedback of surgeons’ own audited results, and the actions that they have taken in response to this information.

The generally low revision rates for CoP and CoC bearing surfaces in primary hip replacement are quite striking features of the data relating to many of the sub-groups regardless of age and gender, but applies particularly to the younger age groups.

It is interesting to note that in cemented THR the CoP failures occur at a similar rate to MoP at 15 years despite the fact that up to 13-14 years the CoP combination fares slightly better. This observation is largely due to the small numbers of cases available for analysis at 15 years, meaning that less reliance can be placed upon the figures at that time point. This difference at 14-15 years may also relate in part to the fact that 14 years ago far fewer highly cross-linked polyethylene implants were being used, compared to the use over the last ten years; that change was a

gradual one though and would, therefore, be unlikely to have produced any sudden change in failure rates. For uncemented THR the difference between MoP and CoP is similar. However, the failure rate of CoC splits the difference between MoP and CoP. Overall the variability of performance of different bearing surfaces within uncemented hips varies widely. Notably, CoP has slightly lower revision rates out to 13-14 years.

The pattern of differences in hybrid hip replacement also persists. With CoP bearings having lower revision rates when compared to other bearing types at 13-14 years, after which the numbers in these groups becomes small and therefore estimates are less reliable.

The large variability in revision rates with age is seen once again. Females under 60 years of age have higher revision rates than their male counterparts whereas those over the age of 60 have lower revision rates. Once MoM total hips and resurfacing hips are excluded however, the markedly higher revision rates in females under the age of 60 is not observed but revision rates remain lower in females over this age.

Knee replacement procedures

The analysis is now based on 1,193,830 primary knee replacements and there are 33,292 linked revisions from these primary operations. Amongst these primary numbers, there has been a slight increase in the proportion of unicompartmental knees, as has already been seen in the past five years. The continuing decline in hybrid, uncemented and patellofemoral knee operations means that these each represents really quite small numbers each year. There are some surgeons performing multiple partial replacements in the same knee in moderate numbers individually, but the overall numbers are currently insufficient to derive much useful information from analysis.

Overall revision rate for knees during the last 15 years appeared to alter from around 2008, such that 1-year revision rates peaked in 2009, 3-year rates peaked in 2011, 5-year rates peaked in 2013, 7-year rates peaked in 2015 and 10-year revision rates were highest in 2018. As discussed for hip replacement, this series of alterations and their timing implies some significant change in about 2008 which has had a knock-on effect on revision rates for procedures from that time onward.

This is also seen to be the case for hips, and although more dramatic in hips due to the additional effects of the decline in MoM hip bearings from a similar time, there is still clearly another factor at work because knees are affected as well as hips. Again, it is possible this could result from the NJR providing feedback to surgeons; a process which commenced in 2008.

> The results show that posterior-stabilised fixed-bearing, posterior-stabilised mobile-bearing, unconstrained mobile-bearing and constrained condylar TKRs all seem to have slightly (but significantly) higher failure rates than unconstrained fixed-bearing cemented TKRs.

The difference in failure rate between (uncemented/hybrid) posterior-stabilised and unconstrained TKRs is increasing year on year. This difference, which is also seen in data from other registries, has sometimes been attributed to the selective use of some of these more constrained implants for more complicated cases. This would be a plausible explanation for why constrained condylar implants might have a higher failure rate in primary cases, as they would not be used without good reason, as they are more complicated to use, more expensive and potentially have additional sources of post-operative complications. This explanation probably does not hold water in the case of posterior-stabilised or mobile-bearing TKRs however, as these are mostly selected by surgeons as a matter of choice (because they prefer them in principle) and they, therefore, use them routinely regardless of the patient's specific characteristics.

It is interesting to note that the observed difference in revision rates between cemented unconstrained mobile-bearing TKR and cemented unconstrained fixed-bearing TKR is not seen for these bearing options in the uncemented/hybrid TKR groups. This lack of difference is being driven by the higher absolute failure rate of uncemented/hybrid unconstrained, fixed bearing. In contrast, the higher revision rate for

fixed bearings in cemented posterior-stabilised TKRs becomes even more apparent in uncemented posterior-stabilised knees.

Considering the higher revision rate of primary unicompartmental knees that is seen across the 15 years of NJR data, it is of interest to see that up to 12 years the re-revision rate for unicompartmental knees that have been revised is lower in the NJR data compared to the re-revision of revised primary TKRs. This difference is small and the number at risk beyond seven years is low so the observation should be considered cautiously in light of the fact that the "first revision" of unicompartmental knees contains a mix of procedures ranging from simple bearing exchange in non-infected cases to full revision using a "revision" type of TKR.

The re-revision rate of revised primary patellofemoral joints is seen to be substantially lower in relation to the re-revision rate of primary total knees and of unicompartmental knees. Since first-revision of patellofemoral replacements is a less diverse procedure this lower re-revision rate is much more likely to be real than the more modest difference seen for unicompartmental knees. However, it is important to balance the survivorship of the revision against the likelihood of revising the primary.

Ankle replacement procedures

Ankle replacements have only been entered into the NJR since April 2010, and the numbers remain relatively small compared to hips, knees and shoulders. Nevertheless, the number of primary cases in the NJR rose by 843 during the year to reach 5,587, which now represents a very large cohort.

There have been 265 revision operations on these procedures, which include 37 conversions to arthrodesis. Unfortunately, the collection of data about arthrodesis and amputation as a "revision" outcome of ankle replacement is known to be incomplete in the NJR data. There may also have been a misunderstanding by some surgeons about whether those procedures are supposed to be registered as revision procedures by the completion of an A2 Minimum Dataset form and submission to the NJR.

> However, the mandatory reporting requirements and NJR definition of a revision are clear that the definition of revision does include any case where a component of an arthroplasty is either removed, modified or added at a subsequent procedure.

Since amputation is commonly performed by vascular surgeons in the UK, this may also have led to difficulties with the completeness of data since those surgeons are not within orthopaedic units and may not be familiar with the NJR and the mandatory reporting requirements. Analysis of data for failure rates and reasons for failure of ankle replacement therefore remains difficult and potentially inaccurate compared to some other joints. The overall revision rates for ankle replacement still need to be interpreted with caution.

It is clear that ankle replacement is being performed predominantly in male patients and that the overwhelming majority of those being registered involved uncemented implants. The numbers of ankle replacements being performed by each surgeon are remarkably similar to the numbers being performed by each unit where they are done, suggesting that surgeons have generally already selected one amongst their number in each unit to perform these procedures.

Notwithstanding the difficulties outlined above with respect to interpreting the data, it seems clear that the main reason for revision in these joints has been loosening of either the talar component, the tibial component or both. The rate of revision for infection must be interpreted with particular caution as that could be a failure mode which might particularly be expected to result in arthrodesis or amputation rather than revision surgery.

The comparative results of different implants and implant types are currently also difficult to interpret with confidence, not least because the most popular implant was voluntarily removed from the market by the manufacturer in 2014, and in the same year a quite different implant was introduced and immediately

became the best-selling implant. This latter implant has a very short-term follow-up in the NJR despite the high numbers implanted.

Elbow replacement procedures

This section relates to radial head replacement, distal humeral hemiarthroplasty and total elbow replacement. As with ankle replacement, the numbers are relatively small compared with hips and knees, but the 3,573 cases still represent a substantial cohort of elbow replacements.

In contrast to some other joints, a large proportion of elbow replacements are performed for acute trauma, with this indication accounting for over 35% of the total. The trauma cases also differ significantly from the elective cases in terms of the type of implant used. In trauma, radial head replacement and distal humeral hemiarthroplasty make up over half the cases, whereas 90% of elective cases are total elbow replacement. Female patients make up 70.6% of cases.

The great majority of revision cases being entered into the NJR have been from primary cases performed before elbow replacements started to be included in the NJR in April 2012.

The number of surgeons entering primary elbow cases into the NJR has diminished slightly over recent years and the number entering revision cases were far fewer during 2018 than over the whole of the previous five years. This may reflect professional advice that elbow replacements are best concentrated in a small number of sites and surgeons so as to increase individual experience.

The majority of elective elbow replacements are still performed for inflammatory arthropathy.

The likelihood of having a revision elbow replacement is substantially higher during the first five years after elective replacements than after replacement for trauma (7.4% vs 3.0%). This could be for a number of reasons but it is important to note the very different spectrum of procedures being compared. At present, the numbers in the database do not allow for stratification and subset analysis to allow the reasons to be fully analysed by gender, age or individual procedure type.

Mortality after elbow replacement is seen to be 16.5% at five years and appears higher in trauma vs elective cases (19.8% vs. 15.2%) though the extent to which this is simply a manifestation of the mean ages is not yet clear.

Shoulder replacement procedures

Shoulder replacements began being registered in NJR in April 2012, and since that time 37,916 primary operations are available for analysis. Of these, 1,158 have undergone a revision operation.

Female patients accounted for 70.5% of shoulder replacements. There has been a quite dramatic change in the type of procedure being performed on the shoulder in recent years such that in 2018, 57% of all such operations were reverse polarity shoulders, which represents a 16% increase since 2015.

> Conventional shoulder replacements seem to be holding a fairly steady rate of implantation while humeral hemiarthroplasty is declining in numbers.

Relatively large numbers of surgeons appear to be performing shoulder replacements (722 surgeons in 395 units) considering the numbers being done overall. Consequently, the numbers performed by each surgeon remain relatively small compared to those performing hips and knees, although each surgeon still tends to perform a greater volume of procedures than surgeons performing ankle and elbow replacements.

A total of 91% of the shoulder replacements were performed for elective indications and 9% for acute trauma.

The changing spectrum of use of differing types of shoulder implant is a notable feature and clarification is still needed about many aspects of these changes. One of the underlying problems which were originally being addressed by reverse polarity shoulder designs was significant rotator cuff deficiency. The dramatic increase in the use of reverse polarity shoulders in recent years

suggests that these devices are not now being used solely in patients with deficient rotator cuffs.

Revision rates are now available for the different types of shoulder implant and these demonstrate lower revision rates for total shoulders (stemmed, stemless and resurfacing) and for stemmed reverse polarity shoulders. The revision rates are higher for hemiarthroplasty (stemmed, stemless and resurfacing) and for stemless reverse polarity shoulders. There is evidence that fewer hemiarthroplasties are now being performed and this should be regarded as encouraging given the revision data.

As with unicompartmental knees, it is reasonable to think that the higher revision rate for some procedures such as hemiarthroplasty may be due to a number of complicated factors. There may be a perception that these operations would be simpler than more major revisions and there may be more willingness to undertake them. Similarly, revision is only one of the important endpoints and the issue of the actual symptomatic benefit is important. This aspect of outcomes may be more accurately reflected by the PROMs score and PROMs gain than by simple revision data.

Shoulder PROMs have therefore been introduced as an integral part of the NJR assessment of shoulders in particular as these have not previously been part of the National PROMs program. It is hoped that as this PROMs data increases in both breadth and duration it will help to demonstrate whether some of those implants which are “surviving” better may be doing so despite less good clinical outcomes or function, or whether these factors coincide to demonstrate the “best” procedures.

> The PROMs data already demonstrate that considerable improvement is being achieved across the cohort of shoulder replacements, and it is anticipated that these data will be able to be stratified by implant and operation type in due course.

This stratification will also be facilitated by the new implant database which is currently being introduced and which will allow for more granular comparisons when the numbers allow. The PROMs data do show that 12% of patients do not attain the minimum clinically significant improvement by six months post-operatively and all the major categories of shoulder replacement contain such patients. There are also seen to be 7% of elective patients who are worse after six months than pre-operatively, a matter that clearly needs investigation and explanation.

Young patients are seen to have high revision rates for shoulder replacement compared to those in similar aged hip and knee replacement patients. The revision rate is around 10% (10.2% males, 9.7% females) at four years in the under 55 year age group, compared to 4% at four years in TKR and 2.5% and 2% at four years for THR. This is important information in allowing properly informed consent for the patients, in particular for elective procedures.

These figures do nevertheless compare quite favourably to the 4-year revision rates for unicompartmental knees in the under 55 year age group (~7.5%).

Part 3

3.2 Summary of data sources, linkage and methodology

The main outcome analyses in this section relate to primary and revision joint replacements, unless otherwise indicated. We included all patients with at least one primary joint replacement carried out between 1 April 2003 and 31 December 2018 inclusive, whose records had been submitted to the NJR by 15 February 2019.

Information governance and patient confidentiality:

NJR data are collected via a web-based data entry application and stored and processed in Northgate Public Services' (NPS) data centre. NPS is ISO 27001 and ISO 9001 accredited, and compliant with the NHS's Data Security and Protection Toolkit. Data linkage to other datasets is approved by the Health Research Authority under Section 251 of the NHS Act 2006. Please visit www.hra.nhs.uk/about-us/committees-and-services/confidentiality-advisory-group.

Data source:

We know that in the early years of the NJR, when reporting was not mandated by the Department of Health, a number of primary procedures were not recorded in the NJR, as indicated by discrepancies between implant levies and procedure rates. In the subsequent years, selective reporting of primary and revision procedures may partly explain temporal increases in volume (primary and revision), and revision outcomes for hip and knee replacements (see sections 3.3 and 3.4).

More recently primary procedures are less likely to have been missed. The recent 2015/16 NJR data completeness and accuracy audit across NHS and independent units reporting to the NJR suggests that about 5.4% and 4.8% of hip and knee primaries respectively may not have been recorded on the NJR.

Our analyses would be more seriously impacted by differential and selective under-reporting of revision procedures associated with the primaries that have been entered. This could lead to reported revision outcomes looking better or worse than they actually are. This issue is being addressed by the NJR's Data Quality Committee. Similarly, the 2015/16 audit suggested 11.4% and 12.4% of hip and knee revisions respectively had been missed during this period. It is important for all those concerned with and involved with the NJR to remember that data reporting of all relevant procedures is mandated by the Department of Health.

As of February 2019, all eligible NHS Trusts and Health Boards and Independent Sector units contributing data to the NJR had completed the 15/16 audit. Although it is possible that some records may have been missed in the audit process, or subsequently entered, we believe this number is small.

Whilst the proportion of missing data in the NJR is relatively small, the propensity to not record revision procedures is problematic and will lead to a reduction in ability to detect trends. From a registry wide perspective, we believe under-reporting of revisions would apply across all types of hip and knee replacements in a random pattern, and therefore would not affect the group comparisons we make.

Patient level data linkage:

Documentation of implant survivorship and mortality requires linkage of person-level identifiers, in order to identify primary and revision procedures and mortality events within the same individual.

Starting with a total of 2,766,764 NJR source records, 8.2% were lost because no suitable person-level identifier was found (see Figure 3.1 overleaf). In around half of these 226,032 procedures (54.1%), the patient had declined to give consent for their details to be held or consent was not obtained, the remainder being attributable to tracing and linkage difficulties. Cases from Northern Ireland were excluded at this step (26,921) because of unresolved issues around tracing mortality; and a further 1,031 cases from the Isle of Man were also excluded due to our inability to audit them against local hospital data. Patients with longer follow-up might be less representative

of the whole cohort of patients undergoing primary joint replacement than those patients with shorter follow-up, due to difficulties with data linkage and differential rates of reporting over time.

Among the linkable procedures with person-level identifiers (2,540,582) there were 101,810 (4.0%) revision procedures within the analysis period (2003 to 2018) with no associated primary operation recorded in the NJR. This would have been either because the primary had taken place at an earlier point in time (before the NJR data collection period began in 2003) or was not included for other reasons such as the operation being performed outside the geographical catchment area of the NJR, or consent for data linkage not being provided at the time of the primary procedure. At the joint level, some further revisions were excluded because they could not be matched to primary joint replacements, i.e. if a primary operation was recorded only for one side and there was only a documented revision for the other side, the latter was excluded. However, we have included these 'unlinked' revisions in our general overview of outcomes after revision, see sections 3.3 and 3.4.

Linkage between primaries and any associated revisions (the 'linked files'):

A total of 1,885,035 patients had at least one record of a primary joint replacement within the NJR, i.e. hip, knee, ankle, shoulder or elbow. At this stage, information about the primary procedures was linked to subsequent associated revisions (i.e. for the same patient-joint-side). Further data cleaning was carried out at this stage, for example, removal of duplicated primary information on the same side or revision dates that appeared to precede the primary procedure, leading to the numbers for analysis shown in Tables 3.1 and 3.2.

In Table 3.2, of the 927,571 patients with primary hip operations, 17.7% had documented primaries for both hips. Of the 963,846 patients with knee operations, 23.9% had documented primaries for both knees. Implant survivorship is first described with respect to the lifetime of the primary joint only. In sections 3.3 and 3.4, we also provide an overview of further revisions following the first hip or knee revision procedure.

As in previous years, the unit of observation for all sets of survivorship analysis has been taken as the individual primary joint replacement. A patient with left and right replacements of a particular type, therefore, will have two entries, and an assumption is made that the survivorship of a replacement on one side is independent of the other. In practice, this would be difficult to validate, particularly given that some patients will have had primary replacements of other joints that were not recorded in the NJR. Established risk factors, such as age, are recorded at the time of primary operation and will therefore be different for the two procedures unless the two operations are performed at the same time.

Within the NJR, a revision is defined as any operation in which any prosthesis or part of a prosthesis is either removed, exchanged or inserted for any reason into a joint in which there is an existing joint replacement. This therefore not only includes complete replacement of one or both of the main components of any joint replacement, but also, for example, liner and/or head exchange at surgery for suspected infection and secondary patella resurfacing of an existing total knee replacement. Additionally we have included DAIRs without modular exchange of components in this definition.

Figure 3.1 Initial numbers of procedures for analysis.

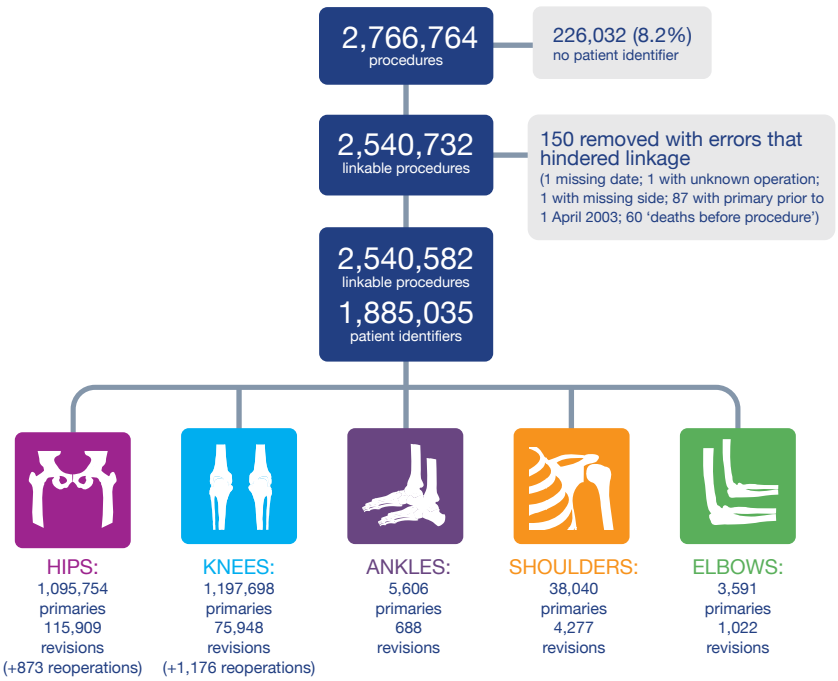


Table 3.1 Summary description of linked datasets used for main survivorship analyses.

Summary of data	NJR data (England and Wales only)				
Time period	All NJR procedure-level data restructured to person-level 1 April 2003 - 31 December 2018 (hips and knees) 1 April 2010* - 31 December 2018 (ankles) 1 April 2012* - 31 December 2018 (shoulders and elbows)				
Data exclusions	- Excludes data where person-level identifier is not present - Excludes patients where no primary operation is recorded in the NJR - Excludes any revisions after the first revision				
Number of primary operations	1,092,068 hips	1,193,960 knees	5,587 ankles	37,916 shoulders	3,573 elbows
Number of primaries that were subsequently revised	NJR identified primary-linked first revisions				
	31,410 hips	33,292 knees	265** ankles	1,158*** shoulders	123**** elbows

*These were the dates when data collection formally started, however the analyses in this section include a small number of primaries in the database that took place before these time points.
**Ankle revisions include 46 conversions to arthrodesis.
***Shoulder revisions include four excisions, two conversion to arthrodesis and four DAIRs.
****Elbow revisions includes four excisions and one DAIR.

Table 3.2 Composition of person-level datasets for main survivorship analysis.

	Joints				
	Hips	Knees	Ankles	Shoulders	Elbows
Number of patients	**927,571**	**963,846**	**5,330**	**35,265**	**3,441**
Number (%) of patients with only one primary joint operation	763,074 (82.3%)	733,732 (76.1%)	5,073 (95.2%)	32,614 (92.5%)	3,309 (96.2%)
Number (%) of patients with both a left and right side primary operation but on different dates	159,561 (17.2%)	217,791 (22.6%)	249 (4.7%)	2,625 (7.4%)	129 (3.7%)
Number (%) of patients with both a left and right side operation on the same date (bilateral operations)	4,936 (0.5%)	12,323 (1.3%)	8 (0.2%)	26 (0.1%)	3 (0.1%)
Total number of primary joints	**1,092,068**	**1,193,960**	**5,587**	**37,916**	**3,573**
Number with at least one revision operation linked to the primary	31,410	33,292	265	1,158	123
Number with more than one revision procedure	4,739*	5,801*	29 (15)**	152 (105)**	22 (13)**

*Discussed more fully in later sections: the numbers shown include some stage two of two-stage revisions.
**In some cases the first revision was the stage one of a two-stage revision; the numbers in parenthesis exclude cases where a further revision procedure appeared to be either another stage one or the respective stage two.

Analytical methods and terminology

The NJR annual report uses a variety of statistical methods to reflect the diversity and range of performance within joint replacement. Analyses are tailored to ensure results are reported in units that can be easily interpreted. Here we define important concepts which underpin the analyses in the following sections.

All cause / all construct revision

All cause revision is used as the primary outcome in the majority of analyses due to the difficulties in defining cause-specific failure i.e. several indications may have been given for a particular revision. In addition, we consider the construct as a single entity, for example, in hips we do not differentiate between stem and acetabular failure as it is sometimes difficult to identify which prosthetic element failed first or is causally responsible for the failure. It is incorrect to assume that the failure of implants that make up a construct are independent of each other. In knees, we similarly do not differentiate between failure of components within the tibia, femur or patella. Secondary patella resurfacing after a total knee replacement is considered a revision.

Debridement And Implant Retention - DAIR

Debridement and Implant Retention (DAIR) without modular exchange is now included in the NJR data as of MDSv7 (June 2018). DAIRs with modular exchange should have been collected (as a type of single stage revision) from inception and their reporting in hips, knees, shoulders and elbows, along with all other procedures captured by the NJR, has been mandatory since 1 April 2011. Before MDSv7, DAIRs with modular exchange have been considered to be a revision in hip, knee, shoulder and elbow but not ankle replacements. In MDSv7, all joint types are treated the same and a DAIR with modular exchange is considered to be a revision in all recorded joint replacements.

Terminology note: Hip replacements

There are four distinctive design features reflected in the analysis of data collected in the NJR and these are: 1) the type of hip replacement i.e. total hip replacements (THR) and hip resurfacings (the NJR does not collect data on hemiarthroplasty); 2) the fixation of the replacement i.e. cemented, uncemented, hybrid and reverse hybrid; 3) the bearing surfaces of the hip replacement; 4) the size of femoral head/internal diameter of the acetabular bearing.

Cemented constructs are fixed using bone cement in both the femoral stem and acetabulum. Uncemented constructs rely on press fit and osseous integration within the femur and acetabulum that may be supplemented (e.g. by screw fixation). Hybrid constructs contain a cemented femoral stem and an uncemented acetabulum. Reverse hybrid constructs contain an uncemented femoral stem and a cemented acetabulum. By convention, the bearing material of the femoral head is listed before the acetabulum. Currently, the six main categories of bearing surfaces for hip replacements are ceramic-on-ceramic (CoC), ceramic-on-metal (CoM), ceramic-on-polyethylene (CoP), metal-on-metal (MoM), metal-on-polyethylene (MoP) and resurfacing procedures. The metal-on-metal group in this section refers to patients with a stemmed prosthesis (THR) and metal bearing surfaces (a monobloc metal acetabular cup or a metal acetabular cup with a metal liner). Although they have metal-on-metal bearing surfaces, resurfacing procedures, which have a surface replacement femoral prosthesis combined with a metal acetabular cup, are treated as a separate category. Ceramic-on-ceramic resurfacings are now being implanted and in future reports, these will be reported as a new category although the numbers are likely to remain too small for meaningful analysis for a number of years. The size of the femoral head is expressed in millimetres.

Terminology note: Knee replacements

Knee replacements within the NJR are principally defined by the number and type of compartments replaced, the fixation of the components (cemented, uncemented or hybrid), level of constraint, the mobility of the bearing and whether the implants are of a modular design.

The knee is made up of three compartments: medial, lateral and patellofemoral. When a total knee replacement (TKR) is implanted, the medial and lateral compartments are always replaced, and the patella may be resurfaced. If a single compartment is replaced then the term unicompartmental is applied to the implant (UKR). The medial, lateral or patellofemoral compartments can all be replaced independently, if clinically appropriate. Medial and lateral unicompartmental knee replacements are also referred to as medial or lateral unicondylar knee replacements.

Knee replacements are also characterised by their level of constraint (stabilisation). For example, there is variation in the constraint of the tibial insert's articulation with the femoral component depending on whether the posterior cruciate ligament is preserved (cruciate retaining; CR) or sacrificed (posterior stabilised; PS) at the time of surgery. Additional constraint may be necessary to allow the implant to deal with additional ligament deficiency or bone loss (where constrained condylar (CCK) or hinged knee implants would be used) in a primary or revision procedure.

In modular tibial components, the tibial insert may be mobile or remain in a fixed position on the tibial tray. This also applies to medial and lateral unicompartmental knees. Many brands of total knee implant exist in fixed and mobile forms with options for either CR or PS constraint.

Tibial elements may or may not be of modular design. Modularity allows some degree of patient-specific customisation. For example, modular tibial components are typically composed of a metal tibial tray and a polyethylene insert which may vary in thickness. Non-modular tibial components consist of an all-polyethylene tibial component (monobloc polyethylene tibia) available in different thicknesses.

The NJR now distinguishes between medial and lateral unicondylar knee replacements during the

data collection process; however this was not so in earlier versions of the minimum dataset form (MDS). In addition, there are other possible knee designs, such as combinations of unicondylar and patellofemoral, but these are not reported on here, as the numbers are too small.

With regard to the use of the word 'constraint' here, for brevity, total knee replacements are termed unconstrained (instead of posterior cruciate-retaining) or posterior-stabilised (instead of posterior cruciate-stabilised).

Descriptive statistics

In simple cases we tend to report simple descriptive statistics including: frequencies (N=), percentages (%), minimums (min), maximums (max), inter-quartile ranges (IQR) (25th centile, 75th centile), means (SD) and medians (50th centile) of the data.

Survival analysis methods

In more complex analyses that focus on either implant failure (denoted revision), recurrent implant failure (re-revision) or mortality we use 'survival analysis methods' which are also known as 'time to event' methods.

Survival analysis methods are necessary in joint replacement data due to a process known as 'censoring'. There are two forms of censoring which are important to consider in joint replacement registry data: administrative censoring and censoring due to events, such as death.

Administrative censoring creates differential amounts of follow-up time, i.e. patients from 2003 will have been followed up for more than 15 years, whilst patients collected last year will have one year of follow-up or less. Survival analyses methods allow us to include all patients in one analysis without being concerned if patients have one day, one year or one decade of observed follow-up time; these methods automatically adjust analyses for the amount of follow-up time.

In the case of analyses which estimate implant failure, death events are also censored, specifically they are considered non-informative censoring events. This assumes that death is unrelated to a failing implant, and can be safely ignored whilst estimating implant failure (revision). See Sayers et al. 2018 Acta Orthopaedica, 89:3, 256-258, for an extensive discussion on this problem.

The survival tables in this report show 'Kaplan-Meier' (KM) estimates of the cumulative chance (probability) of failure (revision) or death, at different times from the primary operation. In the joint replacement literature they are often referred to as KM or simply survival estimates. We additionally show 95% Confidence Intervals for each estimate (95% CI). Confidence intervals illustrate the uncertainty around the estimate, with wide confidence intervals indicating greater uncertainty than narrow ones. Strictly they are interpreted in the context of repeated sampling i.e. if the data were collected in repeated samples we would expect 95% CIs generated to contain the true estimate in 95% of samples. However, confidence intervals are strongly influenced by the numbers of prosthesis constructs at risk and can become unreliable when the numbers at risk become low. In tables, we highlight in *blue italics* all estimates where there are less than 250 prosthesis constructs at risk or remaining at risk at that particular time point.

Kaplan-Meier estimates can also be displayed graphically using a connected line plot. Figures are joined using a 'stair-step' function. Each 'stair' is flat, reflecting the constant nature of the estimate between the events of interest. When a new event occurs the survival estimate changes, creating a 'step'. Changes in the numbers at risk because of censoring do not themselves cause a step change but if the numbers at risk become low, when an event does occur, the stair-step might appear quite dramatic. Whenever possible, the numbers at risk at each time point have been included in the figures, allowing the reader to more appropriately interpret the data given the number of constructs at risk. The Kaplan-Meier estimates shown are technically 1 minus the Kaplan-Meier estimate multiplied by 100, therefore they estimate the cumulative percentage probability of construct failure.

In the case of revisions, no attempt has been made to adjust for the risk of death, as analyses attempt to estimate the underlying implant failure rate in the absence of death, see Sayers et al. 2018 Acta Orthopaedica, 89:3, 256-258 for an extensive discussion on competing risks. Briefly, the Kaplan-Meier estimator estimates the probability of implant failure (revision) assuming the patient is still alive.

Prosthesis (construct) Time Incidence Rates - PTIRs

Prosthesis time incidence rates are used to describe the incidence (the rate of new events) of specific modes of failure in joint replacement. The PTIR expresses the number of revisions divided by the total of the individual prosthesis-years at risk. Figures here show the numbers of revisions per 1,000 years at risk. PTIR in other areas of research are often known as 'person-time' incident rates, however, in joint replacement registers the base unit of analysis is the 'prosthesis construct'.

Note: This method is only appropriate if the hazard rate (the rate at which revisions occur in the unrevised cases) remains constant across the follow-up period. The latter is further explored by sub-dividing the time interval from the primary operation into intervals and calculating PTIRs for each interval. We have explored temporal changes for hips and knees in this report.

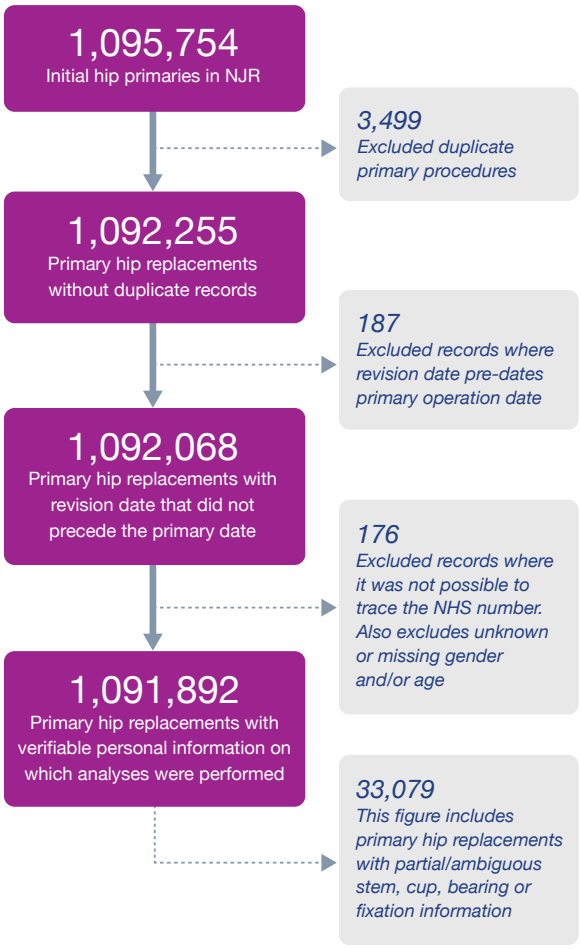
Part 3

3.3 Outcomes after hip replacement

This section looks at revision and mortality outcomes for all primary hip operations performed between 1 April 2003 and 31 December 2018 (inclusive). Patients operated on at the beginning of the registry therefore had a potential 15.75 years of follow-up.

Details of the patient cohort are given in Tables 3.1 and 3.2 of section 3.2. Figure 3.2 describes the data cleaning applied to produce the total of 1,091,892 hips included in the analyses presented in this section.

Figure 3.2 Hip cohort flow diagram.



Over the lifetime of the registry, the 1,091,892 primary hip replacement procedures contributing to our analyses were carried out by a total of 3,581 unique consultant surgeons working across 476 units. Over the last three years (1 January 2016 to 31 December 2018), 281,321 primary hip procedures (representing 25.8% of the current registry) were performed by 2,180 consultant surgeons working across 417 units. Looking at caseload over this three-year period, the median number of primary procedures per consultant surgeon was 63 (inter-quartile range (IQR) 4-203) and the median number of procedures per unit was 598

(IQR 303-903). A proportion of consultants will have just qualified over this period, some may have retired, and some surgeons may have periods of inactivity within the coverage of the NJR, therefore their apparent caseload would be lower.

The majority of primary hip procedures were carried out on women (females 59.8%: males 40.2%). The median age at primary operation was 69 (IQR 61-76) years and the overall range was 7-105 years. Osteoarthritis was given as a documented indication for surgery in 1,001,174 (91.7% of the cohort) and was the sole indication given in 966,771 (88.5%) primary hip replacements.

3.3.1 Overview of primary hip surgery

Table 3.3 Number and percentage of primary hip replacements by fixation and bearing.

Fixation	N (%)	Bearing surface within fixation group	N (%)
All cases	1,091,892 (100)		1,091,892 (100)
All cemented	353,050 (32.3)	MoP MoM CoP Others	310,690 (28.5) 394 (<0.1) 41,955 (3.8) 11 (<0.1)
All uncemented	410,296 (37.6)	MoP MoM CoP CoC CoM Others	161,460 (14.8) 29,066 (2.7) 92,258 (8.4) 125,287 (11.5) 2,119 (0.2) 106 (<0.1)
All hybrid	227,432 (20.8)	MoP MoM CoP CoC Others	135,831 (12.4) 2,369 (0.2) 63,532 (5.8) 25,621 (2.3) 79 (<0.1)
All reverse hybrid	28,789 (2.6)	MoP CoP Others	19,745 (1.8) 8,998 (0.8) 46 (<0.1)
All resurfacing	39,246 (3.6)	MoM Others	39,104 (3.6) 142 (<0.1)
Unsure	33,079 (3.0)	Unsure	33,079 (3.0)

Table 3.3 shows the breakdown of cases by the method of fixation and within each fixation sub-group, by bearing surfaces. The most commonly used operation type overall remains cemented metal-on-polyethylene (88.0% of all cemented primaries, 28.5% of all primaries).

Table 3.4 Percentage* of primary hip replacements by fixation, bearing and calendar year.

Fixation/ bearing	2004 n=42,796	2005 n=40,719	2006 n=48,623	2007 n=60,997	2008 n=67,491	2009 n=68,582	2010 n=71,053	2011 n=74,028	2012 n=78,285	2013 n=80,400	2014 n=87,795	2015 n=89,802	2016 n=93,781	2017 n=94,666	2018 *n=92,874*
All cemented	**53.6**	**46.0**	**40.3**	**37.4**	**31.9**	**30.0**	**29.5**	**30.2**	**31.8**	**32.2**	**31.2**	**30.1**	**28.7**	**27.6**	*27.3*
Cemented by bearing surface:															
MoP	50.5	43.0	37.4	34.8	29.3	27.3	26.4	26.8	27.9	27.9	26.7	25.5	23.9	22.6	*22.3*
MoM	0.1	0.1	0.2	0.2	0.1	<0.1(7)	<0.1(2)	<0.1(2)	0	0	0	<0.1(1)	0	<0.1(1)	*0*
CoP	3.0	2.9	2.8	2.4	2.6	2.7	3.1	3.4	3.8	4.3	4.5	4.6	4.7	5.0	*5.0*
Others	0	0	0	0	0	0	0	<0.1(8)	<0.1(2)	<0.1(1)	0	0	0	0	*0*
All uncemented	**18.4**	**24.3**	**28.4**	**31.5**	**37.3**	**40.9**	**43.2**	**42.9**	**44.1**	**42.0**	**40.3**	**39.0**	**38.2**	**37.4**	*36.4*
Uncemented by bearing surface:															
MoP	7.6	9.5	9.9	10.2	12.4	14.4	16.1	16.6	17.6	17.4	16.9	16.3	16.0	15.7	*15.3*
MoM	1.9	5.5	8.4	10.4	11.1	7.9	3.2	0.4	0.1	<0.1(7)	<0.1(1)	<0.1(1)	0	<0.1(1)	*<0.1(1)*
CoP	4.9	5.0	4.3	3.9	3.8	4.5	5.4	5.9	7.2	8.2	9.5	11.4	12.5	14.2	*14.9*
CoC	3.9	4.3	5.9	6.9	9.7	13.2	17.4	19.5	19.1	16.3	13.9	11.4	9.6	7.6	*6.2*
CoM	<0.1(1)	<0.1(1)	<0.1(7)	0.1	0.4	0.9	1.0	0.5	0.1	<0.1(23)	<0.1(1)	0	0	0	*0*
Others	<0.1(3)	<0.1(4)	<0.1(1)	<0.1(5)	<0.1(2)	<0.1(9)	<0.1(17)	<0.1(15)	<0.1(5)	<0.1(9)	<0.1(6)	<0.1(8)	<0.1(5)	<0.1(13)	*<0.1(4)*
All hybrid	**12.8**	**13.9**	**15.1**	**14.8**	**14.7**	**15.4**	**15.9**	**16.8**	**17.6**	**20.0**	**22.8**	**25.3**	**27.7**	**29.8**	*31.2*
Hybrid by bearing surface:															
MoP	8.9	9.4	9.9	9.9	9.9	10.4	10.8	11.4	11.6	12.2	13.4	14.3	15.3	16.0	*15.6*
MoM	0.7	0.6	0.8	0.9	0.7	0.4	0.2	<0.1(32)	<0.1(3)	0	0	0	0	0	*<0.1(1)*
CoP	1.5	1.2	1.2	1.0	1.3	1.8	1.9	2.2	3.1	5.1	7.0	8.9	10.7	12.4	*14.6*
CoC	1.7	2.7	3.2	2.9	2.7	2.9	3.0	3.1	2.9	2.7	2.4	2.1	1.6	1.4	*1.0*
Others	<0.1(3)	0	0	<0.1(12)	<0.1(4)	<0.1(12)	<0.1(20)	<0.1(13)	<0.1(2)	<0.1(3)	<0.1(1)	<0.1(2)	<0.1(5)	0	*<0.1(2)*
All reverse hybrid	**0.7**	**0.9**	**1.0**	**1.6**	**2.4**	**2.6**	**2.7**	**3.1**	**3.1**	**3.0**	**3.1**	**3.2**	**3.2**	**3.1**	*2.9*
Reverse hybrid by bearing surface:															
MoP	0.5	0.7	0.8	1.0	1.7	1.8	1.9	2.2	2.0	2.0	2.0	2.1	2.2	2.3	*2.1*
CoP	0.2	0.2	0.2	0.6	0.7	0.8	0.9	0.9	1.1	1.0	1.1	1.0	1.0	0.9	*0.8*
Others	<0.1(6)	<0.1(6)	<0.1(12)	<0.1(11)	<0.1(7)	<0.1(1)	<0.1(3)	0	0	0	0	0	0	0	*0*
All resurfacing	**9.8**	**10.3**	**10.4**	**9.8**	**8.3**	**6.2**	**3.8**	**2.5**	**1.4**	**1.1**	**0.9**	**0.9**	**0.7**	**0.6**	*0.6*
Resurfacing by bearing surface:															
MoM	9.8	10.3	10.4	9.8	8.3	6.2	3.7	2.5	1.4	1.1	0.9	0.9	0.7	0.6	*0.5*
Others	0	<0.1(1)	<0.1(1)	<0.1(2)	0	0	<0.1(2)	<0.1(4)	<0.1(3)	<0.1(1)	<0.1(1)	0	<0.1(1)	0.1	*0.1*
All unsure	**4.8**	**4.6**	**4.8**	**4.9**	**5.4**	**4.9**	**4.9**	**4.5**	**2.1**	**1.8**	**1.7**	**1.5**	**1.5**	**1.4**	*1.5*
All types	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	*100*

*Percentages calculated as percentage of total yearly operations.
Note: Where percentage is less than 0.1 the actual number of procedures is included in parenthesis. A zero represents no procedures by this bearing type. Blue italics indicate the data is provisional and likely to increase due to late entry of the data.

Table 3.4 shows the annual rates by fixation and bearing groups for each year for primary hip replacements. Although the absolute number of cemented implants used annually has remained stable between 2006 and the current year, the proportion of all hips that are cemented has nearly halved. The percentage of hybrid implants used has tripled over the same period and the use of uncemented implants doubled. Figure 3.3 illustrates the temporal changes in fixation of primary hip replacements. Since 2012, the most marked feature is the increase in the use of hybrid primary hip replacements.

Figure 3.3 Fixation by year of primary hip replacement.

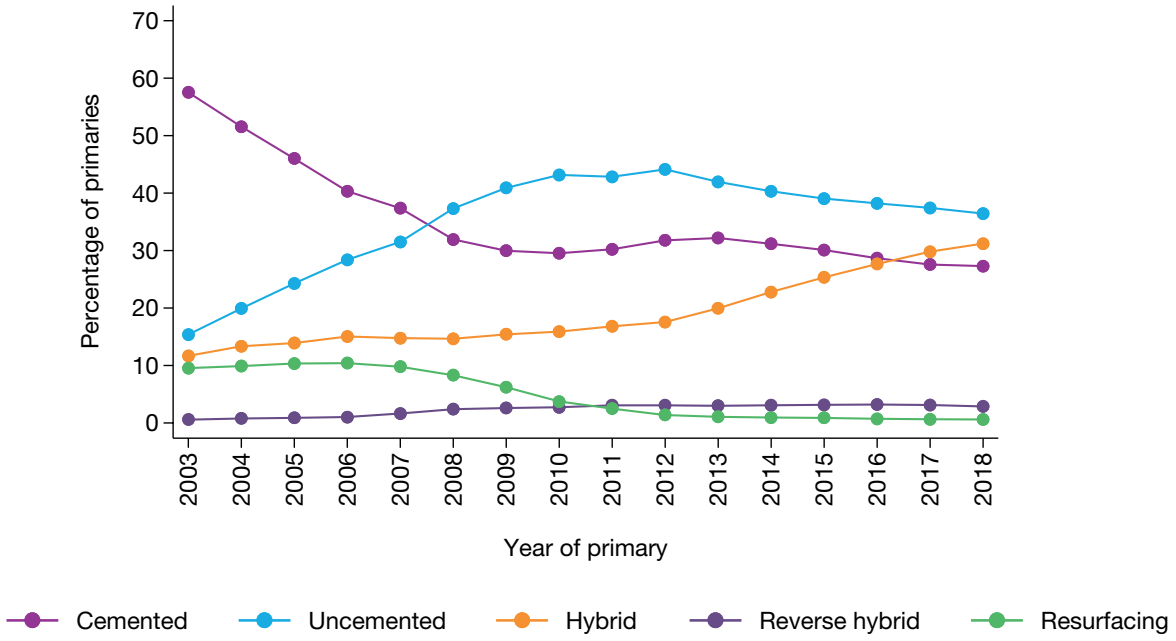
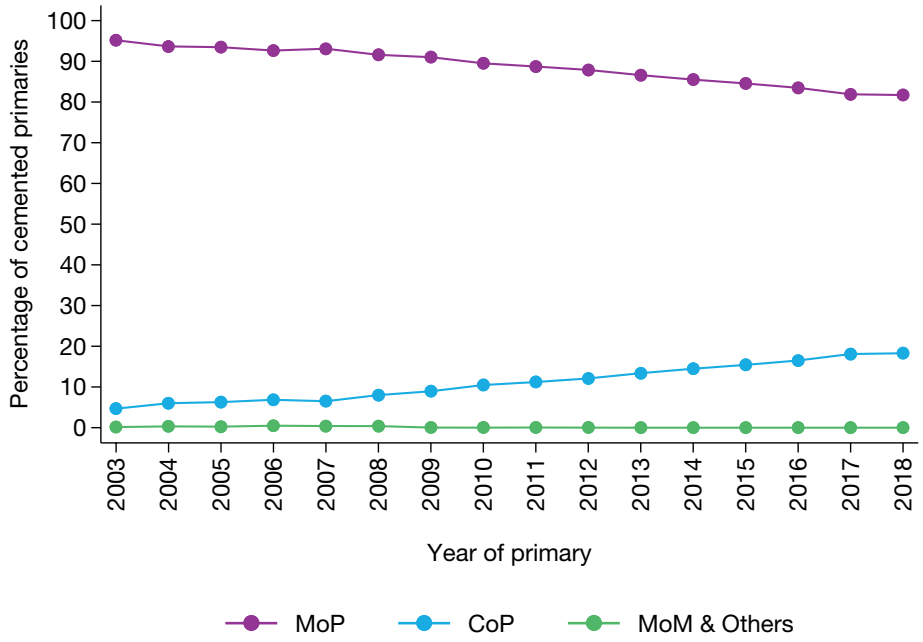


Figure 3.4 (a) Cemented primary hip replacement bearing surface by year.



Figures 3.4 (a) to (d) illustrate the temporal changes in the bearing surface. Since 2012 there has been a marked increase in the use of ceramic-on-polyethylene bearings and a corresponding decrease in the use of ceramic-on-ceramic bearings.

Figure 3.4 (b) Uncemented primary hip replacement bearing surface by year.

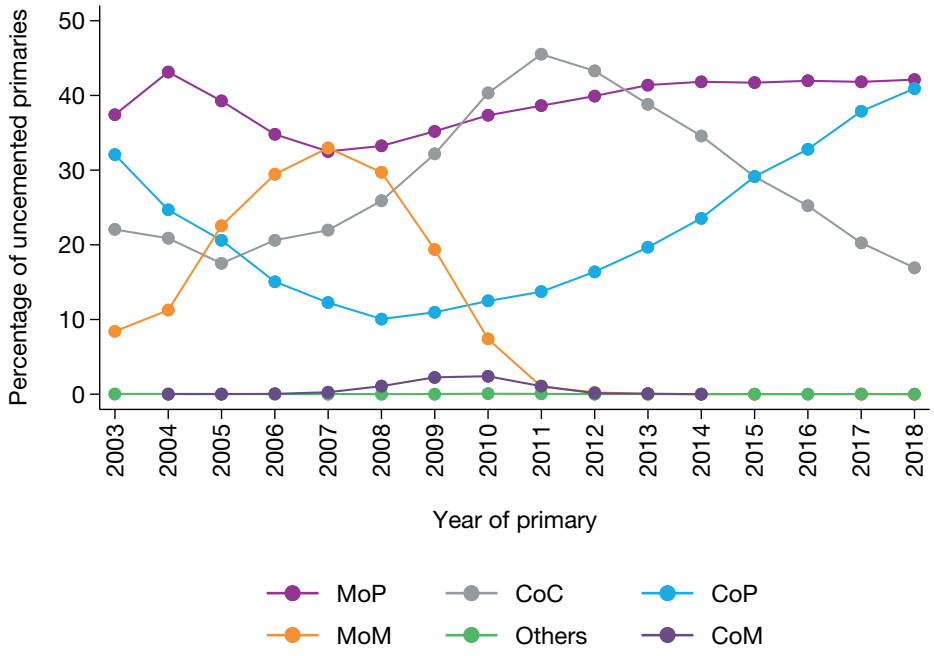


Figure 3.4 (c) Hybrid primary hip replacement **bearing** surface by **year**.

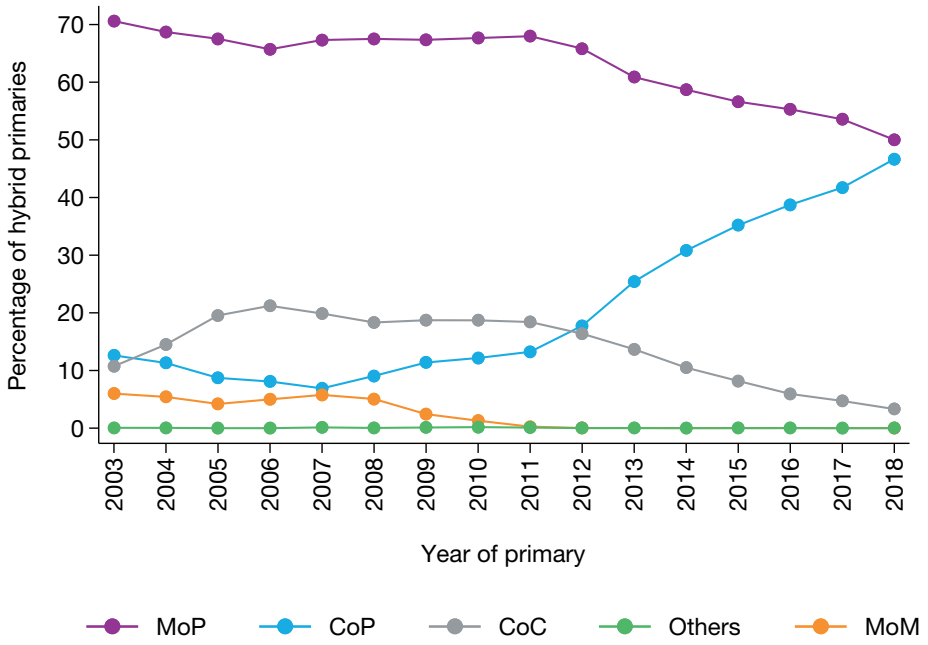


Figure 3.4 (d) Reverse hybrid primary hip replacement bearing surface by year.

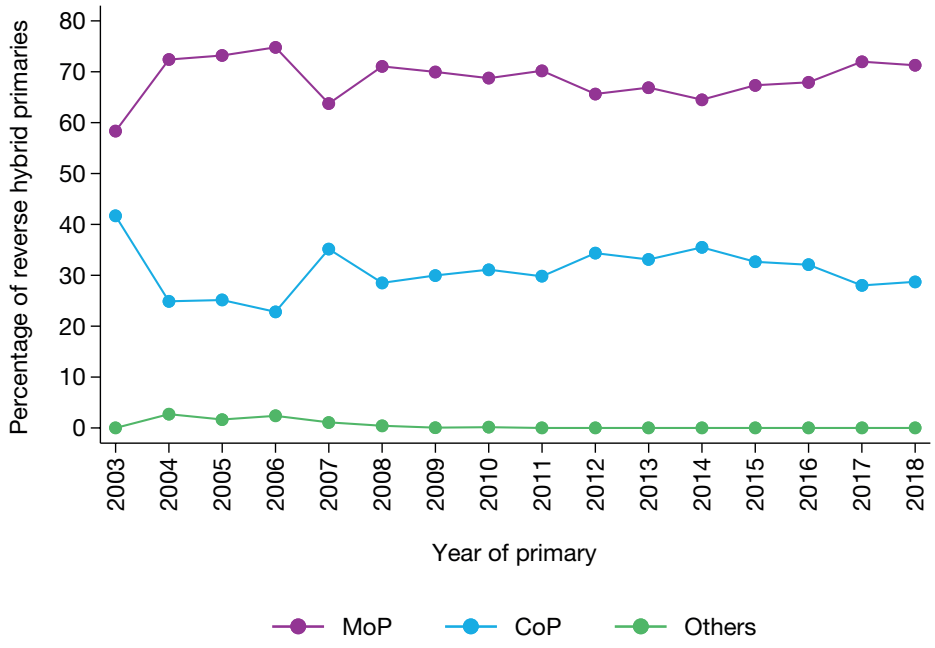


Figure 3.4 (e) Trends in **fixation**, **bearing** and **head size** by **year**.

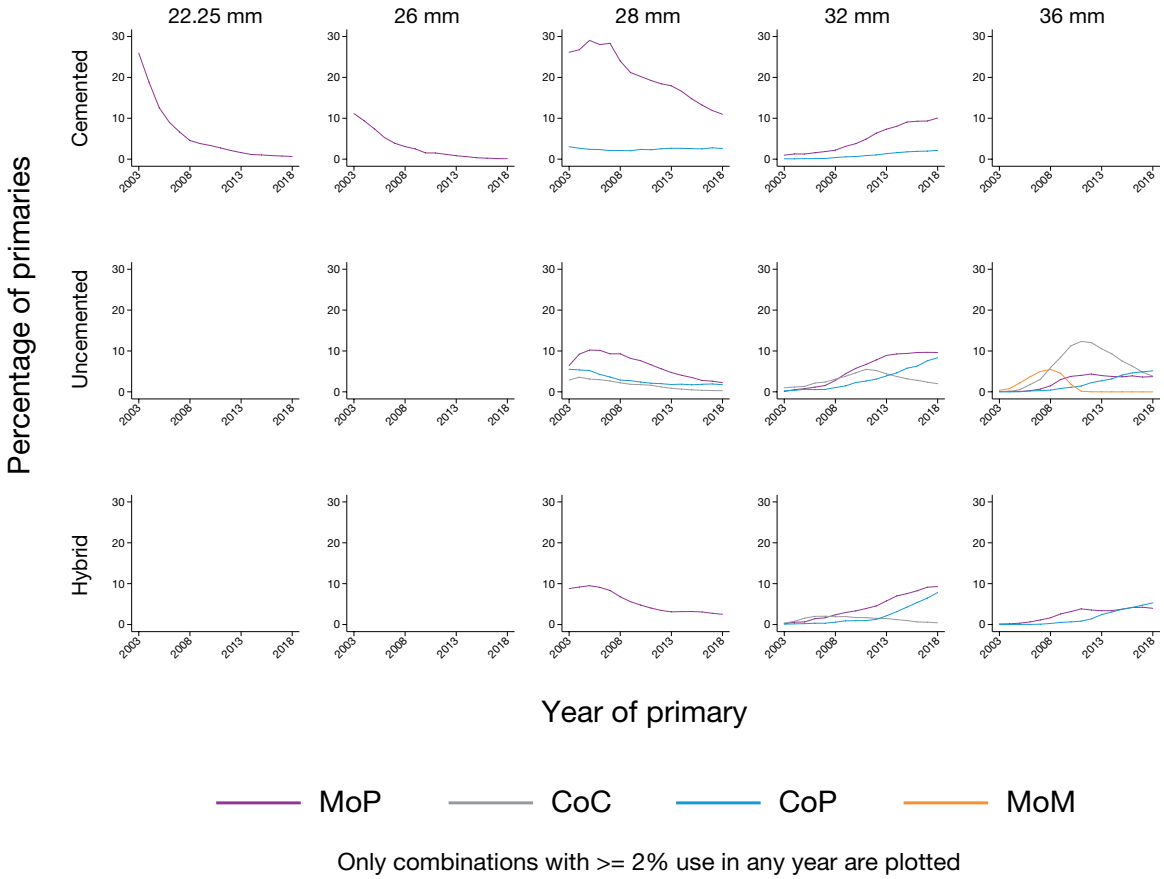


Figure 3.4 (e) illustrates the temporal changes in common head sizes, by method of fixation and bearing type. In 2003 the vast majority of hip replacements utilised heads of 28mm or smaller across all fixation methods. Since 2003 we observe a progressive shift away from small (22.25 or 26mm) heads in cemented hip replacements to larger head sizes (>28mm) with alternative fixation methods (uncemented or hybrid). In 2018 the three most common head sizes are 32mm (1st), 36mm (2nd) and 28mm (3rd), with 22.25mm and 26mm rarely being used. The use of ceramic-on-ceramic bearings across all head sizes, but most notably 36mm, has declined since 2011. This decline, conversely, corresponds with an increase in ceramic-on-polyethylene bearings with 32mm and 36mm heads. The choice of bearing, head size and fixation method is much more heterogenous in 2018 compared to 2003.

Table 3.5 provides a breakdown by fixation type and bearing surface illustrating the age and gender profile of recipients of primary hip replacements. Patients receiving resurfacing and ceramic-on-ceramic bearings tended to be younger than the other groups. Those receiving resurfacings were more likely to be men.

Table 3.5 Age at primary hip replacement by fixation and bearing.

Fixation	By bearing surface within fixation group	N	Age (years)		Percentage males (%)
			Median (IQR*)	Mean (SD)	
All cases		**1,091,892**	**69 (61-76)**	**68.0 (11.4)**	**40.2**
All cemented		**353,050**	**74 (68-79)**	**73.0 (9.1)**	**33.5**
Cemented and					
	MoP	310,690	75 (69-80)	74.1 (8.2)	32.9
	MoM	394	72 (65-78)	71.1 (9.4)	33.5
	CoP	41,955	65 (58-71)	64.3 (10.4)	38.3
	Others	11	47 (34-48)	44.9 (12.5)	54.5
All uncemented		**410,296**	**65 (58-72)**	**64.5 (11.3)**	**44.7**
Uncemented and					
	MoP	161,460	71 (64-77)	70.0 (9.4)	41.2
	MoM	29,066	63 (57-70)	62.9 (11.1)	50.8
	CoP	92,258	64 (57-70)	63.2 (10.1)	45.8
	CoC	125,287	60 (52-66)	58.8 (11.2)	47.0
	CoM	2,119	63 (56-69)	62.1 (10.5)	42.1
	Others	106	62 (52-71)	60.7 (13.8)	45.3
All hybrid		**227,432**	**70 (63-77)**	**69.1 (10.9)**	**37.2**
Hybrid and					
	MoP	135,831	74 (68-79)	73.0 (8.8)	34.9
	MoM	2,369	63 (56-72)	63.3 (12.0)	48.5
	CoP	63,532	66 (59-72)	64.9 (10.7)	40.3
	CoC	25,621	60 (53-66)	59.0 (11.2)	40.8
	Others	79	67 (59-72)	65.8 (11.3)	35.4
All reverse hybrid		**28,789**	**71 (64-77)**	**69.8 (9.8)**	**36.5**
Reverse hybrid and					
	MoP	19,745	73 (68-78)	72.9 (8.1)	35.1
	CoP	8,998	64 (58-69)	63.1 (9.8)	39.7
	Others	46	55 (44-64)	54.5 (16.2)	13.0
All resurfacing		**39,246**	**55 (48-60)**	**53.9 (9.1)**	**72.5**
Resurfacing and					
	MoM	39,104	55 (48-60)	53.9 (9.1)	72.6
	Others	142	55 (48-61)	54.0 (10.5)	48.6
Unsure		**33,079**	**69 (60-76)**	**67.5 (12.5)**	**39.3**

*IQR=interquartile range.

Table 3.6 Primary hip replacement patient **demographics**.

		Males N (%)		Females N (%)		All N (%)
Total		**438,426**		**653,466**		**1,091,892**
ASA 1		81,774 (18.7)		95,088 (14.6)		176,862 (16.2)
ASA 2		284,507 (64.9)		453,071 (69.3)		737,578 (67.6)
ASA 3		69,330 (15.8)		101,908 (15.6)		171,238 (15.7)
ASA 4		2,755 (0.6)		3,313 (0.5)		6,068 (0.6)
ASA 5		60 (<0.1)		86 (<0.1)		146 (<0.1)
Osteoarthritis as a reason for primary		407,162 (92.9)		594,012 (90.9)		1,001,174 (91.7)
Osteoarthritis as the sole reason for primary		394,054 (89.9)		572,717 (87.6)		966,771 (88.5)
Age	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
	66.4 (11.6)	68 (59-75)	69.1 (11.2)	70 (63-77)	68.0 (11.4)	69 (61-76)

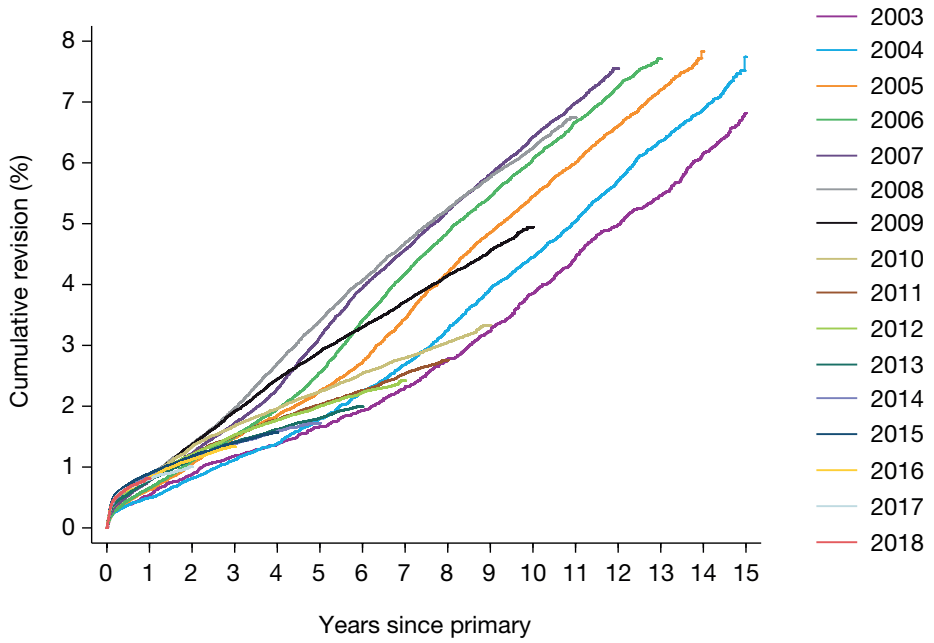
Note: Percentages in this table are calculated by column.

Table 3.6 shows the American Society of Anesthesiologists (ASA) grade and reason for primary hip replacement by gender. A greater number of females than males undergo primary hip replacement and ASA 2 is the most common ASA grade. Only a small number of patients with a grade greater than ASA 3 undergo a primary hip replacement. The majority of cases are performed for osteoarthritis. A total of 966,771 (88.5%) primary hip replacements were recorded in the NJR where the sole indication was osteoarthritis.

3.3.2 First revisions after primary hip surgery

A total of 31,410 first revisions of a hip prosthesis have been linked to NJR primary hip replacement surgery records of operations undertaken between 2003 and 2018.

Figure 3.5 (a) KM estimates of cumulative **revision** by **year**, in primary hip replacements.



Figures 3.5 (a) and (b) illustrate temporal changes in the overall revision rates using Kaplan-Meier estimates; procedures have been grouped by the year of the primary operation. Figure 3.5 (a) plots each Kaplan-Meier survival curve with a common origin, i.e. time zero is equal to the year of operation. This illustrates that revision rates increased between 2003 and 2008 and then declined between 2008 and 2018. Since 2008, the time-specific rate of overall revision appears to have changed with increased early revision and decreased revision in the medium term.

Figure 3.5 (b) KM estimates of cumulative **revision** by **year**, in primary hip replacements plotted by year of primary.

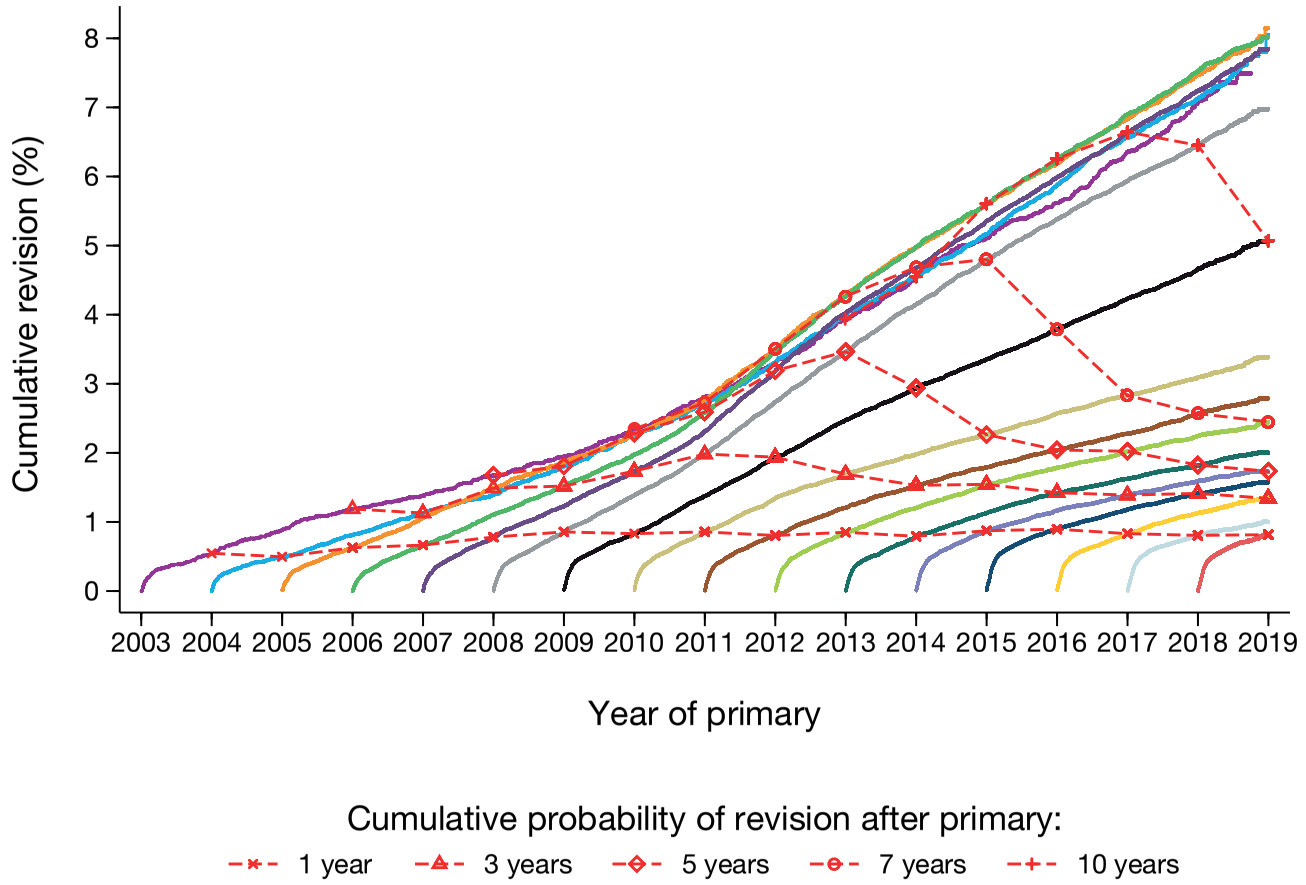


Figure 3.5 (b) shows the same curves plotted against calendar time, where the origin of each curve is the year of operation. In addition, the revision rate at 1, 3, 5, 7 and 10 years has been highlighted. Figure 3.5 (b) separates each year, allowing changes in failure rates over time to be clearly identified. If revision surgery and timing of revision surgery were static across time, we would expect all of the failure curves to be the same shape and equally spaced; departures from this indicate a change in the number and timing of revision procedures. It is also very clear that the three and five-year rate of revision increases for operations occurring between 2003 and 2008 and then reduces for operations occurring between 2009 and 2018. The early increases may be partly a result of under-reporting in the earlier years of the registry, but is also contributed to by the usage of metal-on-metal bearings, which peaked in 2008 and then fell (see Table 3.4 on page 44). Given a similar pattern is observed in knees, which were not affected by the high revision rates of metal-on-metal bearings, the decreases observed since 2009 also represent improved outcomes overall as a result of clinician feedback and adoption of evidence-based practice.

Table 3.7 (overleaf) provides Kaplan-Meier estimates of the cumulative percentage probability of first revision, for any cause, firstly for all cases combined and then by type of fixation and by bearing surface within each fixation group. The table shows updated estimates at 1, 3, 5, 10, 13 and 15 years from the primary operation together with 95% Confidence Intervals (95% CI). Results at 15 years have been added, but in general, the group sizes are too small for meaningful sub-division, hence many of these estimates are shown in *blue italics*. Estimates in *blue italics* indicate time points where fewer than 250 cases remained at risk, meaning that the estimates are less reliable. Kaplan-Meier estimates are not shown at all when the numbers at risk fell below ten cases.

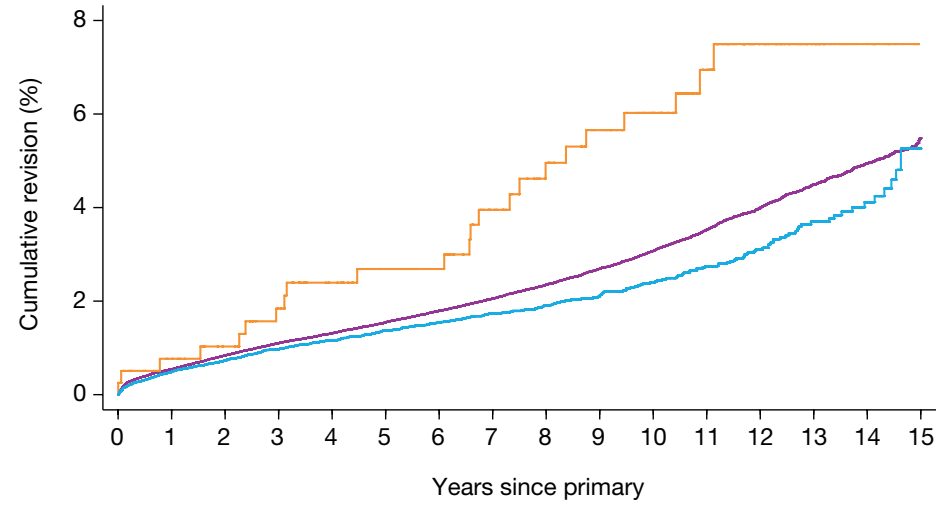
Further revisions in the italicised groups would be highly unlikely and, when they do occur, they may appear to have a disproportionate impact on the Kaplan-Meier estimate, i.e. the step upwards may seem steeper. Furthermore, the upper 95% CI at these time points may be underestimated. Although a number of statistical methods have been proposed to deal with this, they typically give different values and, as yet, there is no clear consensus for the large datasets we have here.

Table 3.7 KM estimates of cumulative **revision** (95% CI) by **fixation** and **bearing**, in primary hip replacements.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

Fixation	Bearing surface	N	Time since primary					
			1 year	3 years	5 years	10 years	13 years	15 years
All cases*		**1,091,892**	**0.81 (0.79-0.82)**	**1.54 (1.52-1.56)**	**2.29 (2.26-2.32)**	**4.79 (4.73-4.86)**	**6.55 (6.45-6.65)**	**7.82 (7.64-8.01)**
All cemented		**353,050**	**0.54 (0.51-0.56)**	**1.09 (1.05-1.12)**	**1.53 (1.48-1.57)**	**3.02 (2.93-3.10)**	**4.43 (4.29-4.58)**	**5.46 (5.20-5.72)**
Cemented and	MoP	310,690	0.55 (0.52-0.57)	1.10 (1.06-1.14)	1.55 (1.50-1.60)	3.07 (2.98-3.16)	4.50 (4.35-4.65)	5.48 (5.22-5.76)
	MoM	394	0.77 (0.25-2.36)	1.84 (0.88-3.83)	2.69 (1.45-4.94)	*6.02 (3.91-9.22)*	*7.50 (4.98-11.20)*	
	CoP	41,955	0.49 (0.42-0.56)	0.97 (0.88-1.08)	1.36 (1.24-1.50)	2.40 (2.17-2.66)	3.70 (3.26-4.20)	*5.26 (4.27-6.48)*
	Others	11**	*0*	*0*	*0*			
All uncemented		**410,296**	**0.98 (0.95-1.01)**	**1.85 (1.80-1.89)**	**2.75 (2.70-2.81)**	**5.96 (5.84-6.08)**	**7.94 (7.74-8.14)**	**9.38 (8.97-9.79)**
Uncemented and	MoP	161,460	1.05 (1.00-1.10)	1.72 (1.65-1.79)	2.17 (2.09-2.25)	3.96 (3.80-4.12)	5.62 (5.32-5.94)	6.50 (5.96-7.09)
	MoM	29,066	1.05 (0.94-1.18)	3.49 (3.28-3.71)	7.71 (7.40-8.02)	17.83 (17.37-18.31)	21.60 (20.98-22.25)	*23.52 (22.40-24.69)*
	CoP	92,258	0.86 (0.80-0.92)	1.42 (1.34-1.51)	1.89 (1.78-1.99)	3.20 (2.99-3.42)	4.17 (3.84-4.52)	6.01 (5.24-6.90)
	CoC	125,287	0.96 (0.90-1.01)	1.79 (1.71-1.87)	2.33 (2.24-2.42)	3.65 (3.51-3.81)	4.81 (4.51-5.12)	6.20 (5.40-7.12)
	CoM	2,119	0.66 (0.39-1.12)	2.82 (2.19-3.63)	4.93 (4.08-5.96)	7.80 (6.64-9.17)		
	Others	106**	*2.83 (0.92-8.52)*	*6.13 (2.79-13.19)*	*7.37 (3.56-14.91)*	*20.86 (11.76-35.45)*		
All hybrid		**227,432**	**0.78 (0.74-0.82)**	**1.31 (1.26-1.37)**	**1.83 (1.77-1.90)**	**3.51 (3.38-3.65)**	**4.80 (4.59-5.03)**	**6.14 (5.66-6.67)**
Hybrid and	MoP	135,831	0.83 (0.78-0.88)	1.37 (1.30-1.44)	1.85 (1.76-1.93)	3.31 (3.16-3.48)	4.56 (4.30-4.84)	5.99 (5.35-6.70)
	MoM	2,369	0.76 (0.48-1.21)	2.76 (2.16-3.51)	6.04 (5.13-7.10)	16.47 (14.94-18.14)	20.20 (18.31-22.25)	*22.68 (19.99-25.68)*
	CoP	63,532	0.75 (0.68-0.82)	1.20 (1.11-1.30)	1.58 (1.46-1.72)	2.52 (2.25-2.81)	3.87 (3.24-4.62)	*5.34 (4.12-6.92)*
	CoC	25,621	0.60 (0.51-0.70)	1.08 (0.95-1.21)	1.57 (1.41-1.74)	2.77 (2.52-3.04)	3.52 (3.16-3.92)	*3.93 (3.36-4.60)*
	Others	79**	*3.87 (1.26-11.51)*	*3.87 (1.26-11.51)*	*3.87 (1.26-11.51)*	*3.87 (1.26-11.51)*		
All reverse hybrid		**28,789**	**0.88 (0.77-0.99)**	**1.55 (1.41-1.71)**	**2.11 (1.93-2.31)**	**3.83 (3.44-4.27)**	**5.82 (4.83-6.99)**	*9.66 (5.72-16.08)*
Reverse hybrid and	MoP	19,745	0.91 (0.78-1.05)	1.54 (1.37-1.74)	2.04 (1.83-2.29)	3.88 (3.38-4.45)	6.09 (4.82-7.68)	*9.98 (4.97-19.48)*
	CoP	8,998	0.78 (0.62-0.99)	1.54 (1.29-1.83)	2.11 (1.79-2.47)	3.45 (2.88-4.14)	*5.00 (3.65-6.84)*	*8.52 (3.73-18.83)*
	Others	46**	*6.83 (2.25-19.70)*	*9.15 (3.54-22.59)*	*20.80 (11.41-36.18)*	*35.58 (23.14-52.04)*		
All resurfacing		**39,246**	**1.23 (1.13-1.35)**	**3.01 (2.84-3.19)**	**5.31 (5.09-5.54)**	**10.83 (10.51-11.17)**	**13.48 (13.07-13.91)**	**15.14 (14.57-15.73)**
Resurfacing and	MoM	39,104	1.23 (1.13-1.35)	3.01 (2.84-3.19)	5.31 (5.09-5.54)	10.84 (10.51-11.17)	13.49 (13.07-13.91)	15.14 (14.57-15.73)
	Others	142**	*1.84 (0.46-7.23)*	*1.84 (0.46-7.23)*	*1.84 (0.46-7.23)*			

*Includes 33,079 with unsure fixation/bearing surface;
**Wide CI because estimates are based on a small group size.
Note: Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Figure 3.6 KM estimates of cumulative **revision** in **cemented** primary hip replacements by **bearing**.

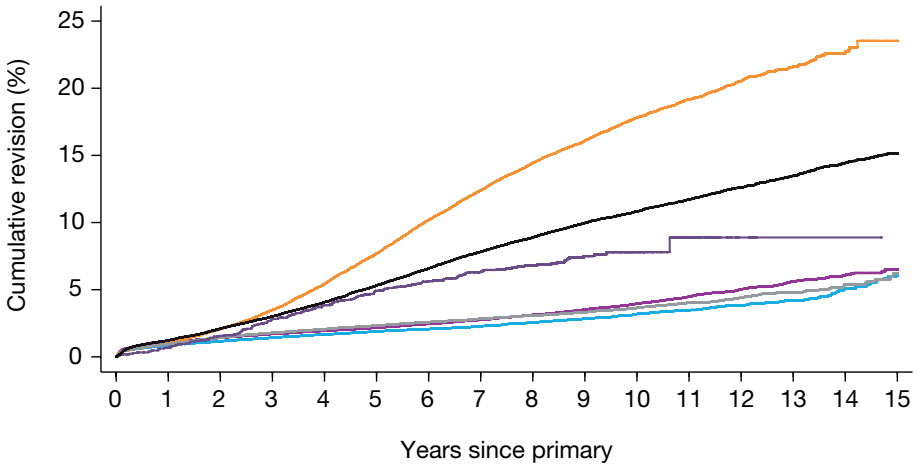


Number at risk

MoP	310,690	282,064	254,579	226,261	197,859	169,803	143,547	119,279	98,059	79,147	61,837	45,777	31,050	19,689	10,089	3,417
MoM	394	382	371	358	341	329	315	295	280	265	244	181	113	53	23	7
CoP	41,955	36,803	31,730	27,003	22,655	18,586	15,054	11,992	9,478	7,319	5,603	4,036	2,779	1,691	837	226

Figures 3.6 to 3.9 illustrate the differences between the various bearing surface sub-groups for cemented, uncemented, hybrid and reverse hybrid hips, respectively. Metal-on-metal bearings continue to perform worse than all other options regardless of fixation. The failure rates for ceramic-on-polyethylene bearings remain particularly low and it is encouraging that these are becoming more widely used with time.

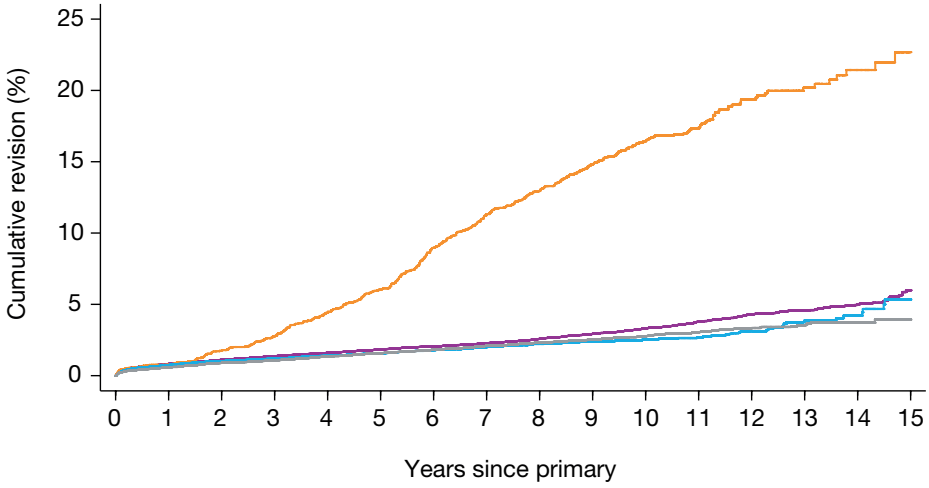
Figure 3.7 KM estimates of cumulative **revision** in **uncemented** primary hip replacements by **bearing**.



Number at risk

MoP	161,460	143,595	126,532	109,560	93,126	77,187	62,579	48,684	37,093	26,881	18,625	12,109	7,542	4,242	1,811	448
MoM	29,066	28,467	27,894	27,127	26,165	25,078	23,909	22,747	21,392	18,689	14,092	8,703	4,451	1,882	516	101
CoP	92,258	77,188	63,189	50,999	40,469	31,955	25,209	19,578	15,219	11,566	8,726	6,495	4,508	2,861	1,415	466
CoC	125,287	117,830	109,562	99,596	88,679	75,935	62,675	48,047	34,259	22,729	14,551	8,805	5,132	2,716	1,278	356
CoM	2,119	2,092	2,056	2,010	1,961	1,907	1,847	1,766	1,442	790	269	42	6	1	1	0
Resurfacing	39,246	38,120	37,086	35,950	34,651	33,268	31,869	30,273	28,022	25,128	21,018	15,971	10,835	6,665	3,349	1,102

Figure 3.8 KM estimates of cumulative **revision** in **hybrid** primary hip replacements by **bearing**.

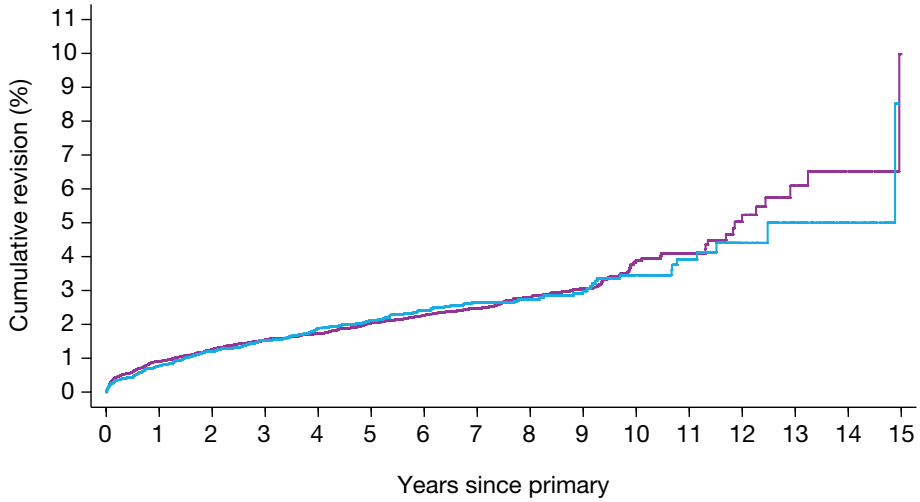


Number at risk

MoP	135,831	118,019	100,822	84,654	70,392	57,647	47,269	38,148	29,919	22,908	16,936	11,857	7,595	4,403	2,144	654
MoM	2,369	2,330	2,270	2,206	2,122	2,054	1,945	1,847	1,737	1,542	1,307	952	578	341	193	67
CoP	63,532	49,230	37,162	26,994	18,991	12,934	8,954	6,572	5,035	3,766	2,664	1,868	1,316	832	441	138
CoC	25,621	24,383	22,839	21,135	19,110	16,864	14,639	12,344	10,083	8,040	6,136	4,485	2,894	1,562	622	145

Figure 3.9 illustrates the revision rate of metal-on-polyethylene and ceramic-on-polyethylene bearings used with reverse hybrid fixation in primary total hip replacement. This shows little difference for the first ten years. After ten years the numbers at risk are very low and thus it is difficult to interpret survivorship at greater than ten years.

Figure 3.9 KM estimates of cumulative **revision** in **reverse hybrid** primary hip replacements by **bearing**.

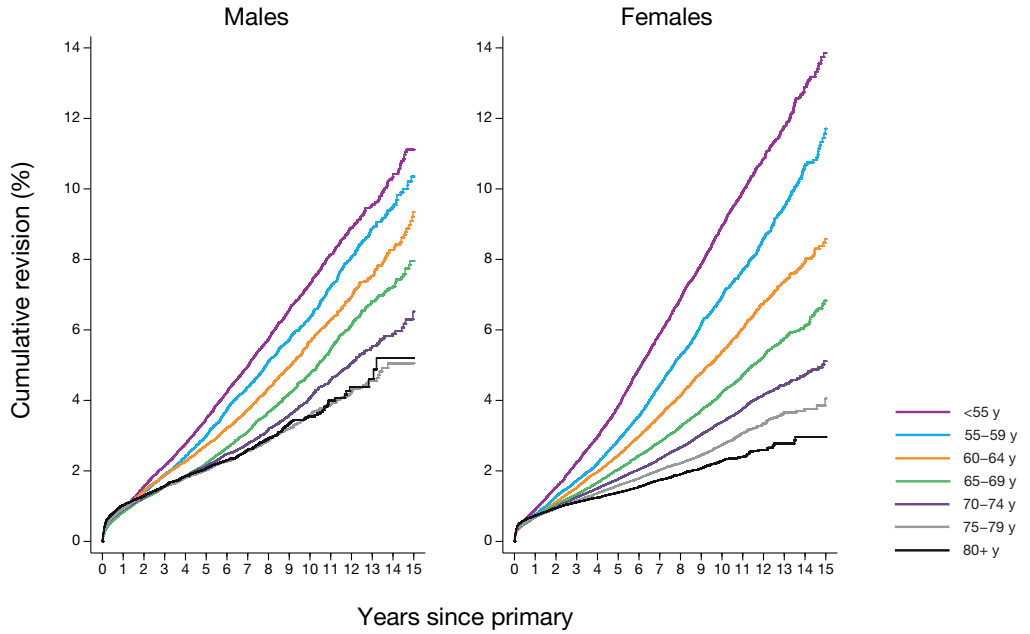


Number at risk

MoP	19,745	17,326	14,870	12,533	10,418	8,511	6,817	5,219	3,761	2,628	1,659	882	468	253	109	23
CoP	8,998	8,111	7,183	6,133	5,155	4,166	3,373	2,564	1,903	1,360	890	501	212	123	63	21

In Figures 3.10 (a) and 3.10 (b), the whole cohort has been sub-divided by age at primary operation and by gender. Across the whole group, there was an inverse relationship between the probability of revision and the age of the patient. A closer look at both genders (Figure 3.10 (a)) shows that the variation between the age groups was greater in women than in men. Thus, for example, women under 55 years had higher revision rates than their male counterparts in the same age band, whereas women aged 80 years and older had a lower revision rate than their male counterparts.

Figure 3.10 (a) **KM** estimates of cumulative **revision** in **all** primary hip replacements by **gender** and **age**.



In Figure 3.10 (b), primary total hip replacements with metal-on-metal (or uncertain) bearing surfaces and resurfacings have been excluded. The revision rates for the younger women are noticeably reduced compared to the data in Figure 3.10 (a) which includes metal-on-metal bearings; an age trend is seen in both genders but rates for women are lower than for men across the entire age spectrum.

Figure 3.10 (b) **KM** estimates of cumulative **revision** in **all** primary hip replacements by **gender** and **age**, **excluding MoM** and **resurfacing**.

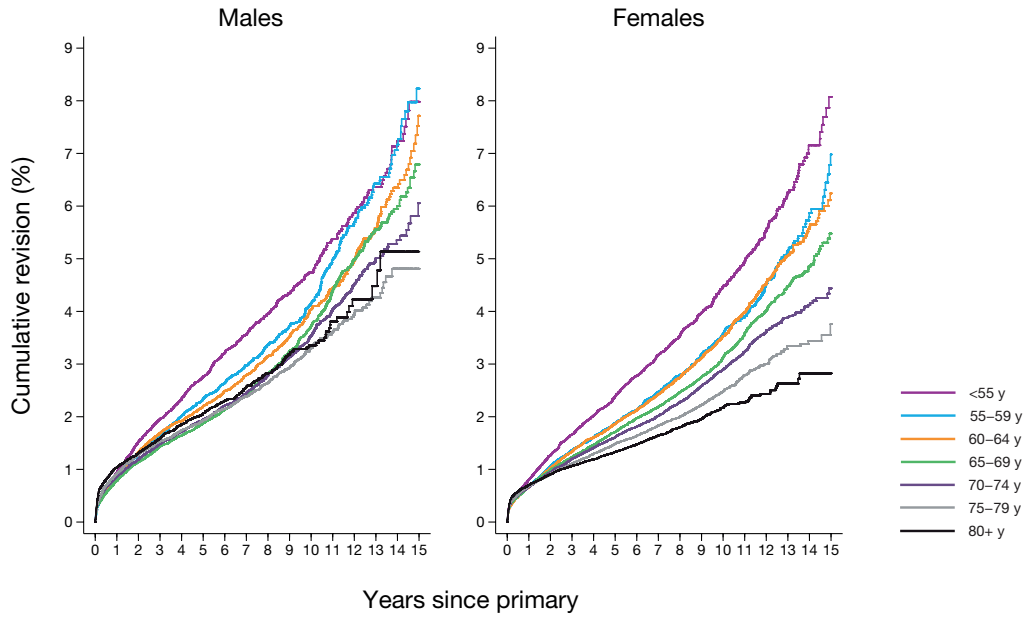


Table 3.8 further expands Table 3.7 to show separate estimates for males and females within each of four age bands, <55, 55-64, 65-74 and 75+ years. Estimates are shown at 1, 3, 5, 10, 13 and 15 years after the primary operation. These refine results shown for the first time in earlier reports, but now with larger numbers of cases and therefore generally narrower confidence intervals. A striking feature is the relatively good results obtained with ceramic-on-ceramic and ceramic-on-polyethylene bearings in younger patients.

Table 3.8 KM estimates of cumulative **revision** (95% CI) of primary hip replacements by **gender**, **age group**, **fixation** and **bearing**.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

Fixation group/ bearing	Age at primary (years)	Males							Females						
		N	Time since primary						N	Time since primary					
			1 year	3 years	5 years	10 years	13 years	15 years		1 year	3 years	5 years	10 years	13 years	15 years
All cases	<55	65,512	0.92 (0.85-1.00)	2.16 (2.04-2.28)	3.50 (3.34-3.66)	7.33 (7.05-7.62)	9.55 (9.15-9.98)	11.11 (10.48-11.78)	65,893	0.92 (0.85-0.99)	2.25 (2.13-2.38)	3.84 (3.68-4.02)	8.97 (8.65-9.30)	11.77 (11.30-12.26)	13.85 (13.08-14.66)
All cemented	<55	4,771	0.73 (0.52-1.02)	1.77 (1.41-2.22)	2.44 (1.99-2.99)	4.80 (3.94-5.84)	7.68 (6.29-9.37)	*9.51 (7.60-11.88)*	7,409	0.70 (0.53-0.92)	1.52 (1.25-1.85)	2.34 (1.98-2.78)	5.12 (4.39-5.96)	7.67 (6.48-9.06)	*9.41 (7.59-11.63)*
MoP	<55	2,100	0.89 (0.56-1.41)	2.35 (1.75-3.14)	3.18 (2.45-4.12)	6.29 (4.99-7.92)	10.00 (8.02-12.45)	*11.82 (9.41-14.80)*	3,600	0.89 (0.63-1.27)	1.86 (1.45-2.40)	2.64 (2.12-3.29)	5.78 (4.80-6.95)	8.53 (7.05-10.31)	*9.76 (7.77-12.23)*
CoP	<55	2,659	0.60 (0.36-0.99)	1.29 (0.90-1.86)	1.80 (1.30-2.49)	3.07 (2.19-4.30)	*4.25 (2.85-6.30)*	*6.84 (3.14-14.55)*	3,793	0.52 (0.33-0.81)	1.20 (0.87-1.64)	2.08 (1.59-2.71)	4.24 (3.23-5.56)	*6.35 (4.49-8.95)*	*9.65 (5.86-15.68)*
All uncemented	<55	34,798	0.97 (0.87-1.08)	2.28 (2.12-2.46)	3.67 (3.44-3.91)	8.00 (7.54-8.49)	10.30 (9.59-11.06)	*11.64 (10.52-12.87)*	36,908	0.92 (0.83-1.03)	2.12 (1.97-2.29)	3.52 (3.31-3.74)	7.74 (7.31-8.19)	10.07 (9.39-10.80)	*11.79 (10.63-13.08)*
MoP	<55	4,283	0.95 (0.69-1.30)	1.97 (1.57-2.48)	3.02 (2.46-3.70)	5.53 (4.50-6.77)	*7.38 (5.85-9.29)*	*7.38 (5.85-9.29)*	5,237	1.06 (0.81-1.38)	1.91 (1.55-2.36)	2.63 (2.17-3.18)	4.47 (3.68-5.44)	*6.78 (5.26-8.72)*	*8.68 (6.31-11.88)*
MoM	<55	3,305	0.76 (0.51-1.12)	3.64 (3.05-4.34)	7.70 (6.83-8.67)	17.79 (16.48-19.19)	21.58 (19.88-23.40)	*23.09 (20.68-25.74)*	2,390	1.76 (1.30-2.38)	5.77 (4.90-6.79)	12.65 (11.37-14.06)	26.44 (24.68-28.29)	30.41 (28.35-32.58)	*32.81 (29.91-35.92)*
CoP	<55	8,158	1.05 (0.84-1.30)	1.84 (1.53-2.20)	2.61 (2.18-3.12)	3.68 (2.95-4.58)	*4.82 (3.61-6.43)*	*7.31 (4.67-11.35)*	8,557	0.89 (0.71-1.12)	1.51 (1.25-1.83)	2.33 (1.95-2.79)	4.22 (3.39-5.26)	*6.06 (4.61-7.94)*	*8.39 (6.00-11.67)*
CoC	<55	18,850	0.98 (0.85-1.13)	2.16 (1.95-2.39)	3.00 (2.74-3.28)	4.64 (4.22-5.11)	5.71 (4.98-6.54)	*6.89 (5.49-8.63)*	20,449	0.80 (0.69-0.93)	1.82 (1.64-2.02)	2.53 (2.30-2.77)	4.57 (4.15-5.04)	5.54 (4.90-6.26)	*6.36 (4.83-8.37)*
All hybrid	<55	9,421	0.90 (0.72-1.12)	1.61 (1.36-1.91)	2.31 (1.97-2.70)	5.56 (4.80-6.44)	7.37 (6.24-8.69)	*10.11 (7.86-12.95)*	12,284	0.72 (0.58-0.89)	1.32 (1.12-1.56)	1.99 (1.72-2.31)	4.49 (3.92-5.14)	6.11 (5.24-7.11)	*8.33 (6.52-10.61)*
MoP	<55	1,649	1.44 (0.96-2.17)	2.46 (1.77-3.40)	3.40 (2.51-4.59)	6.89 (5.15-9.19)	*8.14 (5.89-11.21)*	*10.19 (6.38-16.07)*	2,349	0.85 (0.54-1.33)	1.76 (1.27-2.43)	2.40 (1.78-3.21)	4.94 (3.78-6.44)	*7.27 (5.38-9.79)*	*13.83 (9.27-20.38)*
CoP	<55	4,390	0.99 (0.72-1.34)	1.46 (1.11-1.93)	1.97 (1.47-2.64)	*3.32 (2.28-4.84)*	*5.75 (3.09-10.56)*	*8.89 (4.02-19.05)*	5,317	0.71 (0.51-0.99)	1.25 (0.96-1.64)	1.52 (1.16-1.99)	3.51 (2.49-4.93)	*5.15 (3.11-8.46)*	*5.15 (3.11-8.46)*
CoC	<55	3,073	0.59 (0.37-0.94)	1.23 (0.89-1.71)	1.78 (1.35-2.36)	3.53 (2.75-4.53)	*4.39 (3.28-5.86)*	*5.67 (3.46-9.22)*	4,406	0.58 (0.39-0.85)	1.03 (0.76-1.39)	1.62 (1.26-2.08)	3.17 (2.54-3.95)	4.30 (3.37-5.46)	*4.30 (3.37-5.46)*
All reverse hybrid	<55	802	1.16 (0.60-2.21)	2.23 (1.37-3.62)	2.67 (1.68-4.25)	*6.26 (3.78-10.26)*	*9.10 (4.52-17.83)*		1,149	1.28 (0.76-2.15)	2.04 (1.33-3.13)	3.31 (2.28-4.79)	*6.59 (4.61-9.39)*	*8.32 (5.08-13.49)*	
MoP	<55	161	*0.68 (0.10-4.70)*	*3.77 (1.58-8.84)*	*3.77 (1.58-8.84)*	*6.60 (2.50-16.78)*	*12.82 (4.46-33.83)*		248	*0.45 (0.06-3.17)*	*1.01 (0.25-4.03)*	*1.67 (0.54-5.17)*	*3.91 (1.53-9.81)*	*7.92 (2.68-22.16)*	
All resurfacing	<55	13,567	0.85 (0.71-1.02)	2.19 (1.96-2.46)	3.93 (3.60-4.28)	7.76 (7.28-8.28)	9.80 (9.17-10.47)	11.10 (10.21-12.05)	5,653	1.28 (1.01-1.60)	4.93 (4.40-5.53)	9.13 (8.40-9.91)	19.75 (18.71-20.84)	23.38 (22.17-24.63)	*25.65 (24.13-27.24)*

Note: Includes cases with unknown fixation/bearing.

Table 3.8 (continued)

Fixation group/ bearing	Age at primary (years)	Males							Females						
		N	Time since primary						N	Time since primary					
			1 year	3 years	5 years	10 years	13 years	15 years		1 year	3 years	5 years	10 years	13 years	15 years
All cases	55-64	107,978	0.93 (0.87-0.98)	1.89 (1.81-1.98)	2.85 (2.74-2.96)	5.96 (5.76-6.16)	8.12 (7.81-8.44)	9.77 (9.22-10.34)	130,943	0.72 (0.68-0.77)	1.61 (1.54-1.68)	2.62 (2.53-2.72)	6.01 (5.83-6.20)	8.25 (7.97-8.55)	9.89 (9.39-10.41)
All cemented	55-64	16,416	0.65 (0.53-0.78)	1.48 (1.30-1.69)	2.04 (1.81-2.29)	4.29 (3.87-4.76)	6.36 (5.71-7.08)	7.98 (6.96-9.14)	27,056	0.45 (0.37-0.54)	1.09 (0.97-1.23)	1.68 (1.51-1.85)	3.67 (3.37-4.00)	5.75 (5.25-6.28)	7.10 (6.34-7.94)
MoP	55-64	10,773	0.70 (0.55-0.87)	1.72 (1.48-2.00)	2.37 (2.08-2.71)	4.96 (4.44-5.53)	7.22 (6.45-8.07)	8.92 (7.79-10.22)	18,731	0.49 (0.40-0.60)	1.23 (1.07-1.41)	1.89 (1.69-2.11)	4.02 (3.67-4.41)	6.23 (5.67-6.85)	7.64 (6.82-8.56)
CoP	55-64	5,618	0.56 (0.39-0.80)	0.99 (0.74-1.31)	1.32 (1.02-1.71)	2.42 (1.83-3.19)	3.48 (2.54-4.77)	*4.63 (2.70-7.89)*	8,272	0.34 (0.23-0.49)	0.74 (0.57-0.97)	1.12 (0.89-1.42)	2.47 (1.94-3.12)	3.74 (2.86-4.88)	*4.78 (2.97-7.66)*
All uncemented	55-64	55,740	0.93 (0.86-1.02)	1.96 (1.85-2.09)	2.98 (2.82-3.14)	6.77 (6.45-7.11)	9.29 (8.76-9.86)	*11.38 (10.22-12.66)*	64,027	0.80 (0.73-0.87)	1.74 (1.64-1.85)	2.81 (2.66-2.95)	6.53 (6.24-6.82)	8.54 (8.10-9.01)	10.23 (9.32-11.23)
MoP	55-64	13,609	0.96 (0.81-1.15)	1.98 (1.74-2.25)	2.59 (2.30-2.91)	5.10 (4.54-5.73)	7.74 (6.72-8.90)	*9.96 (7.88-12.54)*	17,339	0.77 (0.65-0.92)	1.66 (1.47-1.88)	2.12 (1.90-2.37)	4.12 (3.70-4.58)	5.78 (5.08-6.57)	*6.95 (5.58-8.65)*
MoM	55-64	5,197	0.89 (0.67-1.18)	3.13 (2.69-3.64)	6.68 (6.03-7.40)	16.70 (15.67-17.80)	20.99 (19.59-22.48)	*21.60 (19.98-23.32)*	4,864	0.89 (0.66-1.19)	3.79 (3.29-4.37)	9.30 (8.51-10.16)	22.45 (21.27-23.69)	26.75 (25.21-28.36)	*28.45 (26.44-30.57)*
CoP	55-64	14,548	0.92 (0.77-1.09)	1.49 (1.29-1.73)	2.03 (1.77-2.34)	3.33 (2.85-3.90)	4.52 (3.74-5.47)	*7.20 (5.18-9.97)*	16,998	0.66 (0.55-0.80)	1.29 (1.12-1.49)	1.76 (1.54-2.02)	3.31 (2.84-3.84)	4.02 (3.40-4.76)	*5.68 (4.31-7.47)*
CoC	55-64	22,055	0.94 (0.82-1.07)	1.86 (1.68-2.05)	2.42 (2.21-2.65)	3.79 (3.44-4.17)	4.87 (4.21-5.63)	*7.05 (4.91-10.06)*	24,346	0.89 (0.78-1.02)	1.59 (1.44-1.76)	2.09 (1.91-2.29)	3.31 (3.01-3.63)	4.38 (3.84-4.99)	*6.39 (4.62-8.80)*
All hybrid	55-64	18,568	0.85 (0.72-0.99)	1.55 (1.37-1.75)	2.15 (1.92-2.41)	4.06 (3.63-4.55)	5.87 (5.16-6.68)	*8.08 (6.53-9.99)*	27,758	0.60 (0.51-0.70)	1.21 (1.08-1.36)	1.79 (1.61-1.98)	3.82 (3.48-4.18)	5.16 (4.65-5.71)	*6.40 (5.37-7.62)*
MoP	55-64	6,085	1.06 (0.82-1.35)	1.83 (1.51-2.23)	2.43 (2.03-2.91)	4.36 (3.67-5.18)	6.13 (5.08-7.40)	*8.24 (6.20-10.92)*	10,202	0.75 (0.60-0.94)	1.31 (1.09-1.56)	1.94 (1.66-2.26)	3.81 (3.32-4.36)	5.23 (4.52-6.06)	*6.78 (5.23-8.78)*
CoP	55-64	7,969	0.79 (0.62-1.02)	1.36 (1.09-1.68)	1.70 (1.35-2.12)	2.95 (2.17-4.02)	*5.14 (3.40-7.75)*	*7.93 (4.51-13.76)*	11,112	0.56 (0.44-0.73)	1.14 (0.93-1.39)	1.39 (1.14-1.71)	2.54 (1.96-3.28)	*4.51 (3.10-6.54)*	*5.53 (3.45-8.83)*
CoC	55-64	4,132	0.64 (0.43-0.93)	1.13 (0.85-1.52)	1.67 (1.30-2.13)	2.70 (2.15-3.39)	3.58 (2.78-4.60)	*4.28 (3.14-5.82)*	6,030	0.40 (0.27-0.60)	0.96 (0.74-1.25)	1.41 (1.13-1.76)	2.54 (2.09-3.07)	2.82 (2.31-3.45)	*3.05 (2.41-3.86)*
All reverse hybrid	55-64	2,269	0.98 (0.64-1.50)	2.00 (1.46-2.73)	2.83 (2.13-3.77)	*4.78 (3.41-6.67)*	*9.66 (5.49-16.69)*		3,567	0.87 (0.61-1.25)	1.74 (1.34-2.27)	2.56 (2.03-3.24)	4.45 (3.45-5.72)	*7.91 (5.38-11.56)*	*14.05 (5.86-31.59)*
MoP	55-64	903	0.95 (0.48-1.90)	1.69 (0.98-2.90)	2.78 (1.73-4.45)	*5.95 (3.48-10.08)*	*13.28 (6.81-25.02)*		1,519	1.23 (0.77-1.94)	1.88 (1.28-2.76)	3.03 (2.17-4.21)	*5.56 (3.91-7.86)*	*8.72 (5.49-13.69)*	
All resurfacing	55-64	11,660	1.23 (1.05-1.45)	2.39 (2.13-2.69)	3.86 (3.52-4.23)	7.17 (6.68-7.69)	9.12 (8.48-9.80)	10.13 (9.26-11.08)	4,352	1.68 (1.34-2.11)	4.47 (3.89-5.13)	8.50 (7.70-9.38)	17.53 (16.40-18.73)	21.69 (20.32-23.14)	*24.53 (22.68-26.50)*

Note: Includes cases with unknown fixation/bearing.

Table 3.8 (continued)

Fixation group/ bearing	Age at primary (years)	Males							Females						
		N	Time since primary						N	Time since primary					
			1 year	3 years	5 years	10 years	13 years	15 years		1 year	3 years	5 years	10 years	13 years	15 years
All cases	65-74	151,366	0.87 (0.83-0.92)	1.57 (1.50-1.63)	2.19 (2.11-2.27)	4.43 (4.28-4.60)	6.21 (5.95-6.48)	7.28 (6.82-7.77)	233,460	0.69 (0.66-0.73)	1.30 (1.25-1.34)	1.90 (1.84-1.96)	3.80 (3.69-3.92)	5.10 (4.92-5.28)	5.98 (5.66-6.32)
All cemented	65-74	46,382	0.62 (0.55-0.70)	1.23 (1.13-1.34)	1.73 (1.60-1.87)	3.67 (3.43-3.92)	5.51 (5.13-5.92)	6.58 (5.95-7.28)	86,182	0.45 (0.40-0.49)	1.02 (0.96-1.10)	1.49 (1.41-1.59)	2.92 (2.77-3.08)	4.16 (3.93-4.42)	5.10 (4.68-5.55)
MoP	65-74	40,668	0.64 (0.57-0.73)	1.27 (1.16-1.39)	1.78 (1.64-1.93)	3.81 (3.56-4.09)	5.77 (5.36-6.21)	6.80 (6.14-7.53)	76,581	0.44 (0.39-0.49)	1.02 (0.95-1.10)	1.51 (1.42-1.61)	2.99 (2.83-3.16)	4.20 (3.96-4.46)	5.10 (4.67-5.56)
CoP	65-74	5,658	0.46 (0.31-0.68)	0.91 (0.68-1.22)	1.34 (1.03-1.75)	2.17 (1.66-2.83)	*2.64 (1.95-3.56)*	*4.45 (2.41-8.15)*	9,503	0.50 (0.37-0.67)	1.03 (0.83-1.28)	1.28 (1.04-1.56)	2.02 (1.62-2.51)	3.82 (2.85-5.11)	*5.47 (3.63-8.21)*
All uncemented	65-74	62,230	0.97 (0.89-1.05)	1.75 (1.64-1.86)	2.45 (2.32-2.59)	5.17 (4.90-5.46)	7.09 (6.58-7.65)	*8.50 (7.39-9.76)*	79,802	0.90 (0.84-0.97)	1.62 (1.53-1.71)	2.44 (2.32-2.56)	5.19 (4.95-5.44)	6.77 (6.38-7.19)	7.54 (6.90-8.24)
MoP	65-74	27,851	0.92 (0.82-1.05)	1.65 (1.50-1.82)	2.05 (1.87-2.24)	4.14 (3.76-4.56)	5.91 (5.16-6.76)	*6.28 (5.39-7.30)*	39,451	0.94 (0.84-1.04)	1.53 (1.41-1.66)	1.97 (1.82-2.12)	3.50 (3.22-3.80)	4.97 (4.45-5.56)	*5.25 (4.60-5.99)*
MoM	65-74	4,573	1.08 (0.81-1.42)	2.99 (2.53-3.53)	6.09 (5.42-6.84)	13.70 (12.66-14.81)	*17.05 (15.41-18.84)*	*17.54 (15.68-19.59)*	4,657	1.08 (0.82-1.42)	3.50 (3.01-4.07)	8.64 (7.86-9.50)	19.33 (18.16-20.56)	22.43 (20.93-24.01)	*28.29 (22.52-35.18)*
CoP	65-74	14,861	0.82 (0.68-0.98)	1.28 (1.10-1.49)	1.55 (1.33-1.79)	2.55 (2.14-3.04)	3.50 (2.77-4.42)	*6.70 (4.20-10.61)*	18,027	0.80 (0.67-0.94)	1.33 (1.16-1.52)	1.71 (1.50-1.95)	3.01 (2.60-3.48)	3.72 (3.16-4.39)	*4.35 (3.39-5.57)*
CoC	65-74	14,636	1.14 (0.98-1.33)	1.83 (1.62-2.07)	2.29 (2.05-2.56)	3.14 (2.78-3.56)	4.71 (3.76-5.89)	*5.62 (3.88-8.11)*	17,270	0.88 (0.75-1.03)	1.47 (1.30-1.67)	1.78 (1.59-2.00)	2.51 (2.21-2.85)	3.58 (2.84-4.51)	*4.02 (2.99-5.39)*
All hybrid	65-74	31,347	0.88 (0.78-0.99)	1.47 (1.34-1.63)	2.00 (1.82-2.19)	3.86 (3.50-4.24)	5.25 (4.68-5.88)	*6.26 (5.14-7.61)*	53,021	0.75 (0.68-0.83)	1.20 (1.10-1.30)	1.70 (1.58-1.84)	3.06 (2.82-3.31)	4.03 (3.67-4.43)	*4.46 (3.95-5.02)*
MoP	65-74	19,030	0.88 (0.76-1.03)	1.51 (1.33-1.71)	2.04 (1.82-2.28)	3.84 (3.42-4.30)	5.33 (4.65-6.09)	*6.41 (5.06-8.10)*	34,407	0.77 (0.68-0.87)	1.27 (1.15-1.41)	1.75 (1.60-1.92)	3.09 (2.82-3.40)	4.08 (3.67-4.54)	*4.52 (3.94-5.17)*
CoP	65-74	9,310	0.88 (0.71-1.10)	1.37 (1.12-1.66)	1.66 (1.35-2.04)	2.57 (1.91-3.45)	*2.57 (1.91-3.45)*	*4.56 (1.91-10.66)*	14,612	0.70 (0.57-0.86)	1.05 (0.88-1.25)	1.45 (1.21-1.73)	1.82 (1.48-2.24)	*2.66 (1.79-3.93)*	*3.39 (2.01-5.71)*
CoC	65-74	2,699	0.79 (0.52-1.21)	1.41 (1.02-1.95)	1.96 (1.47-2.61)	2.86 (2.16-3.78)	*4.16 (2.88-6.00)*		3,638	0.72 (0.49-1.06)	0.91 (0.65-1.29)	1.31 (0.97-1.76)	2.44 (1.85-3.20)	*2.76 (2.07-3.69)*	
All reverse hybrid	65-74	4,168	1.08 (0.80-1.45)	1.83 (1.44-2.32)	2.24 (1.78-2.81)	3.87 (2.96-5.04)	*5.15 (3.61-7.33)*		7,286	0.57 (0.42-0.77)	1.03 (0.81-1.31)	1.56 (1.26-1.92)	3.26 (2.55-4.15)	*3.57 (2.70-4.72)*	*3.57 (2.70-4.72)*
MoP	65-74	2,923	1.33 (0.96-1.83)	2.10 (1.61-2.74)	2.64 (2.04-3.40)	4.43 (3.25-6.03)	*6.26 (4.17-9.33)*		5,431	0.57 (0.40-0.82)	1.01 (0.76-1.34)	1.44 (1.11-1.85)	3.50 (2.64-4.63)	*3.90 (2.82-5.39)*	
All resurfacing	65-74	3,035	1.99 (1.55-2.56)	3.08 (2.51-3.76)	4.48 (3.78-5.30)	7.66 (6.69-8.76)	9.65 (8.36-11.14)	*10.14 (8.71-11.79)*	750	2.01 (1.21-3.31)	3.50 (2.40-5.10)	6.28 (4.74-8.30)	14.89 (12.42-17.81)	*17.77 (14.78-21.29)*	

Note: Includes cases with unknown fixation/bearing.

Table 3.8 (continued)

Fixation group/ bearing	Age at primary (years)	Males							Females						
		N	Time since primary						N	Time since primary					
			1 year	3 years	5 years	10 years	13 years	15 years		1 year	3 years	5 years	10 years	13 years	15 years
All cases	75+	113,570	0.98 (0.92-1.04)	1.57 (1.50-1.65)	2.05 (1.95-2.14)	3.58 (3.40-3.78)	4.57 (4.22-4.94)	*5.10 (4.59-5.66)*	223,170	0.71 (0.68-0.75)	1.13 (1.09-1.18)	1.49 (1.44-1.55)	2.54 (2.44-2.64)	3.31 (3.13-3.51)	3.66 (3.28-4.07)
All cemented	75+	50,846	0.80 (0.73-0.89)	1.34 (1.24-1.45)	1.77 (1.65-1.91)	3.15 (2.91-3.42)	4.00 (3.59-4.45)	*4.58 (3.96-5.29)*	113,988	0.44 (0.41-0.49)	0.84 (0.79-0.90)	1.15 (1.08-1.22)	2.02 (1.90-2.15)	2.69 (2.48-2.91)	3.00 (2.59-3.48)
MoP	75+	48,666	0.80 (0.73-0.89)	1.34 (1.23-1.45)	1.77 (1.64-1.91)	3.16 (2.91-3.43)	4.04 (3.62-4.50)	*4.63 (3.99-5.36)*	109,571	0.45 (0.41-0.49)	0.85 (0.79-0.91)	1.15 (1.08-1.22)	2.03 (1.91-2.17)	2.67 (2.46-2.89)	2.99 (2.57-3.48)
CoP	75+	2,135	0.84 (0.52-1.34)	1.41 (0.96-2.08)	1.85 (1.27-2.69)	*2.40 (1.56-3.67)*	*2.40 (1.56-3.67)*		4,317	0.41 (0.26-0.66)	0.73 (0.50-1.07)	0.97 (0.68-1.39)	1.37 (0.95-1.97)	*2.90 (1.54-5.44)*	*2.90 (1.54-5.44)*
All uncemented	75+	30,645	1.31 (1.19-1.44)	1.92 (1.77-2.09)	2.45 (2.27-2.66)	4.35 (3.95-4.79)	5.65 (4.72-6.75)	*6.08 (4.90-7.53)*	46,146	1.27 (1.17-1.37)	1.76 (1.64-1.89)	2.21 (2.06-2.36)	3.93 (3.64-4.24)	5.32 (4.67-6.06)	*5.53 (4.78-6.40)*
MoP	75+	20,814	1.40 (1.25-1.57)	2.01 (1.82-2.23)	2.44 (2.21-2.69)	3.64 (3.23-4.10)	*5.08 (3.82-6.74)*	*5.80 (4.10-8.18)*	32,876	1.27 (1.15-1.39)	1.67 (1.54-1.82)	2.03 (1.87-2.20)	3.49 (3.16-3.85)	4.32 (3.67-5.09)	*4.66 (3.79-5.72)*
MoM	75+	1,691	1.02 (0.64-1.64)	1.91 (1.35-2.71)	3.82 (2.96-4.92)	8.70 (7.20-10.50)	*10.04 (7.88-12.75)*		2,389	1.39 (0.99-1.95)	3.10 (2.47-3.90)	5.04 (4.21-6.03)	9.59 (8.32-11.04)	*11.97 (9.98-14.32)*	
CoP	75+	4,670	1.08 (0.81-1.43)	1.52 (1.19-1.95)	1.98 (1.55-2.52)	2.95 (2.05-4.23)	*3.72 (2.26-6.10)*		6,439	1.08 (0.85-1.37)	1.54 (1.25-1.90)	1.84 (1.50-2.25)	3.04 (2.41-3.84)	*4.28 (2.97-6.16)*	*4.28 (2.97-6.16)*
CoC	75+	3,372	1.24 (0.91-1.68)	1.90 (1.48-2.44)	2.11 (1.66-2.69)	*4.22 (3.09-5.75)*	*5.04 (3.34-7.56)*		4,309	1.52 (1.20-1.94)	1.90 (1.53-2.36)	2.09 (1.69-2.57)	2.92 (2.18-3.91)	*8.80 (3.82-19.54)*	
All hybrid	75+	25,310	0.92 (0.81-1.05)	1.58 (1.41-1.76)	2.02 (1.82-2.24)	3.61 (3.16-4.13)	*5.06 (4.05-6.31)*	*5.65 (4.25-7.50)*	49,723	0.75 (0.67-0.83)	1.12 (1.02-1.22)	1.52 (1.39-1.65)	2.30 (2.07-2.55)	2.80 (2.44-3.22)	*3.60 (2.30-5.61)*
MoP	75+	20,629	0.90 (0.77-1.04)	1.59 (1.41-1.80)	2.03 (1.81-2.27)	3.51 (3.03-4.06)	*4.94 (3.88-6.28)*	*5.63 (4.09-7.73)*	41,480	0.77 (0.69-0.86)	1.15 (1.05-1.27)	1.50 (1.37-1.65)	2.28 (2.04-2.55)	2.85 (2.45-3.31)	*3.71 (2.32-5.93)*
CoP	75+	3,959	1.06 (0.77-1.44)	1.51 (1.13-2.01)	2.04 (1.53-2.72)	*2.60 (1.86-3.63)*	*2.60 (1.86-3.63)*		6,863	0.61 (0.45-0.84)	0.87 (0.65-1.15)	1.53 (1.15-2.04)	*1.53 (1.15-2.04)*	*1.53 (1.15-2.04)*	
CoC	75+	544	1.13 (0.51-2.50)	1.34 (0.64-2.80)	1.62 (0.81-3.24)	*2.58 (1.10-5.98)*			1,099	0.47 (0.19-1.12)	0.80 (0.40-1.59)	0.98 (0.50-1.93)	*1.34 (0.65-2.73)*		
All reverse hybrid	75+	3,258	1.00 (0.71-1.43)	1.88 (1.43-2.46)	2.39 (1.84-3.11)	*3.64 (2.46-5.38)*	*3.64 (2.46-5.38)*		6,290	0.89 (0.69-1.16)	1.38 (1.11-1.72)	1.71 (1.39-2.11)	2.81 (2.17-3.64)	*4.01 (2.70-5.92)*	
MoP	75+	2,935	1.01 (0.70-1.46)	1.99 (1.50-2.63)	2.45 (1.87-3.22)	*3.78 (2.47-5.76)*	*3.78 (2.47-5.76)*		5,625	0.89 (0.67-1.18)	1.40 (1.11-1.76)	1.71 (1.37-2.14)	2.79 (2.10-3.69)	*3.06 (2.24-4.18)*	
All resurfacing	75+	198	*1.55 (0.50-4.72)*	*2.12 (0.80-5.57)*	*4.17 (1.99-8.61)*	*7.24 (4.04-12.80)*	*7.24 (4.04-12.80)*		31	*3.23 (0.46-20.77)*	*6.95 (1.77-25.14)*	*6.95 (1.77-25.14)*	*13.59 (4.27-38.67)*		

Note: Includes cases with unknown fixation/bearing.

3.3.3 Revisions after primary hip replacement: effect of head size for selected bearing surfaces/fixation sub-groups

This section updates results from the 15th Annual Report on the effect of head size on the probability of revision following primary hip replacement. In total, six bearing groups were defined:

a) Metal-on-polyethylene cemented monobloc cups n=327,147

b) Metal-on-polyethylene uncemented metal shells with polyethylene liners n=297,291

c) Metal-on-metal uncemented metal cups or metal shells with metal liners n=31,435

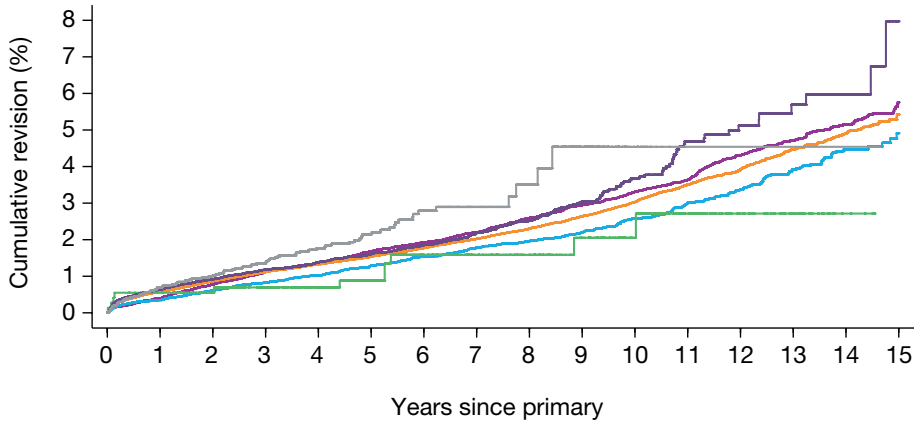
d) Ceramic-on-polyethylene cemented monobloc cups n=50,738

e) Ceramic-on-polyethylene uncemented metal shells with polyethylene liners n=155,790

f) Ceramic-on-ceramic uncemented metal shells with ceramic liners n=150,908

Figures 3.11 (a) to 3.11 (f) on the following pages show respective percentage cumulative probabilities of revision (Kaplan-Meier estimates) for various head sizes, for each of the above groups with follow-up up to 15 years following the primary hip replacement.

Figure 3.11 (a) KM estimates of cumulative **revision** of primary **cemented MoP** hip replacement **(monobloc cups)** by **head size**.

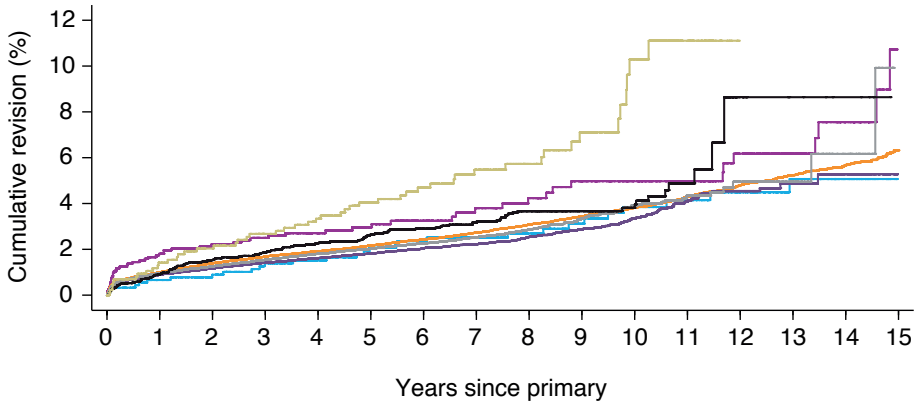


Number at risk, by head size (mm)

22.25	34,375	33,155	31,845	30,323	28,624	26,765	24,665	22,340	19,751	17,074	14,460	11,832	9,010	6,395	3,794	1,444
26	18,762	18,214	17,693	17,024	16,173	15,125	13,911	12,554	11,076	9,695	8,034	6,412	4,787	3,298	1,789	612
28	200,088	184,632	168,705	151,576	133,753	115,092	97,085	80,065	64,826	51,078	38,611	26,967	16,924	9,802	4,409	1,331
30	730	710	686	642	574	457	355	293	251	204	148	102	62	36	8	2
32	66,945	55,174	44,681	34,834	25,952	18,695	12,947	8,417	5,457	3,466	2,087	1,254	699	379	178	51
36	6,213	5,033	4,052	3,182	2,426	1,681	1,041	551	250	88	15	1	1	1	1	0

In Figure 3.11 (a), for metal-on-polyethylene cemented monobloc cups, there was a statistically significant effect of head size (overall difference P<0.001 by logrank test) on revision rates. Overall, implants with head size 32mm had the worst failure rates over the entire duration of follow-up, but implants with head size 36mm had the worst failure rates in the first six years of follow-up. The numbers at risk for patients who received 36mm heads after six years are too small for meaningful comparison.

Figure 3.11 (b) KM estimates of cumulative **revision** of primary **uncemented MoP** hip replacements **(metal shells and polyethylene liner)** by **head size**.

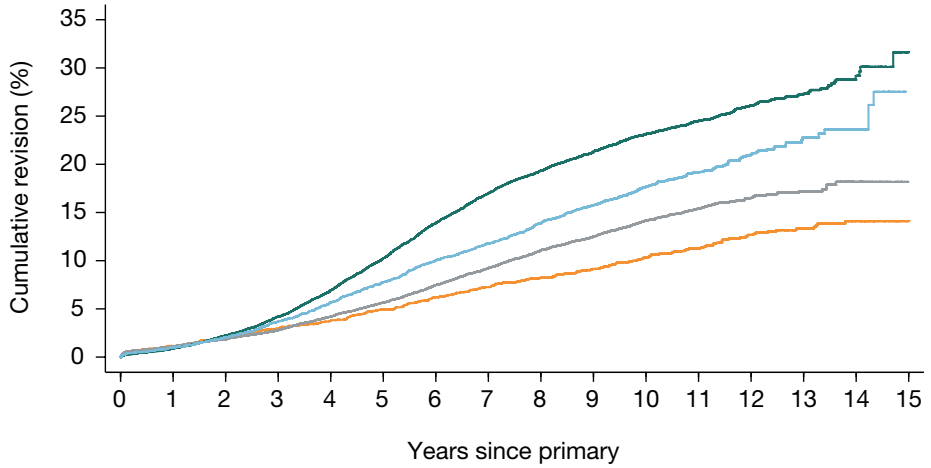


Number at risk, by head size (mm)

22.25	1,558	1,312	1,118	955	827	698	591	499	417	362	326	278	218	161	102	33
26	919	873	832	790	743	697	638	577	506	430	359	295	231	154	85	22
28	102,930	96,143	89,402	82,264	74,620	66,906	59,423	51,441	43,472	35,435	27,792	20,139	13,338	7,838	3,593	1,030
32	124,740	105,017	86,106	68,661	53,104	39,048	27,788	19,046	12,501	7,614	4,185	2,113	1,000	370	121	8
36	62,724	54,048	45,836	37,641	30,544	24,124	18,418	12,875	8,279	4,691	2,158	909	335	115	50	9
40	3,439	3,296	3,167	3,047	2,859	2,634	2,384	1,942	1,505	1,031	613	198	15	7	4	0
44	866	810	780	747	716	641	547	434	330	226	128	34	0	0	0	0

Figure 3.11 (b) shows revision rates for different head sizes for metal-on-polyethylene uncemented metal shell with polyethylene liners. There was a statistically significant effect of head size (overall P<0.001), with head size 44mm showing the worst failure rates, but there were small numbers of 44mm heads at risk after eight years.

Figure 3.11 (c) KM estimates of cumulative **revision** of primary **uncemented MoM** hip replacement **(monobloc cups or metal shell liner)** by **head size**.

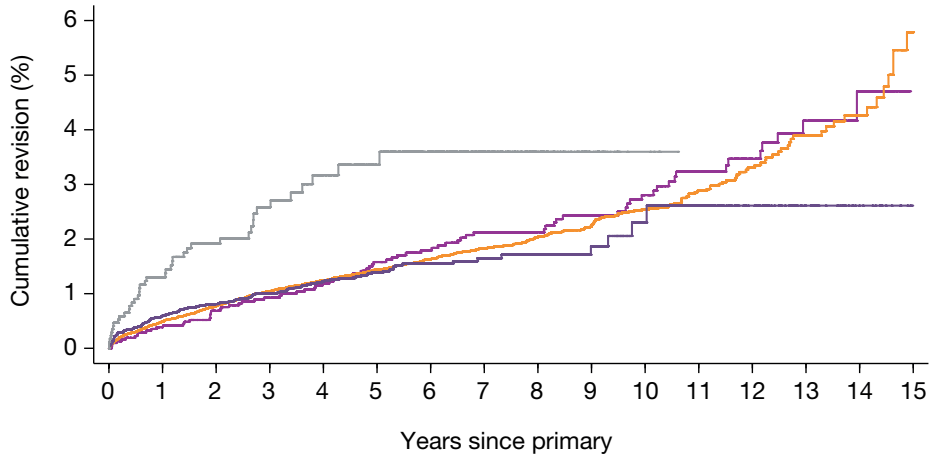


Number at risk, by head size group (mm)

28	2,246	2,204	2,175	2,134	2,094	2,041	1,985	1,886	1,763	1,600	1,347	1,067	733	528	309	97
36	12,602	12,285	12,024	11,726	11,319	10,891	10,410	9,919	9,305	7,963	5,692	3,345	1,589	603	144	22
38–48	11,733	11,542	11,298	10,945	10,494	9,979	9,398	8,878	8,378	7,432	5,897	3,685	1,936	802	169	22
50–54	4,243	4,168	4,080	3,954	3,819	3,672	3,524	3,397	3,205	2,823	2,164	1,374	705	276	82	26

Figure 3.11 (c) shows revision rates for metal-on-metal uncemented metal cup/metal shell with metal liners. Smaller heads had lower failure rates (overall P<0.001), with head size of 28mm having the lowest rate of failure in this group.

Figure 3.11 (d) KM estimates of cumulative **revision** of primary **cemented CoP** hip replacement **(monobloc cups)** by **head size**.

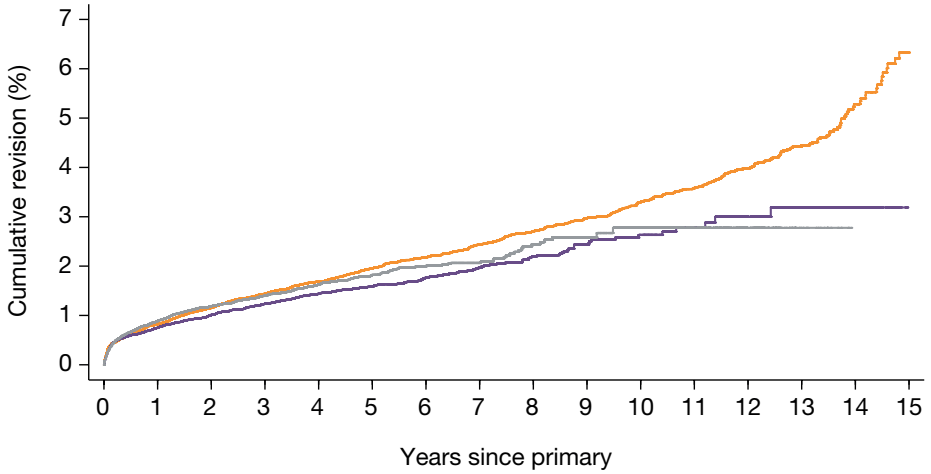


Number at risk, by head size group (mm)

22.25	3,132	3,045	2,937	2,802	2,626	2,398	2,162	1,919	1,672	1,452	1,223	967	688	403	168	0
28	31,578	28,482	25,170	22,014	19,019	15,996	13,255	10,712	8,541	6,567	4,936	3,427	2,220	1,369	714	242
32	14,304	11,883	9,660	7,498	5,566	3,926	2,706	1,752	1,079	629	325	140	81	41	18	5
36	1,722	1,363	1,060	765	557	408	289	164	83	26	5	0	0	0	0	0

Figure 3.11 (d) shows revision rates for ceramic-on-polyethylene cemented monobloc cups, with a statistically significant difference between the head sizes overall (P<0.001) with head size 36mm having the worst failure rate. In contrast to the metal-on-polyethylene cemented monobloc cups, the 32mm head sizes had some of the lowest revision rates.

Figure 3.11 (e) KM estimates of cumulative **revision** of primary **uncemented CoP** hip replacement **(metal shell and polyethylene liner)** by **head size**.

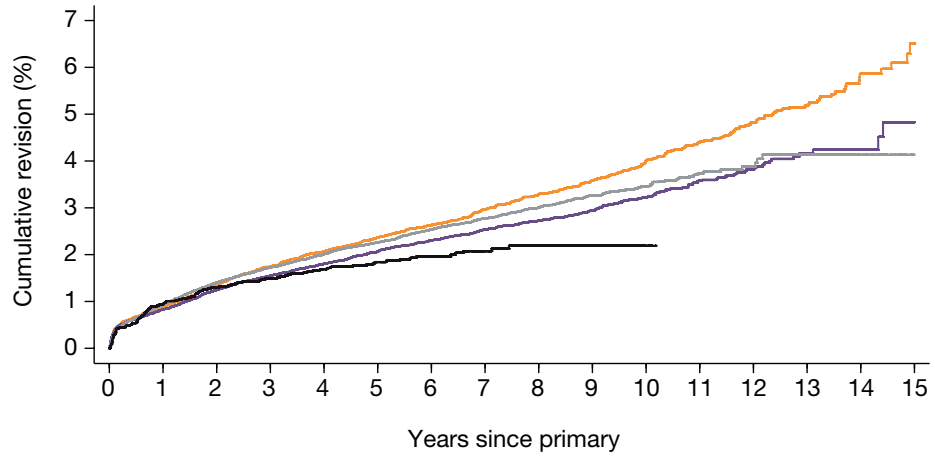


Number at risk, by head size (mm)

28	35,072	31,409	27,968	24,761	21,947	19,271	17,091	14,969	12,952	10,986	9,019	7,085	5,106	3,337	1,729	576
32	70,253	54,821	41,526	30,633	21,781	15,138	10,488	7,274	4,905	3,028	1,777	1,005	612	340	125	28
36	49,825	39,618	30,354	22,150	15,307	10,118	6,282	3,700	2,284	1,294	587	266	101	14	0	0

For ceramic-on-polyethylene metal shells used with polyethylene liners (Figure 3.11 (e)), whilst there was a statistically significant difference between the three head sizes shown (P<0.001), the best implant survival was in the intermediate size group (32mm) at ten years follow-up with 28mm and 36mm showing similar worse outcomes whilst the numbers at risk remained above 250.

Figure 3.11 (f) KM estimates of cumulative **revision** of primary **uncemented CoC** hip replacement **(metal shell and ceramic liner)** by **head size**.



Number at risk, by head size (mm)

28	18,329	17,734	17,093	16,371	15,548	14,564	13,491	12,154	10,515	8,869	7,341	5,707	4,038	2,550	1,297	358
32	46,782	44,004	40,900	37,399	33,509	29,029	24,418	19,342	14,564	10,674	7,407	4,797	2,778	1,345	510	123
36	79,362	74,293	68,565	61,520	53,760	44,830	35,875	26,419	17,869	10,810	5,924	2,786	1,210	383	93	20
40	5,419	5,203	4,924	4,574	4,174	3,655	2,935	2,002	1,118	341	15	0	0	0	0	0

Figure 3.11 (f) shows revision rates for uncemented ceramic-on-ceramic hip replacements by head size. There are statistically significant differences between all four head sizes shown (P<0.001). Head size 40mm showed the best survival rate, though there were small numbers in this bearing group. Head sizes 28mm had the highest failure rates in the long term, 32mm and 36mm showed similar failure rates, but were worse than those of head size 40mm.

3.3.4 Revisions after primary hip surgery for the main stem/cup brand combinations

As in previous reports, we have only included stem/cup brand combinations with more than 2,500 procedures for cemented, uncemented, hybrid and reverse hybrid hips or more than 1,000 procedures in the case of resurfacings. The figures in *blue italics* are at time points where fewer than 250 cases remained at risk; no results are shown at all where the number had fallen below ten cases. No attempt has been made to adjust for other factors that may influence the chance of revision so the figures are unadjusted cumulative probabilities of revision. Given that the sub-groups may differ in composition with respect to age and gender, the percentage of males and the median (IQR) of the ages are also shown in these tables.

Table 3.9 shows Kaplan-Meier estimates of the cumulative percentage probability of revision of primary hip replacement (for any reason) for the main stem/cup brands.

Table 3.9 KM estimates of cumulative **revision** (95% CI) of primary hip replacement by **fixation**, and **stem/cup** brand. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

Stem:cup brand	N	Median (IQR) age at primary	Percentage (%) males	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
Cemented									
C-Stem AMT Cemented Stem[St] : Charnley and Elite Plus LPW[C]	3,161	75 (71-79)	31	0.58 (0.37-0.92)	1.20 (0.86-1.66)	1.48 (1.10-2.00)	2.68 (1.98-3.61)		
C-Stem AMT Cemented Stem[St] : Elite Plus Ogee[C]	4,100	77 (72-81)	33	0.28 (0.16-0.51)	0.82 (0.56-1.20)	1.27 (0.90-1.78)	2.20 (1.57-3.06)		
C-Stem AMT Cemented Stem[St] : Marathon[C]	10,312	75 (69-80)	32	0.45 (0.34-0.61)	0.96 (0.76-1.21)	1.22 (0.95-1.57)	*1.67 (1.21-2.31)*		
C-Stem Cemented Stem[St] : Elite Plus Ogee[C]	5,544	72 (66-77)	40	0.41 (0.27-0.62)	0.92 (0.69-1.23)	1.24 (0.96-1.60)	2.79 (2.25-3.46)	4.22 (3.39-5.24)	*4.43 (3.53-5.55)*
C-Stem Cemented Stem[St] : Marathon[C]	8,215	68 (60-75)	41	0.42 (0.30-0.59)	0.96 (0.75-1.23)	1.44 (1.15-1.80)	*2.37 (1.82-3.08)*		
CPT[St] : Elite Plus Ogee[C]	3,028	73 (67-79)	36	0.67 (0.43-1.03)	1.51 (1.12-2.02)	2.10 (1.63-2.70)	3.91 (3.11-4.91)	*5.04 (3.90-6.52)*	*5.04 (3.90-6.52)*
CPT[St] : ZCA[C]	16,302	76 (71-81)	31	0.84 (0.70-0.99)	1.44 (1.25-1.65)	2.10 (1.85-2.37)	3.83 (3.39-4.32)	4.70 (4.07-5.41)	*4.88 (4.18-5.70)*
Charnley Cemented Stem[St] : Charnley Cemented Cup[C]	4,593	72 (66-78)	38	0.31 (0.18-0.52)	1.13 (0.86-1.49)	1.80 (1.44-2.25)	3.52 (2.96-4.17)	5.17 (4.39-6.09)	6.60 (5.45-8.00)
Charnley Cemented Stem[St] : Charnley Ogee[C]	10,427	73 (67-78)	38	0.38 (0.28-0.52)	1.22 (1.02-1.46)	1.89 (1.64-2.19)	3.79 (3.38-4.24)	5.14 (4.58-5.75)	5.82 (5.12-6.61)
Charnley Cemented Stem[St] : Charnley and Elite Plus LPW[C]	6,829	74 (68-79)	29	0.37 (0.25-0.55)	0.75 (0.57-0.99)	1.17 (0.93-1.46)	2.54 (2.14-3.02)	3.53 (2.98-4.18)	4.45 (3.45-5.74)
Exeter V40[St] : Cenator Cemented Cup[C]	2,521	75 (69-80)	32	0.64 (0.39-1.04)	1.39 (0.99-1.94)	2.06 (1.56-2.72)	2.82 (2.18-3.64)	4.82 (3.67-6.31)	*6.09 (3.84-9.58)*

Note: Blank cells indicate that the number at risk at the time shown has fallen below ten and thus estimates have been omitted as they are highly unreliable. [St] = Stem; [C] = Cup; [SL] = Shell liner.

Table 3.9 (continued)

Stem:cup brand	N	Median (IQR) age at primary	Percentage (%) males	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
Exeter V40[St] : Charnley and Elite Plus LPW[C]	4,984	73 (68-78)	31	0.63 (0.45-0.90)	1.26 (0.98-1.63)	1.50 (1.17-1.90)	2.12 (1.65-2.72)	*2.88 (2.17-3.80)*	*3.45 (2.31-5.12)*
Exeter V40[St] : Elite Plus Cemented Cup[C]	5,142	73 (67-79)	33	0.33 (0.21-0.54)	0.65 (0.46-0.92)	0.87 (0.64-1.18)	1.50 (1.13-1.99)	2.56 (1.82-3.59)	*3.99 (2.49-6.36)*
Exeter V40[St] : Elite Plus Ogee[C]	25,181	74 (69-80)	35	0.39 (0.32-0.48)	0.85 (0.74-0.98)	1.19 (1.05-1.34)	2.23 (2.00-2.49)	2.89 (2.55-3.27)	3.46 (2.76-4.34)
Exeter V40[St] : Exeter Contemporary Flanged[C]	84,353	74 (69-79)	34	0.51 (0.46-0.56)	0.97 (0.90-1.05)	1.34 (1.26-1.43)	2.42 (2.26-2.60)	3.40 (3.09-3.73)	*4.57 (3.79-5.51)*
Exeter V40[St] : Exeter Contemporary Hooded[C]	28,049	75 (70-80)	32	0.93 (0.82-1.05)	1.65 (1.50-1.81)	2.21 (2.03-2.41)	4.19 (3.86-4.56)	6.53 (5.87-7.26)	*7.51 (6.47-8.71)*
Exeter V40[St] : Exeter Duration[C]	16,880	73 (67-79)	32	0.59 (0.49-0.72)	1.18 (1.03-1.36)	1.62 (1.43-1.83)	3.84 (3.50-4.23)	5.75 (5.18-6.39)	*6.79 (5.86-7.86)*
Exeter V40[St] : Exeter X3 Rimfit[C]	30,579	70 (63-77)	35	0.49 (0.41-0.57)	0.90 (0.79-1.03)	1.28 (1.12-1.46)			
Exeter V40[St] : Marathon[C]	6,870	71 (64-78)	36	0.44 (0.31-0.63)	0.94 (0.71-1.25)	1.35 (1.03-1.78)	*2.00 (1.30-3.09)*		
Exeter V40[St] : Opera[C]	2,811	74 (68-80)	32	0.40 (0.22-0.71)	0.85 (0.57-1.28)	1.25 (0.89-1.76)	3.30 (2.50-4.35)	*5.45 (4.06-7.30)*	*10.41 (5.28-19.96)*
MS-30[St] : Low Profile Durasul Cup[C]	3,768	74 (68-80)	32	0.22 (0.11-0.44)	0.50 (0.31-0.81)	0.79 (0.53-1.18)	1.62 (1.12-2.35)	*2.59 (1.57-4.23)*	*2.59 (1.57-4.23)*
Muller Straight Stem[St] : Low Profile Durasul Cup[C]	3,641	75 (70-80)	28	0.50 (0.32-0.80)	0.80 (0.55-1.17)	1.12 (0.80-1.58)	2.62 (1.93-3.56)	*3.90 (2.72-5.57)*	*5.33 (2.96-9.50)*
Stanmore Modular Stem[St] : Stanmore-Arcom Cup[C]	5,414	75 (70-80)	29	0.45 (0.30-0.67)	1.07 (0.83-1.40)	1.54 (1.23-1.93)	2.48 (2.01-3.05)	4.17 (3.27-5.33)	*4.48 (3.44-5.82)*
Uncemented									
Accolade[St] : Trident[SL]	26,651	66 (59-73)	44	0.95 (0.84-1.07)	1.89 (1.73-2.07)	2.60 (2.40-2.81)	4.39 (4.04-4.76)	*5.32 (4.73-5.98)*	*6.84 (4.38-10.61)*
Accolade II[St] : Trident[SL]	6,735	65 (58-72)	46	0.81 (0.60-1.08)	1.16 (0.88-1.54)	*2.37 (1.29-4.32)*			
Anthology[St] : R3 Cementless[SL]	4,433	62 (54-70)	42	1.09 (0.82-1.44)	1.75 (1.38-2.21)	2.31 (1.84-2.91)	*4.87 (2.64-8.88)*		
Corail[St] : ASR Resurfacing Cup[C]	2,745	61 (54-67)	54	0.99 (0.68-1.43)	7.47 (6.54-8.52)	23.46 (21.90-25.12)	43.76 (41.86-45.71)	*48.35 (45.94-50.83)*	
Corail[St] : Duraloc Cementless Cup[SL]	4,004	70 (64-75)	39	0.75 (0.53-1.07)	1.68 (1.32-2.13)	2.46 (2.02-3.01)	5.53 (4.81-6.36)	8.90 (7.79-10.17)	*11.18 (9.34-13.37)*
Corail[St] : Pinnacle Gription[SL]	7,924	67 (58-74)	41	0.97 (0.77-1.22)	1.59 (1.30-1.95)	2.20 (1.75-2.77)			
Corail[St] : Pinnacle[SL]	150,407	66 (59-73)	45	0.80 (0.75-0.84)	1.56 (1.49-1.63)	2.33 (2.25-2.42)	5.48 (5.28-5.69)	7.27 (6.89-7.68)	
Corail[St] : Trilogy[SL]	3,133	68 (61-74)	40	0.62 (0.40-0.98)	1.11 (0.79-1.56)	1.59 (1.19-2.13)	3.12 (2.43-4.01)	*3.84 (2.85-5.17)*	*3.84 (2.85-5.17)*
Furlong Evolution Cementless[St] : Furlong HAC CSF Plus[SL]	4,114	62 (52-70)	39	1.31 (1.00-1.73)	1.86 (1.45-2.37)	2.17 (1.70-2.78)			

Note: Blank cells indicate that the number at risk at the time shown has fallen below ten and thus estimates have been omitted as they are highly unreliable. [St] = Stem; [C] = Cup; [SL] = Shell liner.

Table 3.9 (continued)

Stem:cup brand	N	Median (IQR) age at primary	Percentage (%) males	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
Furlong HAC Stem[St] : CSF[SL]	17,006	69 (63-76)	40	1.10 (0.95-1.26)	1.80 (1.61-2.02)	2.18 (1.97-2.42)	3.63 (3.32-3.96)	4.40 (4.03-4.81)	5.58 (4.87-6.40)
Furlong HAC Stem[St] : Furlong HAC CSF Plus[SL]	23,339	66 (59-73)	45	1.14 (1.01-1.28)	1.82 (1.65-2.01)	2.11 (1.92-2.31)	2.81 (2.51-3.15)		
M/L Taper Cementless[St] : Continuum[SL]	5,809	61 (53-68)	50	1.28 (1.02-1.60)	1.87 (1.54-2.27)	2.18 (1.80-2.63)			
M/L Taper Cementless[St] : Trilogy IT[SL]	4,534	64 (55-71)	51	1.23 (0.95-1.61)	2.30 (1.86-2.85)	2.44 (1.96-3.03)			
Metafix Stem[St] : Trinity[SL]	5,278	64 (56-70)	46	0.78 (0.57-1.07)	1.27 (0.98-1.65)	1.57 (1.19-2.06)			
Polarstem Cementless[St] : R3 Cementless[SL]	12,099	66 (58-73)	46	0.66 (0.52-0.83)	0.94 (0.77-1.16)	1.06 (0.86-1.32)			
SL-Plus Cementless Stem[St] : EP-Fit Plus[SL]	5,410	66 (59-73)	43	1.29 (1.02-1.63)	2.71 (2.30-3.19)	3.87 (3.36-4.45)	6.10 (5.40-6.88)	7.37 (6.38-8.50)	
Synergy Cementless Stem[St] : R3 Cementless[SL]	3,586	65 (57-71)	51	0.96 (0.69-1.34)	1.45 (1.09-1.92)	1.99 (1.52-2.59)	*4.09 (2.85-5.86)*		
Taperloc Cementless Stem[St] : Exceed ABT[SL]	24,365	65 (58-72)	44	1.10 (0.98-1.24)	1.54 (1.39-1.71)	1.82 (1.65-2.01)	2.22 (2.00-2.47)		
Taperloc Complete Cementless Stem[St] : Exceed ABT[SL]	3,281	63 (56-70)	49	0.85 (0.58-1.24)	1.46 (1.07-1.99)	1.63 (1.19-2.23)			
Hybrid									
C-Stem AMT Cemented Stem[St] : Pinnacle[SL]	12,722	71 (65-77)	38	0.72 (0.58-0.89)	1.21 (1.01-1.45)	1.73 (1.44-2.07)	3.74 (2.87-4.86)	*3.98 (3.02-5.24)*	
CPCS[St] : R3 Cementless[SL]	2,582	73 (67-79)	31	0.82 (0.53-1.27)	1.42 (0.96-2.10)	*1.94 (1.28-2.94)*			
CPT[St] : Continuum[SL]	8,052	70 (61-77)	36	1.64 (1.38-1.96)	2.36 (2.02-2.76)	2.72 (2.31-3.21)			
CPT[St] : Trabecular Metal Modular Cementless Cup[SL]	2,536	72 (64-79)	32	1.06 (0.72-1.55)	1.81 (1.34-2.46)	2.38 (1.77-3.18)	*4.50 (3.27-6.18)*	*5.63 (3.53-8.91)*	
CPT[St] : Trilogy IT[SL]	8,618	68 (61-75)	37	1.29 (1.07-1.55)	1.93 (1.63-2.29)	2.20 (1.84-2.64)			
CPT[St] : Trilogy[SL]	21,800	72 (65-78)	35	0.92 (0.80-1.06)	1.50 (1.34-1.68)	2.34 (2.11-2.58)	4.43 (3.96-4.95)	5.72 (5.00-6.54)	*5.91 (5.12-6.83)*
Exeter V40[St] : ABG II Cementless Cup[SL]	2,620	65 (59-73)	35	0.31 (0.15-0.61)	0.79 (0.51-1.23)	1.24 (0.87-1.77)	2.30 (1.73-3.06)	2.94 (2.23-3.86)	*3.90 (2.72-5.56)*
Exeter V40[St] : Pinnacle[SL]	8,216	72 (65-78)	38	0.78 (0.61-1.00)	1.17 (0.95-1.45)	1.43 (1.17-1.76)	2.59 (1.97-3.41)	*3.84 (2.34-6.28)*	
Exeter V40[St] : Trident[SL]	84,865	69 (61-76)	40	0.59 (0.54-0.64)	1.06 (0.99-1.14)	1.43 (1.33-1.53)	2.59 (2.40-2.79)	3.38 (3.05-3.75)	*4.05 (3.23-5.09)*

Note: Blank cells indicate that the number at risk at the time shown has fallen below ten and thus estimates have been omitted as they are highly unreliable. [St] = Stem; [C] = Cup; [SL] = Shell liner.

Table 3.9 (continued)

Stem:cup brand	N	Median (IQR) age at primary	Percentage (%) males	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
Exeter V40[St] : Trilogy[SL]	14,022	70 (63-76)	40	0.58 (0.47-0.72)	0.95 (0.80-1.13)	1.31 (1.12-1.52)	2.33 (2.04-2.67)	3.10 (2.67-3.61)	*3.10 (2.67-3.61)*
Exeter V40[St] : Tritanium[SL]	4,354	67 (59-74)	45	0.95 (0.70-1.30)	1.63 (1.25-2.11)	2.09 (1.61-2.72)			
Taperfit Cemented Stem[St] : Trinity[SL]	4,688	71 (65-77)	33	0.83 (0.60-1.15)	1.36 (1.02-1.81)	1.43 (1.07-1.91)			
Reverse hybrid									
Corail[St] : Elite Plus Ogee[C]	2,942	71 (65-77)	37	0.62 (0.39-0.99)	1.40 (1.02-1.93)	1.88 (1.41-2.49)	3.27 (2.47-4.31)	*5.98 (3.61-9.81)*	
Corail[St] : Marathon[C]	13,399	70 (64-76)	38	0.64 (0.51-0.79)	1.16 (0.98-1.38)	1.42 (1.20-1.68)	*2.62 (1.85-3.71)*		
Resurfacing									
ASR Resurfacing Cup	2,934	55 (49-60)	68	1.67 (1.27-2.20)	5.91 (5.12-6.83)	13.30 (12.12-14.59)	26.17 (24.59-27.82)	29.72 (27.96-31.56)	*30.45 (28.49-32.52)*
Adept Resurfacing Cup	3,569	54 (47-59)	74	1.13 (0.83-1.54)	2.46 (2.00-3.04)	4.52 (3.87-5.27)	8.25 (7.32-9.30)	*12.70 (10.32-15.58)*	
BHR Resurfacing Cup	22,572	55 (48-60)	74	1.05 (0.92-1.19)	2.36 (2.17-2.57)	3.66 (3.42-3.92)	7.80 (7.43-8.20)	10.04 (9.56-10.53)	11.53 (10.91-12.19)
Conserve Plus Resurfacing Cup	1,325	56 (50-61)	63	2.04 (1.40-2.96)	5.15 (4.09-6.49)	8.30 (6.93-9.93)	14.17 (12.35-16.23)	*15.99 (13.77-18.53)*	*15.99 (13.77-18.53)*
Cormet 2000 Resurfacing Cup	3,632	55 (48-60)	65	1.57 (1.21-2.03)	3.81 (3.24-4.49)	7.77 (6.94-8.69)	17.01 (15.81-18.30)	21.28 (19.79-22.86)	*24.52 (22.38-26.83)*
Durom Resurfacing Cup	1,691	55 (49-60)	70	1.36 (0.91-2.04)	3.62 (2.82-4.62)	5.47 (4.48-6.66)	8.67 (7.40-10.14)	9.91 (8.47-11.58)	
Recap Magnum	1,694	54 (49-59)	73	1.89 (1.34-2.66)	3.31 (2.56-4.28)	5.54 (4.54-6.74)	10.43 (8.99-12.08)	*13.15 (10.89-15.82)*	

Note: Blank cells indicate that the number at risk at the time shown has fallen below ten and thus estimates have been omitted as they are highly unreliable. [St] = Stem; [C] = Cup; [SL] = Shell liner.

Table 3.10 further divides the data by stratifying for bearing surface. This table shows the estimated cumulative percentage probability of revision for the resulting fixation/bearing sub-groups provided there were more than 2,500 procedures.

Table 3.10 KM estimates of cumulative **revision** (95% CI) of primary hip replacement by **fixation**, **stem/cup brand**, and **bearing**. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

Stem:cup brand	Bearing surface	N	Median (IQR) age at primary	Percentage (%) males	Time since primary					
					1 year	3 years	5 years	10 years	13 years	15 years
Cemented										
C-Stem AMT Cemented Stem[St] : Charnley and Elite Plus LPW[C]	MoP	3,136	75 (71-79)	31	0.59 (0.37-0.93)	1.21 (0.87-1.68)	1.50 (1.11-2.02)	2.70 (2.00-3.65)		
C-Stem AMT Cemented Stem[St] : Elite Plus Ogee[C]	MoP	3,646	77 (73-82)	32	0.26 (0.13-0.49)	0.81 (0.54-1.21)	1.24 (0.87-1.78)	2.26 (1.60-3.20)		
C-Stem AMT Cemented Stem[St] : Marathon[C]	MoP	8,515	76 (71-81)	32	0.41 (0.29-0.58)	0.96 (0.74-1.25)	1.29 (0.98-1.71)	*1.89 (1.30-2.74)*		
C-Stem Cemented Stem[St] : Elite Plus Ogee[C]	MoP	4,653	73 (68-78)	39	0.45 (0.29-0.69)	1.00 (0.74-1.35)	1.33 (1.02-1.74)	3.04 (2.43-3.80)	4.47 (3.55-5.62)	*4.72 (3.71-6.00)*
C-Stem Cemented Stem[St] : Marathon[C]	MoP	4,784	73 (68-78)	37	0.33 (0.20-0.55)	0.87 (0.62-1.22)	1.31 (0.95-1.79)	*2.60 (1.79-3.75)*		
C-Stem Cemented Stem[St] : Marathon[C]	CoP	3,431	59 (52-64)	46	0.55 (0.34-0.87)	1.09 (0.76-1.55)	1.62 (1.17-2.23)	*2.05 (1.48-2.85)*		
CPT[St] : Elite Plus Ogee[C]	MoP	2,962	73 (67-79)	36	0.61 (0.39-0.97)	1.44 (1.06-1.94)	2.04 (1.57-2.64)	3.89 (3.08-4.90)	*5.05 (3.88-6.56)*	*5.05 (3.88-6.56)*
CPT[St] : ZCA[C]	MoP	15,496	77 (72-81)	30	0.87 (0.74-1.03)	1.49 (1.30-1.71)	2.17 (1.91-2.46)	3.90 (3.45-4.40)	4.81 (4.16-5.55)	*5.00 (4.27-5.86)*
Charnley Cemented Stem[St] : Charnley Cemented Cup[C]	MoP	4,593	72 (66-78)	38	0.31 (0.18-0.52)	1.13 (0.86-1.49)	1.80 (1.44-2.25)	3.52 (2.96-4.17)	5.17 (4.39-6.09)	6.60 (5.45-8.00)
Charnley Cemented Stem[St] : Charnley Ogee[C]	MoP	10,427	73 (67-78)	38	0.38 (0.28-0.52)	1.22 (1.02-1.46)	1.89 (1.64-2.19)	3.79 (3.38-4.24)	5.14 (4.58-5.75)	5.82 (5.12-6.61)
Charnley Cemented Stem[St] : Charnley and Elite Plus LPW[C]	MoP	6,829	74 (68-79)	29	0.37 (0.25-0.55)	0.75 (0.57-0.99)	1.17 (0.93-1.46)	2.54 (2.14-3.02)	3.53 (2.98-4.18)	4.45 (3.45-5.74)
Exeter V40[St] : Charnley and Elite Plus LPW[C]	MoP	3,885	75 (70-80)	28	0.66 (0.45-0.97)	1.24 (0.92-1.66)	1.46 (1.10-1.92)	2.24 (1.68-2.97)	*3.15 (2.32-4.27)*	*3.78 (2.50-5.71)*
Exeter V40[St] : Elite Plus Cemented Cup[C]	MoP	4,850	74 (68-79)	33	0.35 (0.22-0.57)	0.62 (0.43-0.90)	0.81 (0.58-1.12)	1.40 (1.03-1.90)	2.43 (1.68-3.50)	*3.00 (1.87-4.81)*
Exeter V40[St] : Elite Plus Ogee[C]	MoP	23,079	75 (70-80)	34	0.38 (0.31-0.47)	0.85 (0.73-0.98)	1.18 (1.04-1.34)	2.23 (1.99-2.50)	2.88 (2.53-3.27)	3.50 (2.75-4.46)
Exeter V40[St] : Exeter Contemporary Flanged[C]	MoP	78,170	75 (69-80)	34	0.51 (0.46-0.56)	0.97 (0.90-1.05)	1.34 (1.25-1.44)	2.45 (2.28-2.63)	3.43 (3.12-3.77)	*4.69 (3.86-5.70)*

Note: Blank cells indicate that the number at risk at the time shown has fallen below ten and thus estimates have been omitted as they are highly unreliable.
[St] = Stem; [C] = Cup; [SL] = Shell liner.

Table 3.10 (continued)

Stem:cup brand	Bearing surface	N	Median (IQR) age at primary	Percentage (%) males	Time since primary					
					1 year	3 years	5 years	10 years	13 years	15 years
Exeter V40[St] : Exeter Contemporary Flanged[C]	CoP	6,183	66 (61-71)	37	0.55 (0.39-0.78)	1.01 (0.77-1.31)	1.32 (1.03-1.69)	2.09 (1.60-2.74)	*3.00 (2.01-4.47)*	*3.00 (2.01-4.47)*
Exeter V40[St] : Exeter Contemporary Hooded[C]	MoP	26,295	76 (70-81)	31	0.94 (0.83-1.06)	1.64 (1.49-1.81)	2.21 (2.02-2.41)	4.14 (3.80-4.51)	6.46 (5.79-7.21)	*7.14 (6.27-8.13)*
Exeter V40[St] : Exeter Duration[C]	MoP	15,907	74 (68-79)	32	0.61 (0.50-0.74)	1.22 (1.05-1.40)	1.67 (1.47-1.88)	3.91 (3.55-4.32)	5.80 (5.21-6.47)	*6.96 (5.95-8.12)*
Exeter V40[St] : Exeter X3 Rimfit[C]	MoP	21,614	73 (67-79)	33	0.50 (0.41-0.60)	0.91 (0.77-1.06)	1.25 (1.07-1.47)			
Exeter V40[St] : Exeter X3 Rimfit[C]	CoP	8,965	62 (56-68)	39	0.46 (0.34-0.63)	0.88 (0.69-1.12)	1.34 (1.06-1.70)			
Exeter V40[St] : Marathon[C]	MoP	4,875	74 (69-80)	34	0.51 (0.34-0.76)	0.98 (0.71-1.37)	1.29 (0.93-1.78)			
Exeter V40[St] : Opera[C]	MoP	2,678	75 (69-80)	31	0.38 (0.20-0.70)	0.85 (0.56-1.29)	1.28 (0.91-1.80)	3.37 (2.55-4.45)	*5.53 (4.13-7.40)*	*9.95 (4.92-19.58)*
Muller Straight Stem[St] : Low Profile Durasul Cup[C]	MoP	2,963	75 (70-80)	28	0.55 (0.34-0.89)	0.84 (0.55-1.26)	1.22 (0.85-1.76)	2.83 (2.03-3.95)	*4.26 (2.84-6.36)*	*4.26 (2.84-6.36)*
Stanmore Modular Stem[St] : Stanmore-Arcom Cup[C]	MoP	4,954	75 (70-81)	30	0.41 (0.26-0.63)	1.07 (0.81-1.41)	1.58 (1.25-2.00)	2.61 (2.11-3.23)	4.01 (3.11-5.16)	*4.01 (3.11-5.16)*
Uncemented										
Accolade[St] : Trident[SL]	MoP	12,411	71 (65-76)	41	0.98 (0.82-1.18)	1.99 (1.75-2.25)	2.80 (2.51-3.12)	5.35 (4.75-6.03)	*7.95 (6.14-10.27)*	
Accolade[St] : Trident[SL]	CoP	6,876	62 (55-67)	46	0.83 (0.64-1.08)	1.54 (1.26-1.88)	1.88 (1.56-2.27)	2.88 (2.26-3.67)	*2.88 (2.26-3.67)*	
Accolade[St] : Trident[SL]	CoC	7,364	62 (55-68)	46	0.99 (0.79-1.25)	2.04 (1.74-2.39)	2.79 (2.43-3.20)	4.02 (3.53-4.58)	*4.43 (3.79-5.17)*	*6.24 (3.50-10.97)*
Accolade II[St] : Trident[SL]	MoP	2,836	70 (64-76)	43	0.76 (0.48-1.20)	1.09 (0.71-1.69)	*1.36 (0.81-2.28)*			
Accolade II[St] : Trident[SL]	CoP	3,618	62 (55-69)	48	0.87 (0.59-1.28)	1.27 (0.88-1.85)	*2.10 (0.94-4.67)*			
Anthology[St] : R3 Cementless[SL]	MoP	3,524	64 (55-71)	39	1.17 (0.86-1.59)	1.88 (1.46-2.43)	2.31 (1.79-2.98)			
Corail[St] : ASR Resurfacing Cup[C]	MoM	2,745	61 (54-67)	54	0.99 (0.68-1.43)	7.47 (6.54-8.52)	23.46 (21.90-25.12)	43.76 (41.86-45.71)	*48.35 (45.94-50.83)*	
Corail[St] : Duraloc Cementless Cup[SL]	MoP	3,682	70 (65-75)	38	0.63 (0.42-0.94)	1.47 (1.12-1.92)	2.30 (1.85-2.85)	5.40 (4.65-6.26)	8.47 (7.32-9.79)	*9.51 (7.83-11.53)*
Corail[St] : Pinnacle Gription[SL]	MoP	2,974	74 (68-79)	36	1.13 (0.80-1.60)	1.72 (1.26-2.36)	2.14 (1.53-2.99)			
Corail[St] : Pinnacle Gription[SL]	CoP	2,868	64 (57-71)	43	0.64 (0.40-1.03)	1.31 (0.86-1.99)	*1.90 (1.11-3.23)*			
Corail[St] : Pinnacle[SL]	MoP	60,875	71 (65-77)	41	0.80 (0.74-0.88)	1.31 (1.22-1.41)	1.59 (1.49-1.71)	2.97 (2.72-3.23)	4.07 (3.56-4.64)	
Corail[St] : Pinnacle[SL]	MoM	11,930	67 (60-74)	47	0.88 (0.73-1.07)	2.45 (2.19-2.75)	5.21 (4.82-5.63)	13.52 (12.87-14.20)	16.50 (15.58-17.48)	

Note: Blank cells indicate that the number at risk at the time shown has fallen below ten and thus estimates have been omitted as they are highly unreliable.
[St] = Stem; [C] = Cup; [SL] = Shell liner.

Table 3.10 (continued)

Stem:cup brand	Bearing surface	N	Median (IQR) age at primary	Percentage (%) males	Time since primary					
					1 year	3 years	5 years	10 years	13 years	15 years
Corail[St] : Pinnacle[SL]	CoP	34,002	64 (57-69)	46	0.72 (0.63-0.81)	1.13 (1.01-1.26)	1.58 (1.42-1.77)	2.88 (2.39-3.48)	*3.13 (2.55-3.83)*	
Corail[St] : Pinnacle[SL]	CoC	41,769	59 (52-66)	49	0.84 (0.75-0.93)	1.80 (1.67-1.94)	2.44 (2.29-2.60)	3.94 (3.68-4.23)	4.87 (4.31-5.49)	
Furlong Evolution Cementless[St] : Furlong HAC CSF Plus[SL]	CoC	3,470	60 (50-69)	39	1.17 (0.85-1.60)	1.59 (1.19-2.11)	1.95 (1.47-2.59)			
Furlong HAC Stem[St] : CSF[SL]	MoP	8,048	73 (67-78)	39	1.37 (1.13-1.65)	2.18 (1.88-2.53)	2.53 (2.20-2.91)	4.34 (3.84-4.89)	5.21 (4.58-5.94)	*5.88 (4.72-7.32)*
Furlong HAC Stem[St] : CSF[SL]	CoP	7,303	67 (61-73)	41	0.76 (0.58-0.99)	1.30 (1.06-1.59)	1.67 (1.40-2.00)	2.71 (2.32-3.15)	3.45 (2.96-4.01)	4.88 (3.93-6.05)
Furlong HAC Stem[St] : Furlong HAC CSF Plus[SL]	MoP	5,653	74 (70-79)	39	1.66 (1.36-2.04)	2.37 (1.99-2.81)	2.90 (2.46-3.41)	*4.14 (3.35-5.10)*		
Furlong HAC Stem[St] : Furlong HAC CSF Plus[SL]	CoP	3,001	67 (62-72)	46	0.99 (0.69-1.42)	1.67 (1.25-2.23)	1.95 (1.48-2.57)	*3.13 (1.96-4.97)*		
Furlong HAC Stem[St] : Furlong HAC CSF Plus[SL]	CoC	14,685	63 (56-69)	47	0.96 (0.81-1.13)	1.65 (1.45-1.87)	1.84 (1.63-2.09)	2.31 (2.03-2.62)		
Polarstem Cementless[St] : R3 Cementless[SL]	MoP	10,533	67 (59-73)	46	0.68 (0.53-0.86)	0.97 (0.78-1.21)	1.15 (0.90-1.46)			
SL-Plus Cementless Stem[St] : EP-Fit Plus[SL]	MoP	2,889	68 (62-75)	40	1.36 (1.00-1.86)	2.70 (2.16-3.37)	3.55 (2.90-4.33)	6.25 (5.24-7.45)	*7.30 (5.79-9.18)*	
Synergy Cementless Stem[St] : R3 Cementless[SL]	MoP	2,895	66 (57-72)	50	0.98 (0.68-1.42)	1.33 (0.96-1.84)	1.59 (1.16-2.19)			
Taperloc Cementless Stem[St] : Exceed ABT[SL]	MoP	7,853	72 (66-77)	40	1.27 (1.04-1.55)	1.81 (1.53-2.14)	2.05 (1.74-2.42)	*2.50 (2.11-2.96)*		
Taperloc Cementless Stem[St] : Exceed ABT[SL]	CoP	4,942	65 (58-70)	45	0.86 (0.64-1.17)	1.05 (0.80-1.40)	1.26 (0.96-1.66)	*1.91 (1.29-2.82)*		
Taperloc Cementless Stem[St] : Exceed ABT[SL]	CoC	11,557	61 (54-67)	47	1.09 (0.91-1.29)	1.55 (1.34-1.80)	1.89 (1.64-2.17)	2.20 (1.91-2.54)		
Hybrid										
C-Stem AMT Cemented Stem[St] : Pinnacle[SL]	MoP	6,722	75 (71-80)	34	0.73 (0.54-0.97)	1.28 (1.01-1.63)	1.73 (1.35-2.20)	*2.83 (1.85-4.33)*		
C-Stem AMT Cemented Stem[St] : Pinnacle[SL]	CoP	4,330	67 (60-71)	42	0.73 (0.51-1.05)	1.11 (0.79-1.56)	1.38 (0.94-2.01)	*2.45 (1.27-4.70)*		
CPT[St] : Continuum[SL]	MoP	4,026	75 (70-80)	33	1.91 (1.52-2.40)	2.58 (2.08-3.19)	2.96 (2.33-3.75)			
CPT[St] : Continuum[SL]	CoP	2,585	66 (59-71)	38	1.51 (1.10-2.08)	2.25 (1.68-3.01)	*2.51 (1.80-3.50)*			
CPT[St] : Trilogy IT[SL]	MoP	4,282	74 (69-79)	34	1.54 (1.20-1.96)	2.38 (1.92-2.96)	2.82 (2.23-3.55)			

Note: Blank cells indicate that the number at risk at the time shown has fallen below ten and thus estimates have been omitted as they are highly unreliable.
[St] = Stem; [C] = Cup; [SL] = Shell liner.

Table 3.10 (continued)

Stem:cup brand	Bearing surface	N	Median (IQR) age at primary	Percentage (%) males	Time since primary					
					1 year	3 years	5 years	10 years	13 years	15 years
CPT[St] : Trilogy IT[SL]	CoP	3,061	64 (58-70)	40	1.05 (0.73-1.50)	1.58 (1.14-2.19)	*1.77 (1.24-2.53)*			
CPT[St] : Trilogy[SL]	MoP	14,280	73 (67-79)	35	0.87 (0.73-1.03)	1.46 (1.27-1.68)	2.28 (2.02-2.57)	4.38 (3.89-4.93)	5.68 (4.93-6.53)	*5.87 (5.05-6.82)*
CPT[St] : Trilogy[SL]	CoP	7,520	69 (62-75)	36	1.03 (0.82-1.29)	1.58 (1.29-1.93)	2.56 (2.08-3.15)	*3.44 (2.60-4.54)*	*4.84 (2.65-8.73)*	
Exeter V40[St] : Pinnacle[SL]	MoP	5,649	75 (70-80)	31	0.82 (0.61-1.09)	1.24 (0.97-1.59)	1.50 (1.18-1.90)	2.54 (1.87-3.43)	*3.90 (2.29-6.60)*	
Exeter V40[St] : Trident[SL]	MoP	46,384	73 (68-79)	37	0.63 (0.56-0.70)	1.14 (1.03-1.25)	1.48 (1.35-1.62)	2.77 (2.47-3.10)	3.66 (3.12-4.29)	*4.33 (3.36-5.58)*
Exeter V40[St] : Trident[SL]	CoP	25,681	65 (57-71)	42	0.54 (0.46-0.65)	0.90 (0.78-1.05)	1.15 (0.99-1.34)	1.88 (1.47-2.39)	*2.33 (1.52-3.55)*	
Exeter V40[St] : Trident[SL]	CoC	12,792	59 (53-65)	44	0.55 (0.44-0.70)	1.05 (0.89-1.25)	1.54 (1.33-1.78)	2.71 (2.39-3.06)	3.47 (3.00-4.01)	*4.19 (3.07-5.71)*
Exeter V40[St] : Trilogy[SL]	MoP	11,389	71 (65-77)	40	0.57 (0.45-0.73)	0.93 (0.76-1.12)	1.31 (1.11-1.55)	2.38 (2.05-2.77)	3.13 (2.65-3.70)	*3.13 (2.65-3.70)*
Exeter V40[St] : Trilogy[SL]	CoP	2,632	63 (58-69)	42	0.58 (0.35-0.96)	1.01 (0.68-1.49)	1.25 (0.87-1.78)	2.13 (1.58-2.88)	2.97 (2.12-4.16)	*2.97 (2.12-4.16)*
Taperfit Cemented Stem[St] : Trinity[SL]	MoP	2,520	75 (70-80)	32	1.05 (0.71-1.55)	1.66 (1.18-2.35)	*1.66 (1.18-2.35)*			
Reverse hybrid										
Corail[St] : Marathon[C]	MoP	9,272	73 (68-78)	37	0.66 (0.51-0.85)	1.16 (0.94-1.43)	1.37 (1.11-1.69)	*1.94 (1.49-2.52)*		
Corail[St] : Marathon[C]	CoP	4,127	63 (56-68)	41	0.58 (0.39-0.88)	1.16 (0.85-1.58)	1.50 (1.12-2.01)	*4.11 (2.13-7.84)*		

Note: Blank cells indicate that the number at risk at the time shown has fallen below ten and thus estimates have been omitted as they are highly unreliable.
[St] = Stem; [C] = Cup; [SL] = Shell liner.

3.3.5 Revisions for different causes after primary hip replacement

Overall, 31,410 (2.9%) of the 1,091,892 primary hip replacements had an associated first revision. The most common indications for revision were aseptic loosening (7,644), adverse soft tissue reaction to particulate debris (5,114, a figure that is likely to be an underestimate due to changes in MDS collection, see later), dislocation/subluxation (5,383), pain (4,705), and infection (4,555). Pain was not usually cited alone; in 3,225 out of the 4,705 instances, it was cited together with one or more other indications. Associated PTIRs for these and the other indications are shown in Table 3.11. Here, implant wear denotes either wear of the polyethylene component, wear of the acetabular component or dissociation of the liner.

The number of adverse reactions to particulate debris is likely to be underestimated because this was not solicited (i.e. it was not available as an indication for revision) on the revision data collection forms in the early phase of the registry, i.e. was not included in MDSv1 and MDSv2. Some of these cases may have recorded the indication for revision as 'other' but we simply do not know. Adoption of the later revision report forms (MDSv3 onwards) was staggered over time and so revisions associated with a few primaries as late as 2011 had revisions reported on MDSv1 and MDSv2 of the data collection forms. Restricting our analyses to primaries from 2008 onwards, as we did in our recent annual reports, ensures that >99% of revisions were recorded on later forms (MDSv3 onwards). We noted that only 2,316 of the 5,114 instances of adverse reactions to particulate debris would thus be included, i.e. we are thereby missing 2,798 of the earlier cases. Therefore, as we did last year, we present two sets of PTIRs: one set for all primary hip replacements, which are likely to be underestimates, and the other set for all primary hip replacements performed since the beginning of 2008, which has better ascertainment but does not include the cases with the longest follow-up.

Table 3.11 reports revision by indication with further breakdowns by hip fixation and bearing. Metal-on-metal (irrespective of the type of fixation) and resurfacings seem to have the highest PTIRs for both aseptic loosening and pain. Metal-on-metal bearings have the highest incidence of adverse reaction to particulate debris.

Table 3.11 PTIR estimates of **indications** for hip **revision** (95% CI) by **fixation** and **bearing**.

Fixation/ bearing type	Prosthesis-years at risk (x1,000)	Number of revisions per 1,000 prosthesis-years for:												Adverse reaction to particulate debris for primaries from 1.1.2008***	
		Aseptic loosening	Pain	Dislocation/ subluxation	Infection	Peripros-thetic fracture	Malalign-ment	Lysis	Implant wear	Implant fracture	Head/ socket size mis-match	Other indi-cation	Adverse reaction to particulate debris**	Prosthesis-years at risk (x1,000)	Number of revisions per 1,000 prosthesis-years
All cases*	6,249.9	1.22 (1.20-1.25)	0.75 (0.73-0.77)	0.86 (0.84-0.88)	0.73 (0.71-0.75)	0.70 (0.68-0.72)	0.35 (0.34-0.37)	0.29 (0.27-0.30)	0.27 (0.26-0.29)	0.16 (0.15-0.17)	0.04 (0.03-0.04)	0.45 (0.43-0.46)	0.82 (0.80-0.84)	4,211.8	0.55 (0.53-0.57)
All cemented	2,116.1	1.06 (1.02-1.10)	0.30 (0.27-0.32)	0.84 (0.80-0.88)	0.68 (0.65-0.72)	0.50 (0.47-0.53)	0.20 (0.18-0.22)	0.21 (0.19-0.23)	0.17 (0.15-0.19)	0.08 (0.07-0.09)	0.01 (0.01-0.02)	0.14 (0.13-0.16)	0.03 (0.03-0.04)	1,259.6	0.03 (0.02-0.04)
Cemented and															
MoP	1,895.7	1.09 (1.04-1.14)	0.30 (0.27-0.32)	0.87 (0.83-0.91)	0.67 (0.64-0.71)	0.51 (0.48-0.55)	0.20 (0.18-0.22)	0.22 (0.20-0.24)	0.18 (0.16-0.20)	0.07 (0.06-0.09)	0.01 (0.01-0.02)	0.15 (0.13-0.16)	0.03 (0.02-0.04)	1,102.0	0.03 (0.02-0.04)
MoM	3.7	1.34 (0.56-3.21)	0.27 (0.04-1.90)	1.34 (0.56-3.21)	0.80 (0.26-2.49)	1.07 (0.40-2.85)	0	0.53 (0.13-2.14)	0.27 (0.04-1.90)	0.80 (0.26-2.49)	0	0.53 (0.13-2.14)	0.53 (0.13-2.14)	0.8	0
CoP	216.5	0.81 (0.70-0.94)	0.27 (0.21-0.35)	0.62 (0.52-0.73)	0.74 (0.64-0.87)	0.36 (0.29-0.45)	0.16 (0.11-0.22)	0.14 (0.10-0.20)	0.12 (0.08-0.17)	0.10 (0.07-0.15)	0.00 (0.00-0.03)	0.12 (0.08-0.18)	0.05 (0.03-0.09)	156.8	0.06 (0.03-0.11)
All uncemented	2,293.4	1.47 (1.42-1.52)	0.93 (0.89-0.97)	0.90 (0.86-0.94)	0.75 (0.72-0.79)	0.71 (0.68-0.75)	0.48 (0.45-0.51)	0.30 (0.28-0.33)	0.39 (0.36-0.41)	0.21 (0.20-0.23)	0.06 (0.05-0.07)	0.59 (0.56-0.62)	1.36 (1.31-1.40)	1,750.2	0.90 (0.86-0.95)
Uncemented and															
MoP	849.7	1.16 (1.09-1.24)	0.49 (0.45-0.54)	1.10 (1.03-1.18)	0.70 (0.65-0.76)	0.91 (0.85-0.97)	0.44 (0.40-0.49)	0.22 (0.19-0.26)	0.45 (0.40-0.49)	0.10 (0.08-0.12)	0.05 (0.04-0.07)	0.28 (0.25-0.32)	0.18 (0.15-0.21)	659.9	0.19 (0.16-0.23)
MoM	265.9	3.67 (3.45-3.91)	3.83 (3.60-4.07)	0.86 (0.76-0.98)	1.43 (1.30-1.58)	0.74 (0.64-0.85)	0.79 (0.69-0.91)	1.37 (1.23-1.51)	0.65 (0.56-0.76)	0.17 (0.13-0.23)	0.09 (0.06-0.13)	2.43 (2.25-2.62)	10.40 (10.02-10.80)	130.3	9.90 (9.38-10.46)
CoP	405.1	1.01 (0.92-1.11)	0.41 (0.35-0.48)	1.03 (0.93-1.13)	0.66 (0.59-0.75)	0.58 (0.51-0.66)	0.40 (0.34-0.46)	0.15 (0.11-0.19)	0.35 (0.30-0.41)	0.11 (0.08-0.15)	0.05 (0.03-0.07)	0.29 (0.24-0.35)	0.08 (0.05-0.11)	308.3	0.08 (0.05-0.12)
CoC	754.8	1.25 (1.17-1.33)	0.66 (0.60-0.72)	0.61 (0.55-0.66)	0.60 (0.55-0.66)	0.55 (0.50-0.60)	0.45 (0.40-0.50)	0.10 (0.08-0.13)	0.24 (0.21-0.28)	0.42 (0.37-0.47)	0.06 (0.04-0.08)	0.43 (0.39-0.48)	0.15 (0.13-0.18)	634.5	0.15 (0.12-0.18)
CoM	17.3	2.60 (1.94-3.48)	1.50 (1.02-2.21)	0.75 (0.44-1.29)	1.16 (0.75-1.79)	0.46 (0.23-0.92)	0.69 (0.39-1.22)	0.46 (0.23-0.92)	0.64 (0.35-1.15)	0.17 (0.06-0.54)	0.17 (0.06-0.54)	1.10 (0.70-1.72)	2.02 (1.45-2.82)	16.7	1.98 (1.40-2.78)

*Including 33,079 with unknown fixation/bearing.
**Rates likely to be underestimated: this reason not solicited in the early phase of the registry (revision report forms MDSv1/MDSv2).
***For primaries from 2008 onwards the majority of revision report forms were MDSv3/MDSv6 which explicitly gave this indication for revision as an option.

Table 3.11 (continued)

Fixation/ bearing type	Prosthesis-years at risk (x1,000)	Number of revisions per 1,000 prosthesis-years for: Aseptic loosening	Pain	Dislocation/ subluxation	Infection	Periprosthetic fracture	Malalignment	Lysis	Implant wear	Implant fracture	Head/ socket size mismatch	Other indication	Adverse reaction to particulate debris**	Adverse reaction to particulate debris for primaries from 1.1.2008*** Prosthesis-years at risk (x1,000)	Number of revisions per 1,000 prosthesis-years
All hybrid	1,088.9	0.56 (0.52-0.61)	0.37 (0.33-0.41)	1.01 (0.95-1.07)	0.82 (0.77-0.88)	0.92 (0.86-0.98)	0.27 (0.24-0.31)	0.18 (0.15-0.20)	0.22 (0.20-0.25)	0.15 (0.12-0.17)	0.02 (0.02-0.03)	0.28 (0.25-0.32)	0.24 (0.21-0.27)	793.8	0.14 (0.12-0.17)
Hybrid and															
MoP	680.0	0.56 (0.51-0.62)	0.29 (0.25-0.34)	1.11 (1.04-1.20)	0.83 (0.76-0.90)	1.00 (0.93-1.08)	0.28 (0.24-0.32)	0.17 (0.14-0.20)	0.25 (0.21-0.29)	0.10 (0.08-0.13)	0.02 (0.01-0.03)	0.22 (0.19-0.26)	0.07 (0.05-0.09)	488.0	0.06 (0.04-0.09)
MoM	22.7	3.17 (2.52-4.00)	3.31 (2.64-4.14)	1.41 (1.00-1.99)	1.23 (0.85-1.79)	1.98 (1.48-2.66)	0.57 (0.33-0.99)	1.76 (1.29-2.40)	0.31 (0.15-0.65)	0.35 (0.18-0.70)	0.09 (0.02-0.35)	2.56 (1.98-3.31)	7.84 (6.77-9.09)	7.7	7.37 (5.68-9.55)
CoP	207.6	0.33 (0.26-0.42)	0.22 (0.16-0.29)	1.08 (0.95-1.23)	0.99 (0.87-1.14)	0.91 (0.79-1.04)	0.17 (0.13-0.24)	0.10 (0.06-0.15)	0.19 (0.14-0.26)	0.10 (0.06-0.15)	0.02 (0.01-0.06)	0.26 (0.20-0.34)	0.04 (0.02-0.08)	180.5	0.03 (0.01-0.07)
CoC	178.1	0.51 (0.41-0.62)	0.46 (0.37-0.57)	0.46 (0.37-0.57)	0.54 (0.44-0.66)	0.50 (0.41-0.62)	0.34 (0.27-0.44)	0.11 (0.07-0.17)	0.16 (0.11-0.23)	0.35 (0.27-0.45)	0.03 (0.01-0.07)	0.26 (0.19-0.34)	0.13 (0.09-0.19)	117.1	0.15 (0.09-0.23)
All reverse hybrid	141.9	1.32 (1.15-1.53)	0.40 (0.31-0.52)	0.94 (0.80-1.12)	0.79 (0.66-0.95)	0.70 (0.58-0.86)	0.32 (0.24-0.42)	0.18 (0.12-0.27)	0.23 (0.17-0.33)	0.05 (0.02-0.10)	0.03 (0.01-0.08)	0.32 (0.24-0.42)	0.12 (0.07-0.19)	120.0	0.07 (0.03-0.13)
Reverse and															
MoP	95.2	1.24 (1.03-1.48)	0.26 (0.18-0.39)	1.01 (0.83-1.23)	0.82 (0.66-1.02)	0.81 (0.65-1.01)	0.29 (0.20-0.43)	0.18 (0.11-0.29)	0.20 (0.13-0.31)	0.04 (0.02-0.11)	0.02 (0.01-0.08)	0.28 (0.19-0.41)	0.07 (0.04-0.15)	80.6	0.05 (0.02-0.13)
CoP	46.3	1.47 (1.16-1.86)	0.65 (0.45-0.93)	0.80 (0.58-1.10)	0.73 (0.52-1.03)	0.48 (0.31-0.72)	0.32 (0.20-0.54)	0.17 (0.09-0.35)	0.30 (0.18-0.51)	0.06 (0.02-0.20)	0.04 (0.01-0.17)	0.32 (0.20-0.54)	0.04 (0.01-0.17)	39.3	0.03 (0.00-0.18)
All resurfacing	372.9	2.38 (2.23-2.54)	3.49 (3.30-3.68)	0.29 (0.24-0.36)	0.50 (0.43-0.58)	1.15 (1.05-1.26)	0.65 (0.57-0.74)	0.92 (0.83-1.03)	0.27 (0.23-0.33)	0.25 (0.20-0.31)	0.06 (0.04-0.09)	1.80 (1.67-1.94)	3.96 (3.76-4.17)	147.5	3.43 (3.14-3.74)

*Including 33,079 with unknown fixation/bearing.
**Rates likely to be underestimated: this reason not solicited in the early phase of the registry (revision report forms MDSv1/MDSv2).
***For primaries from 2008 onwards the majority of revision report forms were MDSv3/MDSv6 which explicitly gave this indication for revision as an option.

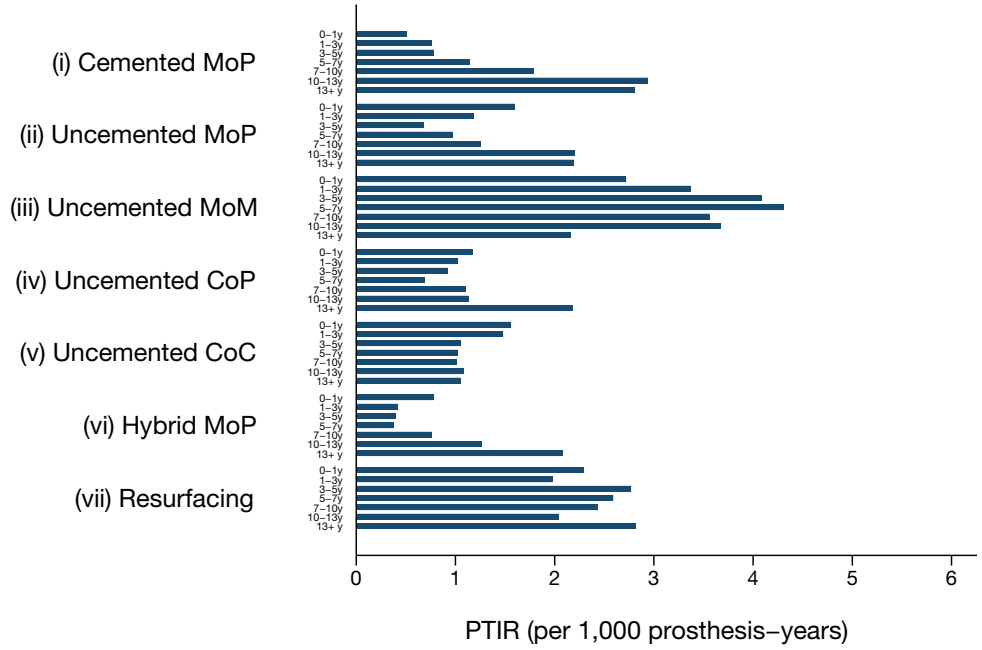
Table 3.12 PTIR estimates of **indications** for hip **revision** (95% CI) by **years** following primary hip replacement.

Time since primary	Pros-thesis-years at risk (x1,000)	Number of revisions per 1,000 prosthesis-years for:												Adverse reaction to particulate debris for primaries from 1.1.2008***	
		Aseptic loosening	Pain	Dislocation/ subluxation	Infection	Peri-prosthetic fracture	Malalignment	Lysis	Implant wear	Implant fracture	Head/ socket size mismatch	Other indication	Adverse reaction to particulate debris**	Prosthesis-years at risk (x1,000)	Number of revisions per 1,000 prosthesis-years
All cases	6,249.9	1.22 (1.20-1.25)	0.75 (0.73-0.77)	0.86 (0.84-0.88)	0.73 (0.71-0.75)	0.70 (0.68-0.72)	0.35 (0.34-0.37)	0.29 (0.27-0.30)	0.27 (0.26-0.29)	0.16 (0.15-0.17)	0.04 (0.03-0.04)	0.45 (0.43-0.46)	0.82 (0.80-0.84)	4,211.8	0.55 (0.53-0.57)
<1 year	1,031.0	1.09 (1.02-1.15)	0.57 (0.53-0.62)	2.47 (2.38-2.57)	1.80 (1.72-1.88)	1.72 (1.64-1.80)	0.74 (0.69-0.79)	0.08 (0.06-0.09)	0.34 (0.30-0.37)	0.22 (0.20-0.25)	0.10 (0.09-0.13)	0.71 (0.66-0.76)	0.10 (0.08-0.12)	840.5	0.12 (0.09-0.14)
1-3 years	1,735.0	1.03 (0.98-1.08)	0.77 (0.73-0.82)	0.62 (0.58-0.66)	0.72 (0.68-0.76)	0.38 (0.35-0.41)	0.33 (0.31-0.36)	0.15 (0.13-0.16)	0.13 (0.12-0.15)	0.13 (0.11-0.14)	0.03 (0.02-0.04)	0.38 (0.35-0.41)	0.24 (0.22-0.26)	1,365.3	0.28 (0.26-0.31)
3-5 years	1,315.6	1.00 (0.95-1.06)	0.86 (0.81-0.92)	0.46 (0.42-0.50)	0.45 (0.42-0.49)	0.42 (0.39-0.46)	0.24 (0.22-0.27)	0.22 (0.20-0.25)	0.20 (0.18-0.23)	0.11 (0.10-0.13)	0.02 (0.01-0.03)	0.41 (0.38-0.45)	0.81 (0.76-0.86)	964.7	0.68 (0.63-0.74)
5-7 years	944.1	1.24 (1.17-1.32)	0.92 (0.87-0.99)	0.45 (0.41-0.49)	0.38 (0.34-0.42)	0.55 (0.51-0.60)	0.25 (0.22-0.29)	0.35 (0.32-0.39)	0.27 (0.23-0.30)	0.15 (0.12-0.17)	0.02 (0.01-0.03)	0.44 (0.40-0.48)	1.49 (1.41-1.57)	616.5	0.97 (0.90-1.05)
7-10 years	842.2	1.61 (1.53-1.70)	0.72 (0.67-0.78)	0.57 (0.52-0.63)	0.40 (0.36-0.45)	0.65 (0.60-0.71)	0.26 (0.22-0.29)	0.59 (0.54-0.65)	0.38 (0.34-0.42)	0.16 (0.14-0.19)	0.02 (0.01-0.03)	0.42 (0.38-0.47)	1.78 (1.70-1.88)	401.3	1.31 (1.20-1.43)
10-13 years	327.9	2.30 (2.14-2.47)	0.40 (0.34-0.48)	0.63 (0.55-0.73)	0.42 (0.35-0.49)	0.91 (0.81-1.01)	0.19 (0.15-0.25)	0.83 (0.74-0.94)	0.73 (0.64-0.83)	0.22 (0.17-0.28)	0.02 (0.01-0.04)	0.26 (0.21-0.32)	1.69 (1.56-1.84)	23.6	2.03 (1.53-2.70)
13+ years*	53.9	2.54 (2.15-3.00)	0.39 (0.25-0.60)	0.80 (0.59-1.07)	0.35 (0.22-0.55)	0.80 (0.59-1.07)	0.26 (0.15-0.44)	0.95 (0.72-1.24)	1.08 (0.83-1.39)	0.44 (0.30-0.66)	0	0.24 (0.14-0.42)	1.45 (1.16-1.81)		

*Current maximum observed follow-up is 15.75 years.
**Rates likely to be underestimated: this reason not solicited in the early phase of the registry (ie revision report forms MDSv1/MDSv2).
***For primaries from 2008 onwards the majority of revision report forms were MDSv3/MDSv6 which explicitly gave this indication for revision as an option.
Note: Blank cells where there are no current data.

In Table 3.12 (on the previous page), the PTIRs for each indication are shown separately for different time periods from the primary hip replacement, within the first year, and between 1-3, 3-5, 5-7, 7-10, 10-13 and 13+ years after surgery (the maximum follow-up for any implant is now 15.75 years). The same overall time trends are seen as before: revision rates due to aseptic loosening and pain both increased with time from surgery, whereas the rates due to subluxation/ dislocation, infection, periprosthetic fracture, and malalignment were all higher in the first year and then fell. Adverse reaction to particulate debris increased with time, as did lysis, although the PTIRs for the latter was low.

Figure 3.12 (a) PTIR estimates of **aseptic loosening** by **fixation** and **bearing**.



Figures 3.12 (a) to 3.12 (g) show how PTIRs for aseptic loosening, pain, dislocation/subluxation, infection, lysis and adverse soft tissue reaction to particulate debris changed with time in an arbitrary selection of well-used bearing sub-groups from Table 3.11. Only sub-groups with a total overall prosthesis-years at risk of more than 150,000 have been included. With time from the operation, PTIRs for aseptic loosening and pain tended to rise in uncemented metal-on-metal primary total hip replacements and resurfacings. These trends were not seen in the other groups shown (Figures 3.12 (a) and (b)). Conversely, there was a high initial rate for dislocation/subluxation in all fixation/bearing groups which later fell (Figure 3.12 (c)). Revision rates for infection were initially high and then fell in all groups apart from uncemented metal-on-metal primary total hip replacement (Figure 3.12 (d)).

Revision rates due to an adverse reaction to particulate debris increased with time up to five years in uncemented metal-on-metal primary total hip replacement and resurfacings (Figures 3.12 (f) and (g)). Confidence Intervals have not been shown here for simplicity, but could be quite wide; these trends require more in-depth investigation.

Figure 3.12 (b) PTIR estimates of **pain** by **fixation** and **bearing**.

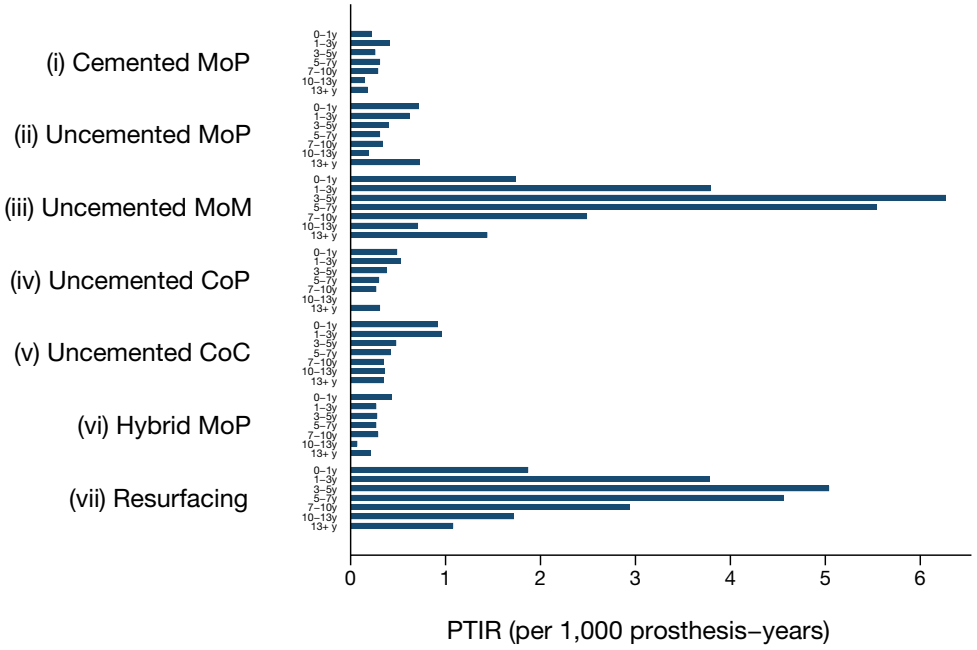


Figure 3.12 (c) PTIR estimates of **dislocation/subluxation** by **fixation** and **bearing**.

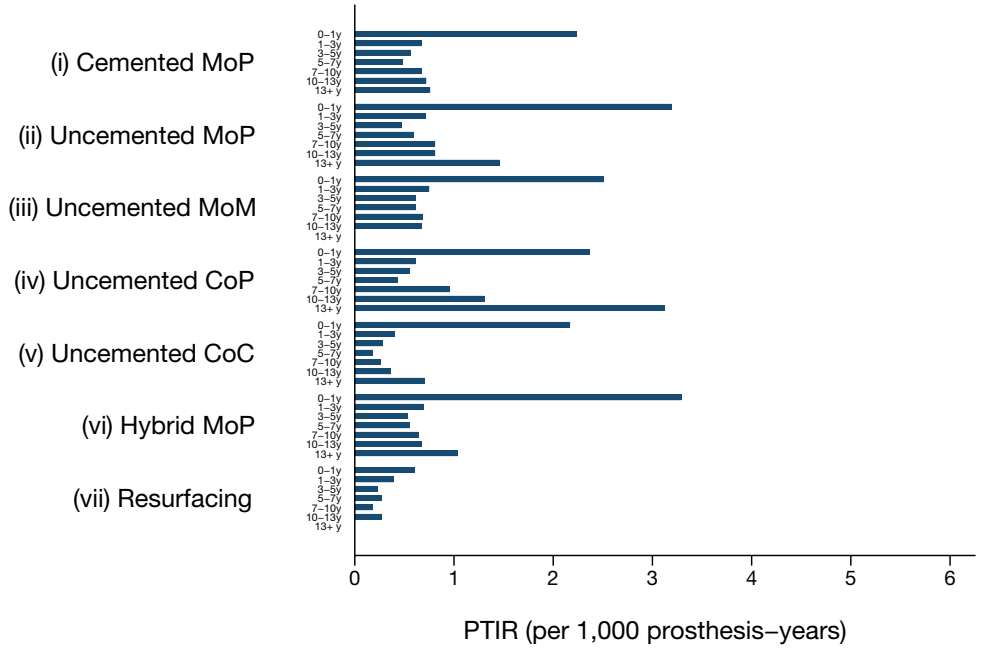


Figure 3.12 (d) PTIR estimates of infection by fixation and bearing.

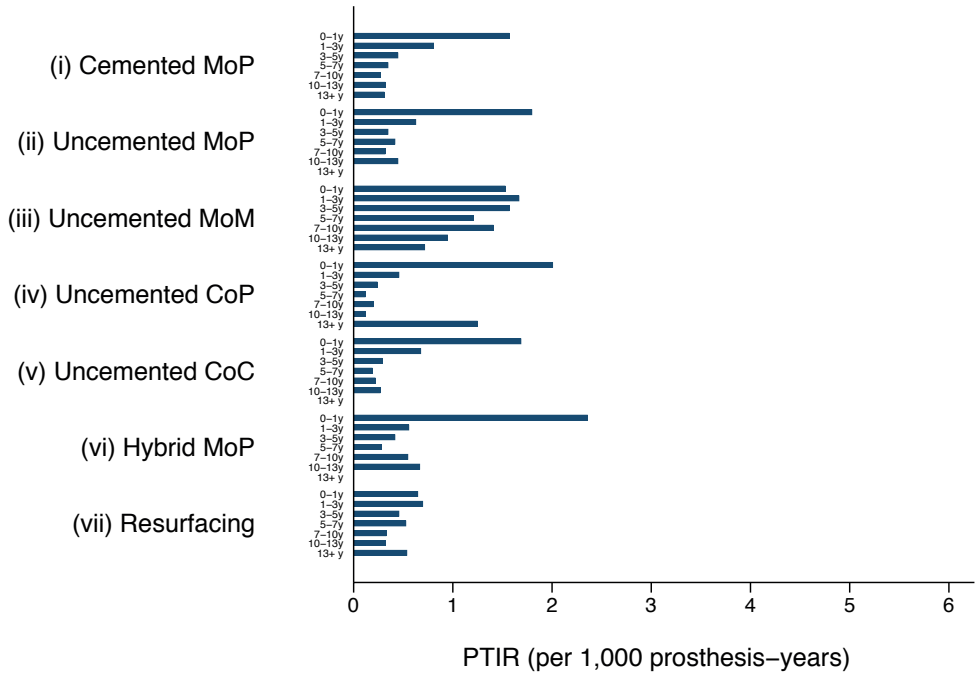


Figure 3.12 (e) PTIR estimates of lysis by fixation and bearing.

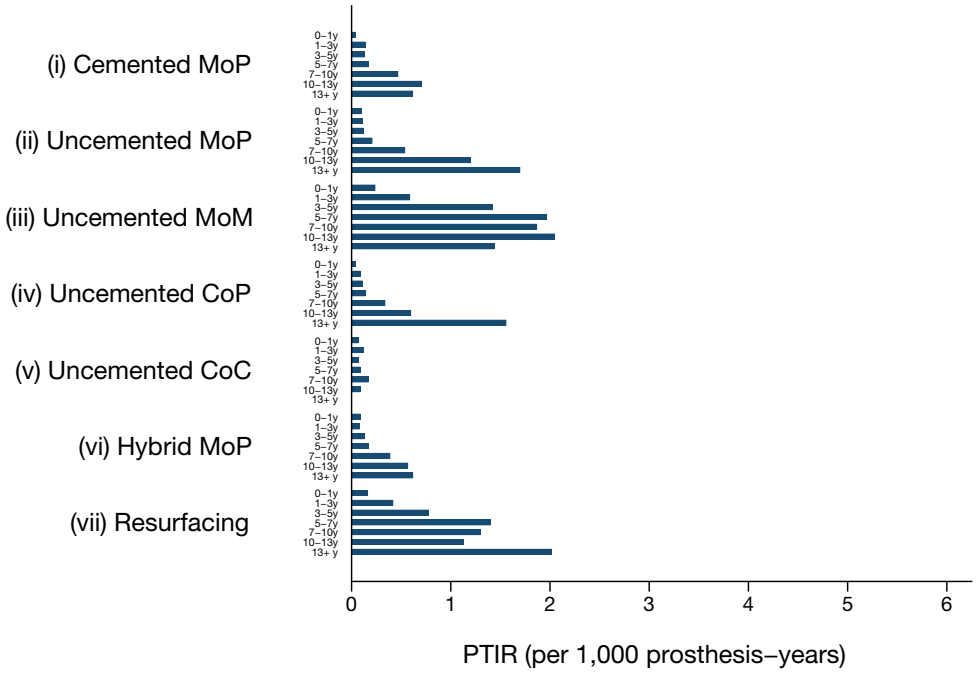


Figure 3.12 (f) PTIR estimates of **adverse soft tissue reaction** by **fixation** and **bearing**.

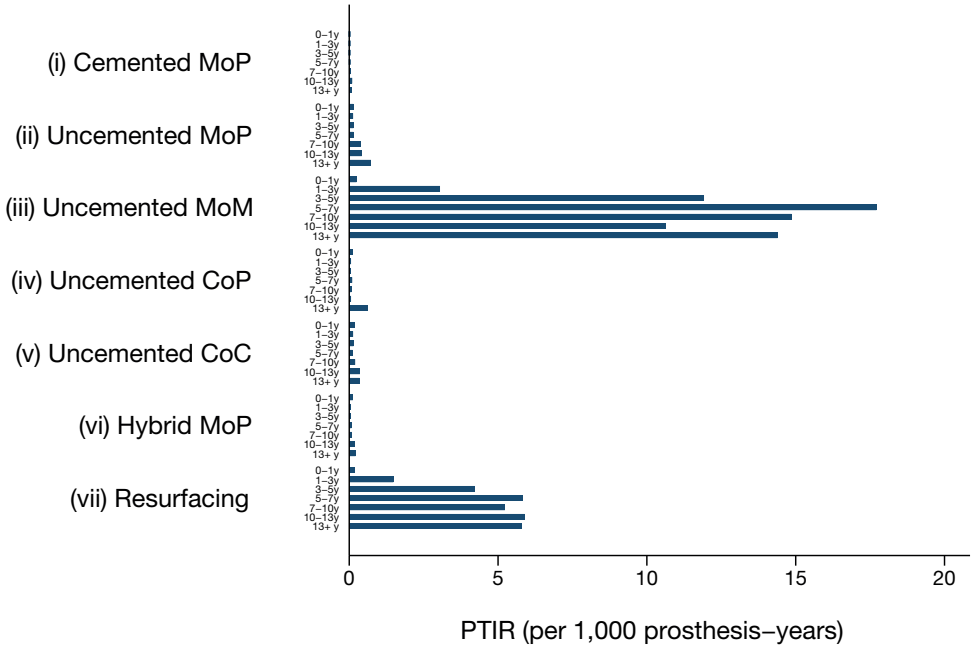
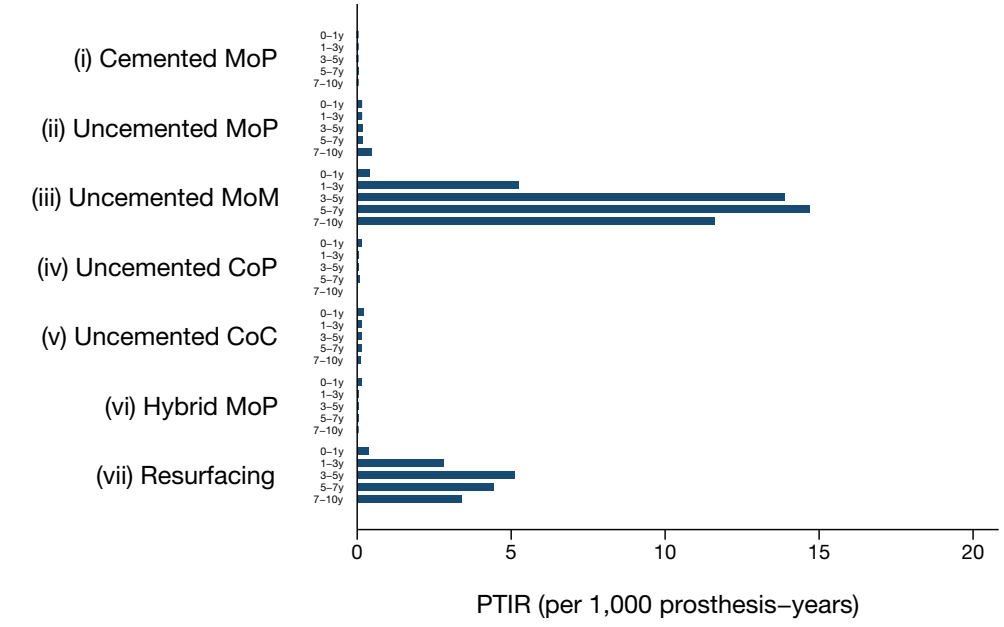


Figure 3.12 (g) PTIR estimates of **adverse soft tissue reaction** by **fixation** and **bearing**, since 2008.



3.3.6 Mortality after primary hip replacement surgery

This section describes the mortality of the cohort up to 15 years from primary hip replacement, according to gender and age group. Deaths were updated on 16 February 2019 using data from the NHS Personal Demographic Service. For simplicity, we do not take into account whether the patient had a first (or further) joint revision after the primary operation when calculating the cumulative probability of death (see Survival analysis methods note in section 3.2). Amongst the 1,091,892 primary hip replacements, there were 4,935 bilateral operations, with the left and right side operated on the same day; here the second of the two has been excluded, leaving 1,086,957 primary hip replacements, of whom 166,770 had died before the end of 2018.

Table 3.13 KM estimates of cumulative **mortality** (95% CI) by **age** and **gender**, in primary hip replacement.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

Age group (years)	n	Time since primary					
		30 days	90 days	1 year	5 years	10 years	15 years
All cases	1,086,957*	0.22 (0.21-0.23)	0.47 (0.46-0.48)	1.47 (1.44-1.49)	9.53 (9.46-9.59)	25.07 (24.95-25.20)	43.20 (42.88-43.52)
Males							
<55	64,627	0.07 (0.05-0.10)	0.16 (0.13-0.19)	0.51 (0.46-0.57)	2.26 (2.13-2.39)	5.07 (4.83-5.31)	9.60 (8.88-10.38)
55-59	44,425	0.06 (0.04-0.09)	0.20 (0.16-0.25)	0.63 (0.55-0.70)	3.31 (3.12-3.50)	8.51 (8.14-8.90)	16.94 (15.87-18.08)
60-64	62,695	0.12 (0.09-0.15)	0.25 (0.21-0.29)	0.84 (0.77-0.92)	4.74 (4.56-4.94)	12.30 (11.93-12.68)	23.74 (22.63-24.89)
65-69	75,141	0.16 (0.13-0.19)	0.36 (0.32-0.40)	1.12 (1.04-1.20)	6.81 (6.60-7.02)	18.65 (18.22-19.08)	38.32 (37.05-39.62)
70-74	75,660	0.21 (0.18-0.25)	0.45 (0.40-0.50)	1.62 (1.53-1.72)	10.56 (10.31-10.82)	29.01 (28.52-29.51)	56.35 (54.97-57.73)
75-79	61,956	0.40 (0.35-0.45)	0.76 (0.70-0.83)	2.50 (2.38-2.63)	16.82 (16.48-17.17)	46.08 (45.44-46.72)	*77.04 (75.39-78.65)*
80-84	36,075	0.79 (0.70-0.89)	1.47 (1.35-1.60)	4.14 (3.94-4.36)	26.80 (26.26-27.36)	66.43 (65.57-67.30)	*91.77 (90.27-93.11)*
85+	15,381	1.71 (1.51-1.92)	3.03 (2.77-3.31)	7.79 (7.36-8.23)	43.57 (42.61-44.54)	85.72 (84.69-86.72)	
Females							
<55	65,255	0.06 (0.05-0.08)	0.21 (0.17-0.24)	0.66 (0.60-0.73)	2.46 (2.33-2.60)	5.07 (4.84-5.32)	8.18 (7.58-8.83)
55-59	51,360	0.07 (0.05-0.10)	0.19 (0.15-0.23)	0.60 (0.53-0.67)	3.03 (2.86-3.20)	6.94 (6.63-7.26)	12.57 (11.72-13.48)
60-64	78,795	0.07 (0.05-0.09)	0.17 (0.15-0.20)	0.60 (0.54-0.65)	3.70 (3.55-3.85)	9.21 (8.92-9.51)	17.84 (16.98-18.74)
65-69	109,564	0.08 (0.06-0.10)	0.21 (0.19-0.24)	0.74 (0.69-0.79)	4.76 (4.62-4.91)	13.72 (13.41-14.03)	28.68 (27.73-29.66)
70-74	123,143	0.12 (0.10-0.14)	0.27 (0.24-0.30)	0.95 (0.89-1.01)	7.12 (6.95-7.29)	21.53 (21.17-21.90)	44.85 (43.78-45.93)
75-79	110,587	0.22 (0.20-0.25)	0.45 (0.41-0.49)	1.48 (1.41-1.56)	11.50 (11.28-11.73)	34.71 (34.26-35.16)	66.27 (65.10-67.43)
80-84	73,955	0.34 (0.30-0.39)	0.79 (0.73-0.86)	2.49 (2.38-2.61)	18.55 (18.22-18.88)	53.65 (53.06-54.24)	*85.09 (83.91-86.23)*
85+	38,338	0.83 (0.74-0.92)	1.77 (1.65-1.91)	4.85 (4.64-5.08)	32.38 (31.83-32.94)	74.77 (74.04-75.51)	*95.32 (94.19-96.30)*

*Some patients had operations on the left and right side on the same day. The second of 4,935 pairs of simultaneous bilateral operations were excluded.
Note: Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Table 3.13 shows Kaplan-Meier estimates of cumulative percentage mortality at 30 days, 90 days and at 1, 5, 10 and 15 years from the primary hip replacement, for all cases and by age and gender.

Note: These cases were not censored when further revision surgery was undertaken. Whilst such surgery may have contributed to the overall mortality, the impact of this is not investigated in this report.

3.3.7 Primary hip replacement for fractured neck of femur compared with other reasons for implantation

As total hip replacement is an increasingly popular treatment option for fractured neck of femur, this section further updates results from last year's annual report on revision and mortality rates for primary total hip replacements performed as a result of fractured neck of femur compared to cases implanted for other indications. A total of 35,249 (3.2%) of the primary total hip replacements were performed for a fractured neck of femur (#NOF)[2].

Table 3.14 shows that the proportion of primary hip replacements performed for an indication of fractured neck of femur has continued to increase with time to a maximum of 5.3% in 2018, up from 5.1% in 2017.

Table 3.14 Number and percentage fractured NOF in the NJR by year.

Year of primary	N (Primary total hip replacements for all indications)	N (#NOF) (%)
2003	14,590	143 (1.0)
2004	28,206	292 (1.0)
2005	40,719	391 (1.0)
2006	48,623	529 (1.1)
2007	60,997	781 (1.3)
2008	67,491	863 (1.3)
2009	68,582	1,082 (1.6)
2010	71,053	1,365 (1.9)
2011	74,028	1,712 (2.3)
2012	78,285	2,446 (3.1)
2013	80,400	3,126 (3.9)
2014	87,795	3,763 (4.3)
2015	89,802	4,218 (4.7)
2016	93,781	4,789 (5.1)
2017	94,666	4,799 (5.1)
2018	92,874	4,950 (5.3)
All years	1,091,892*	35,249 (3.2)

*Excludes 40 with no data.

[2] These comprised 2,232 cases with the indication for primary hip replacement including fractured neck of femur in the early phase of the registry (i.e. 201,669 implants entered using MDSv1 and v2) and 33,017 cases with reasons including acute trauma neck of femur in the later phase (i.e. 890,223 entered using MDSv3, v6 and v7). 40 cases were omitted as no indication for the primary hip replacement was given.

Table 3.15 Fractured **NOF** vs **OA only** by **gender**, **age** and **fixation**.

	Reason for primary hip replacement		
	Fractured neck of femur (n=35,249)	Osteoarthritis only (n=966,771)	Comparison
% Females	72.8%	59.2%	P<0.001 (Chi-squared test)
Median age (IQR)			
Both genders	73 (66-79)	70 (62-76)	P<0.001 (Mann-Whitney U-test)
Males only	72 (65-79)	68 (60-75)	P<0.001 (Mann-Whitney U-test)
Females only	73 (66-79)	71 (63-77)	P<0.001 (Mann-Whitney U-test)
% Hip type*			
Cemented	43.5	33.4	Overall P<0.001 (Chi-squared test)
Uncemented	21.1	39.3	
Hybrid	32.9	20.8	
Reverse hybrid	2.4	2.7	
Resurfacing	0.1	3.8	

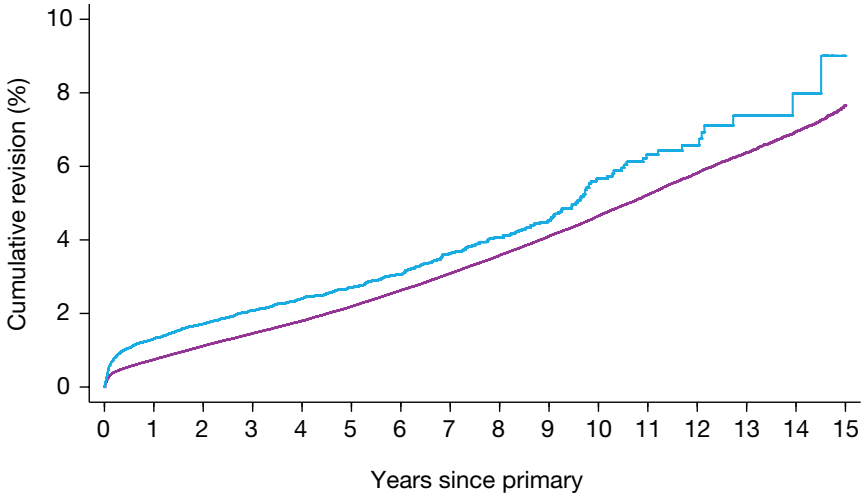
*Excludes 89,872 cases who had other reasons in addition to osteoarthritis.

Table 3.15 compares the #NOF group with the remainder with respect to gender and age composition together and type of hip replacement received. A significantly larger percentage of the #NOF cases, compared with the remainder, were women (72.8% versus 59.2%: P<0.001, Chi-squared test).

The #NOF cases were significantly older (median age 73 years versus 70 years at operation: P<0.001 by Mann-Whitney U-test). Cemented and hybrid hips were used more commonly in #NOF than in hip replacements performed for other indications. Figure 3.13 shows that the cumulative revision rate was higher in the #NOF group compared with the remainder (P<0.001, logrank test). This effect was not fully explained by differences in age and gender, as stratification by these variables left the result unchanged (P<0.001 using stratified logrank test: 14 sub-groups of age <55, 55-59, 60-64, 65-69, 70-74, 75-79, 80+ for each gender).

Figure 3.14 shows a markedly worse overall survival in the #NOF cases compared to cases implanted for other reasons (P<0.001, logrank test). As in the overall mortality section, the second of 4,617 simultaneous bilateral procedures were excluded. Gender/age differences did not fully explain the difference seen as a stratified analysis still showed a difference (P<0.001) but the results warrant further exploration.

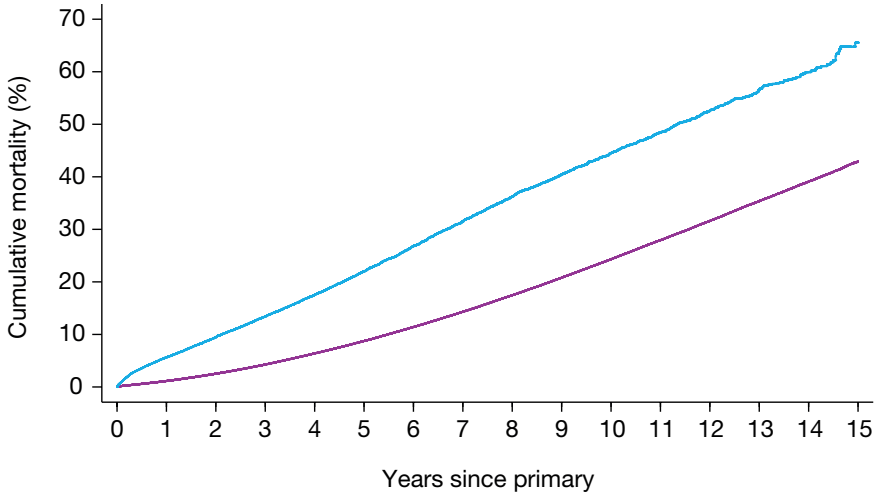
Figure 3.13 KM estimates of cumulative **revision** for **fractured NOF** and **OA only** cases for primary hip replacements.



Number at risk

Osteoarthritis only	966,771	869,683	774,746	681,090	591,246	504,793	426,136	351,918	283,998	222,079	166,549	117,072	75,766	45,032	21,743	6,813
Fractured neck of femur	35,249	28,166	22,589	17,397	13,062	9,402	6,597	4,510	3,179	2,177	1,442	943	537	294	144	37

Figure 3.14 KM estimates of cumulative **mortality** for **fractured NOF** and **OA only** in primary hip replacements.



Number at risk

Osteoarthritis only	962,521	872,080	779,644	687,690	599,123	513,754	436,016	362,328	294,576	232,427	175,657	124,073	80,580	47,958	23,134	7,252
Fractured neck of femur	35,225	28,500	22,953	17,740	13,356	9,657	6,806	4,689	3,320	2,303	1,547	1,025	585	324	157	40

3.3.8 Overview of hip revision procedures

This section looks at all hip revision procedures performed since the start of the registry, 1 April 2003, up to 31 December 2018, for all patients with valid patient identifiers (i.e. whose data could therefore be linked).

In total, there were 115,777 revisions on 99,915 individual patient-sides[3] (94,011 actual patients). In addition to the 31,410 revised primary hip replacements described in section 3.3.2 of this report, there were 68,505 revisions for which no primary hip replacement had been recorded in the NJR.

Revisions are classified as single stage, stage one and stage two of two-stage revisions. Information on stage one and stage two revisions are entered into the database separately, whereas stage one and stage two revisions in practice have to be linked. Although not all patients who undergo a stage one of two revision will undergo a stage two of two revision, in some cases stage one revisions have been entered without a stage two, and vice versa, making identification of individual revision episodes difficult. An attempt has been made to do this later in this section.

Table 3.16 Number and percentage of hip revisions by procedure type and year.

Year of revision surgery	Type of revision procedure			All procedures
	Single stage N(%)	Stage one of two-stage N(%)	Stage two of two-stage N(%)	
2003*	1,435 (100.0)	- - - -	- - - -	1,435
2004	2,460 (90.1)	117 (4.3)	154 (5.6)	2,731
2005	3,461 (87.2)	206 (5.2)	304 (7.7)	3,971
2006	4,214 (86.8)	268 (5.5)	373 (7.7)	4,855
2007	5,589 (87.4)	348 (5.4)	461 (7.2)	6,398
2008	6,061 (86.2)	421 (6.0)	550 (7.8)	7,032
2009	6,339 (84.4)	520 (6.9)	656 (8.7)	7,515
2010	7,087 (86.6)	500 (6.1)	592 (7.2)	8,179
2011	8,008 (87.5)	531 (5.8)	609 (6.7)	9,148
2012	9,262 (88.1)	599 (5.7)	650 (6.2)	10,511
2013	8,564 (87.8)	568 (5.8)	624 (6.4)	9,756
2014	8,423 (87.0)	664 (6.9)	593 (6.1)	9,680
2015	8,036 (86.1)	707 (7.6)	595 (6.4)	9,338
2016	7,666 (87.3)	577 (6.6)	534 (6.1)	8,777
2017	7,473 (87.3)	581 (6.8)	508 (5.9)	8,562
2018	6,934 (87.9)	510 (6.5)	445 (5.6)	7,889
All years	101,012 (87.2)	7,117 (6.1)	7,648 (6.6)	115,777

*Incomplete year.
Note: MDSv1, in use in 2003, only defined operations as primary or revision. All revisions using MDSv1 have been listed as single stage revisions in this table. Single stages include DAIRs (debridement and implant retention) and hip excision arthroplasty.

[3] For 80 patient-sides, multiple procedures had been entered on the same operation date. Details of the components that had been entered for these cases were reviewed. As a result of this, 132 of the 160 revision procedures have been dropped and 22 have been reclassified.

Table 3.16 gives an overview of all hip replacement revision procedures carried out each year since April 2003. There were a maximum number of ten documented revision procedures associated with any individual patient side (making up nine revision episodes as one episode consisted of a stage one of a two-stage procedure and a stage two of a two-stage procedure).

The incidence of revision hip replacement peaked in 2012 and has steadily declined since then, despite the increasing number of at-risk implants prevailing in the database.

Table 3.17 (a) Number and percentage of hip revision by indication and procedure type.

Reason	Type of revision procedure		
	Single stage N(%) (n=101,012)	Stage one of two-stage N(%) (n=7,117)	Stage two of two-stage N(%) (n=7,648)
Aseptic loosening	48,608 (48.1)	876 (12.3)	891 (11.7)
Pain	18,100 (17.9)	814 (11.4)	627 (8.2)
Dislocation/subluxation	16,091 (15.9)	291 (4.1)	264 (3.5)
Lysis	15,062 (14.9)	657 (9.2)	445 (5.8)
Implant wear	14,098 (14.0)	307 (4.3)	229 (3.0)
Periprosthetic fracture	11,077 (11.0)	278 (3.9)	307 (4.0)
Other indication	7,326 (7.3)	245 (3.4)	599 (7.8)
Malalignment	5,526 (5.5)	100 (1.4)	65 (0.8)
Infection	4,500 (4.5)	5,789 (81.3)	5,634 (73.7)
Implant fracture	3,626 (3.6)	73 (1.0)	88 (1.2)
Head-socket size mismatch	723 (0.7)	20 (0.3)	14 (0.2)
Adverse reaction to particulate debris*	8,623 (11.0) n= 78,320	194 (3.4) n=5,759	142 (2.4) n=5,990

*Not recorded in the early phase of the registry; MDSv3, v6 and v7 only.

Table 3.17 (b) Number and percentage of hip revision by indication and procedure type in last five years.

Reason	Type of revision procedure		
	Single stage N(%) (n=38,550)	Stage one of two-stage N(%) (n=3,039)	Stage two of two-stage N(%) (n=2,675)
Aseptic loosening	15,596 (40.5)	251 (8.3)	198 (7.4)
Dislocation/subluxation	6,699 (17.4)	125 (4.1)	85 (3.2)
Periprosthetic fracture	5,637 (14.6)	140 (4.6)	118 (4.4)
Implant wear	5,364 (13.9)	158 (5.2)	85 (3.2)
Lysis	5,050 (13.1)	230 (7.6)	111 (4.1)
Adverse reaction to particulate debris	4,784 (12.4)	122 (4.0)	78 (2.9)
Pain	3,192 (8.3)	144 (4.7)	73 (2.7)
Infection	2,366 (6.1)	2,542 (83.6)	2,099 (78.5)
Other indication	2,231 (5.8)	87 (2.9)	180 (6.7)
Malalignment	1,897 (4.9)	34 (1.1)	17 (0.6)
Implant fracture	1,452 (3.8)	21 (0.7)	19 (0.7)
Head-socket size mismatch	196 (0.5)	5 (0.2)	3 (0.1)

Table 3.17 (a) (on the previous page) shows the stated indication for the revision hip replacement surgery. Please note that, as several reasons can be stated, the reasons are not mutually exclusive and therefore column percentages may not add up to 100%. Aseptic loosening is the most common indication for revision.

Table 3.17 (b) shows the stated indication for the revision hip replacement surgery performed in the last five years (1,826 days). The most notable difference, between all the data and that recorded in the last five years is surgeons citing “pain” as a reason for revision, falling from 17.9% to 8.3% of single stage revisions. The ratio of stage two of two-stage, stage one of two-stage and single stage revisions overall (1:0.93:13.2) is different compared to those performed in the last five years (1:1.13:14.4).

3.3.9 Rates of hip re-revision

In most instances (91.5% of 99,915 individual patient-sides), the first revision procedure was a single stage revision, however in the remaining 8.5% it was part of a two-stage procedure. For a given patient-side, we have looked at the survival following the first documented revision hip replacement procedure for those with a linked primary in the NJR (n=31,410). We have looked at the time from the first documented revision procedure (of any type) to the time at which a second revision episode was undertaken. For this purpose, we regarded an initial stage one followed by either a stage one or a stage two as being the same revision episode and these were disregarded, looking instead for the start of a second revision episode. (We counted the maximum number of distinct revision episodes for any patient-side to be nine).

Kaplan-Meier estimates of the cumulative percentage probability of having a subsequent revision (re-revision) were calculated. There were 9,743 re-revisions and, for 22,482 cases, the patient died without having been revised. The censoring date for the remainder was the end of 2018.

Figure 3.15 (a) KM estimates of cumulative **re-revision** in linked primary hip replacements (shaded area indicate point-wise 95% CI).

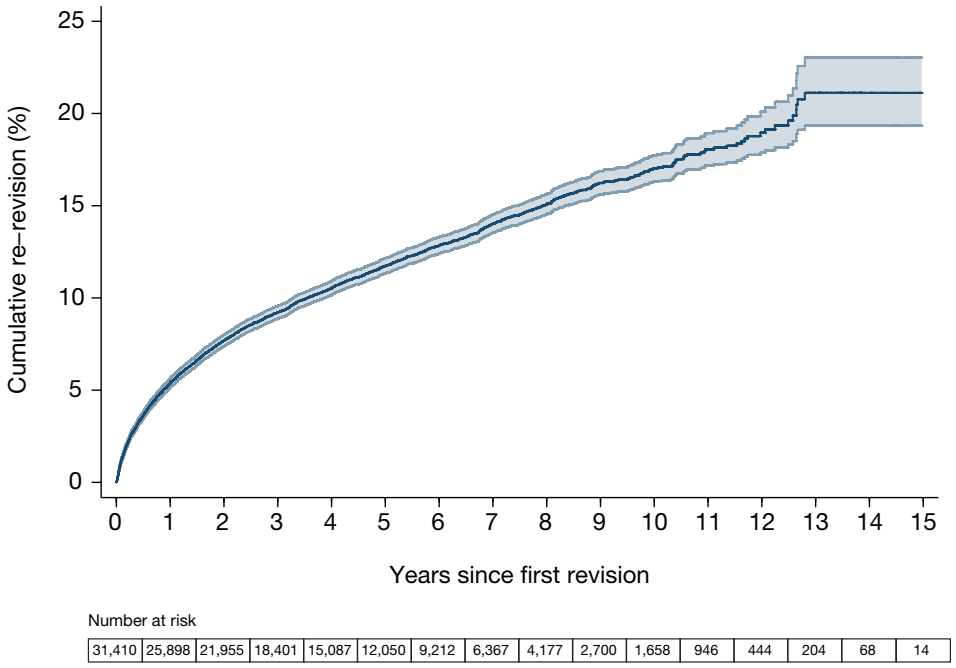
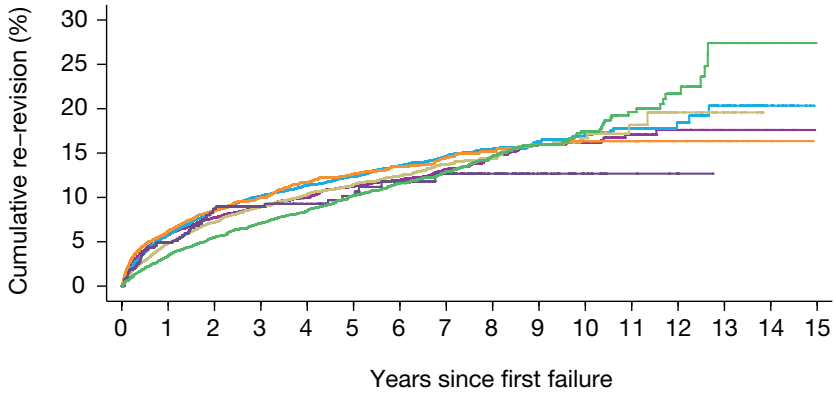


Figure 3.15 (a) plots Kaplan-Meier estimates of the cumulative probability of a subsequent revision between 1 and 15 years since the primary operation.

Figure 3.15 (b) KM estimates of cumulative **re-revision** by **primary fixation** in linked primary hip replacements.

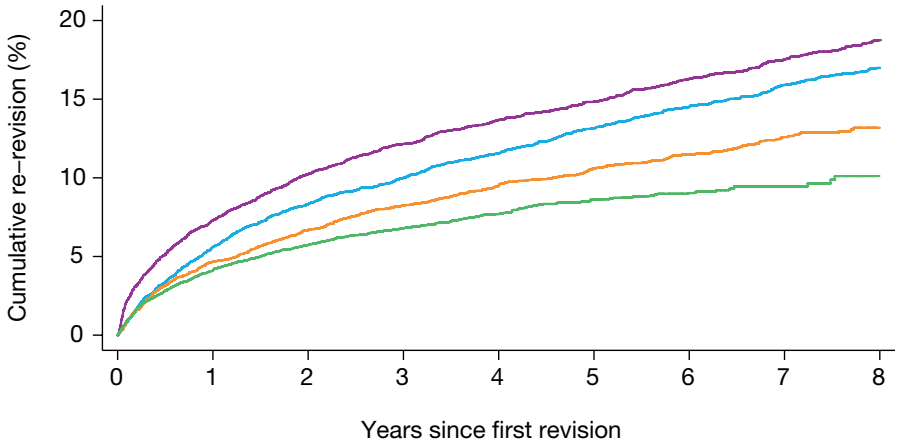


Number at risk

Cemented	6,938	5,427	4,390	3,546	2,811	2,166	1,661	1,182	828	550	361	221	110	46	19	2
Uncemented without MoM	8,970	7,292	6,080	4,997	3,951	3,054	2,296	1,600	1,110	728	435	249	123	58	18	4
Uncemented MoM	5,038	4,437	3,996	3,508	3,007	2,461	1,806	1,102	576	324	173	77	23	11	1	1
Hybrid	4,348	3,369	2,702	2,115	1,622	1,241	956	690	472	301	184	113	59	30	11	3
Reverse hybrid	611	473	373	305	242	180	129	89	57	32	13	5	2	0	0	0
Resurfacing	4,214	3,806	3,451	3,088	2,761	2,367	1,905	1,349	899	595	390	220	100	46	12	4

Figure 3.15 (b) shows estimates of re-revision by type of primary hip replacement. Resurfacing has the lowest re-revision rate until approximately seven years after which the revision rate appears to be worse than that associated with alternatives. However, after ten years the numbers at risk are low and should therefore be interpreted with caution.

Figure 3.15 (c) KM estimates of cumulative **re-revision** by **years to first revision**, in linked primary hip replacements.

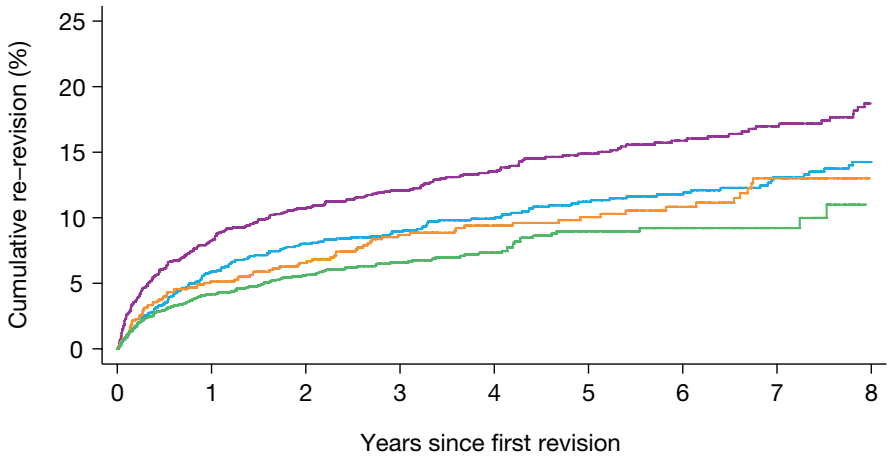


Number at risk

First rev. <1y	8,541	6,969	5,933	5,041	4,163	3,427	2,810	2,235	1,721
First rev. 1–3y	6,459	5,586	4,905	4,334	3,734	3,216	2,712	2,148	1,538
First rev. 3–5y	5,004	4,394	3,949	3,538	3,127	2,694	2,096	1,332	688
First rev. 5+y	11,406	8,949	7,168	5,488	4,063	2,713	1,594	652	230

Figure 3.15 (c) shows the relationship between time to first revision and the risk of subsequent revision. The earlier the primary hip replacement is revised, the higher the risk of a second revision. There is a relationship between the indication for first revision and time to first revision; earlier in this report (section 3.3.5) we showed, for example, that revisions for dislocation/subluxation and pain were more prevalent in the early period after the primary hip replacement and aseptic loosening and pain later on. The relationship between (i) the time to first revision and the subsequent time to re-revision, and (ii) the indication for the first revision and the time to re-revision require further investigation.

Figure 3.16 (a) KM estimates of cumulative **re-revision** in **cemented** primary hip replacement by **years to first revision**, in linked primary hip replacements.

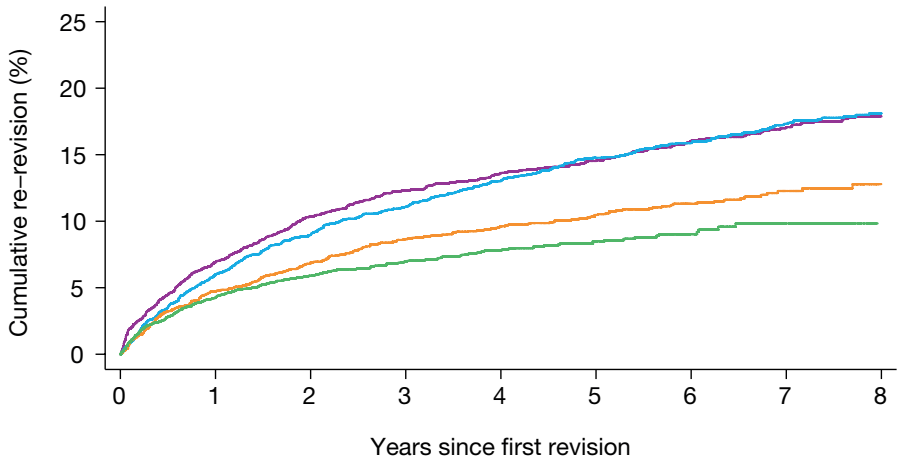


Number at risk

First rev. <1y	1,844	1,450	1,202	997	813	655	527	402	294
First rev. 1–3y	1,592	1,323	1,139	993	826	670	555	423	322
First rev. 3–5y	985	800	672	554	468	386	297	217	151
First rev. 5+y	2,517	1,854	1,377	1,002	704	455	282	140	61

For those with a documented primary hip replacement within the NJR, Figures 3.16 (a) to (e) show cumulative re-revision rates following the first revision hip replacement, according to the main fixation used in the primary. Each sub-group has been further sub-divided according to the time interval from the primary hip replacement to the first revision, i.e. less than 1 year, 1 to 3, 3 to 5 and more than 5 years. For cemented, uncemented, hybrid, reverse hybrid and resurfacing hip replacements, those who had their first revision within one year of the initial primary hip replacement, experienced the worst re-revision rates.

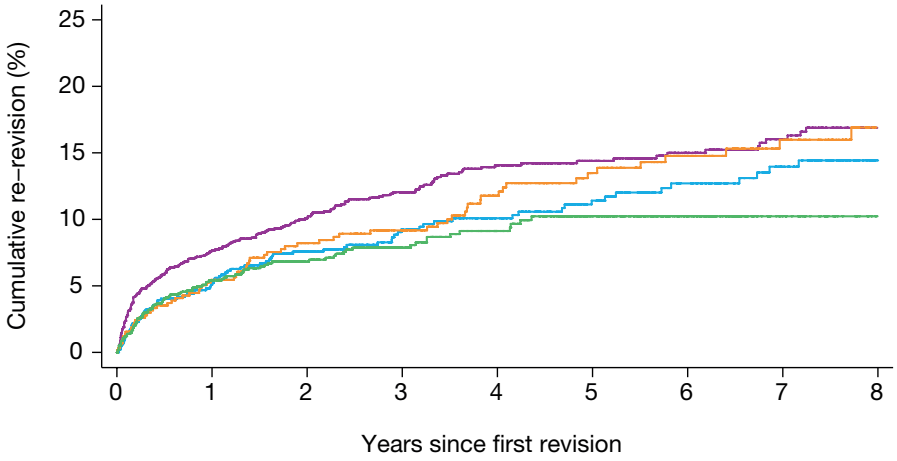
Figure 3.16 (b) KM estimates of cumulative **re-revision** in **uncemented** primary hip replacement by **years to first revision**, in linked primary hip replacements.



Number at risk

First rev. <1y	3,910	3,264	2,828	2,435	2,028	1,660	1,332	1,027	774
First rev. 1–3y	2,906	2,556	2,271	2,022	1,741	1,499	1,246	966	659
First rev. 3–5y	2,321	2,072	1,885	1,696	1,498	1,289	967	527	209
First rev. 5+y	4,871	3,837	3,092	2,352	1,691	1,067	557	182	44

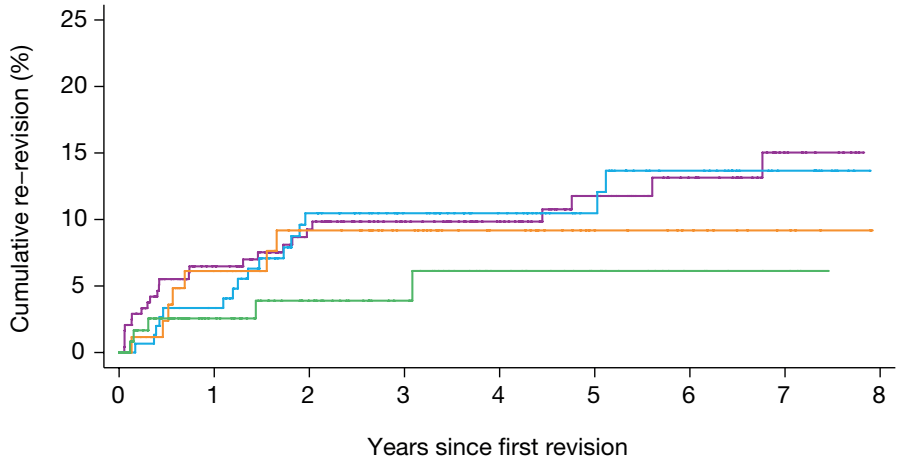
Figure 3.16 (c) KM estimates of cumulative **re-revision** in **hybrid** primary hip replacement by **years to first revision**, in linked primary hip replacements.



Number at risk

First rev. <1y	1,703	1,313	1,048	823	609	472	381	300	219
First rev. 1–3y	893	721	581	460	376	305	244	190	138
First rev. 3–5y	584	477	400	350	283	220	171	126	78
First rev. 5+y	1,168	858	673	482	354	244	160	74	37

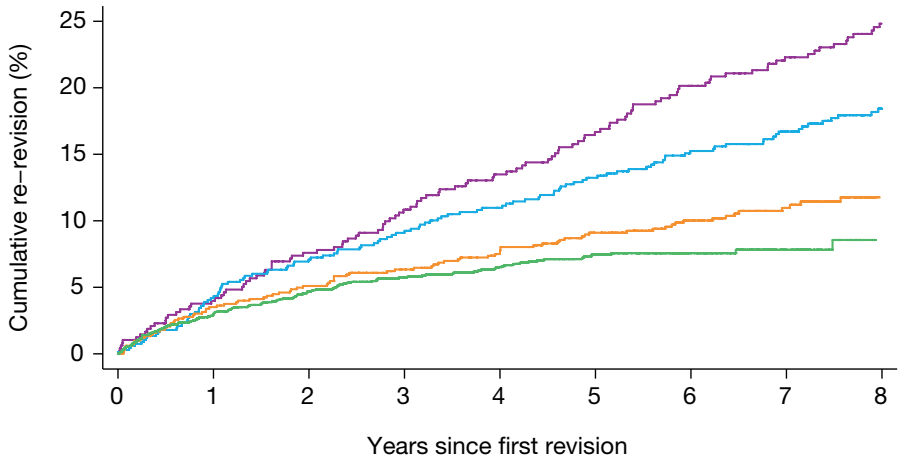
Figure 3.16 (d) KM estimates of cumulative **re-revision** in **reverse hybrid** primary hip replacement by **years to first revision**, in linked primary hip replacements.



Number at risk

First rev. <1y	243	187	155	130	111	84	58	40	29
First rev. 1–3y	153	136	103	86	69	56	45	33	21
First rev. 3–5y	87	71	56	46	35	22	17	11	6
First rev. 5+y	130	81	61	45	29	20	11	7	3

Figure 3.16 (e) KM estimates of cumulative **re-revision** in **resurfacing** primary hip replacement by **years to first revision**, in linked primary hip replacements.



Number at risk

First rev. <1y	480	455	431	410	384	362	343	318	291
First rev. 1–3y	673	634	608	585	555	533	493	433	324
First rev. 3–5y	830	793	772	737	706	657	554	388	215
First rev. 5+y	2,231	1,924	1,640	1,356	1,116	815	515	210	69

Table 3.18 (a) shows the re-revision rate of the 31,410 primary hip replacements registered in the NJR that were revised. Of these, 3,365 were re-revised. Table 3.18 (b) shows that primary hip replacements that fail within the first year after surgery have approximately twice the chance of needing re-revision at each time point compared with primaries that last more than five years.

Table 3.18 (a) KM estimates of cumulative **re-revision** (95% CI).
Blue italics signify that fewer than 250 cases remained at risk at these time points.

	Number of first revised joints at risk of re-revision	Time since first revision					
		1 year	3 years	5 years	10 years	13 years	15 years
Primary recorded in the NJR	31,410	5.40 (5.15-5.66)	9.22 (8.88-9.57)	11.74 (11.34-12.16)	17.00 (16.29-17.74)	*21.12 (19.34-23.03)*	*21.12 (19.34-23.03)*

Table 3.18 (b) KM estimates of cumulative **re-revision** (95% CI) by **years since first failure**.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

Primary in the NJR where the first revision took place:	Number of first revised joints at risk of re-revision	Time since first revision				
		1 year	3 years	5 years	7 years	10 years
<1 year after primary	8,541	7.31 (6.76-7.89)	12.15 (11.43-12.92)	14.85 (14.02-15.72)	17.55 (16.58-18.56)	20.85 (19.62-22.14)
1-3 years after primary	6,459	5.61 (5.07-6.21)	9.99 (9.25-10.79)	13.16 (12.28-14.10)	15.90 (14.88-16.98)	18.75 (17.48-20.12)
3-5 years after primary	5,004	4.68 (4.12-5.31)	8.25 (7.48-9.09)	10.60 (9.71-11.57)	12.59 (11.55-13.72)	*14.66 (13.12-16.36)*
5+ years after primary	11,406	4.14 (3.77-4.54)	6.81 (6.31-7.34)	8.61 (7.99-9.28)	9.46 (8.72-10.26)	

Note: Maximum interval was 15.1 years. Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Table 3.18 (c) KM estimates of cumulative **re-revision** (95% CI) by **fixation** and **bearing**.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

Fixation	Bearing surface	n	Time since first revision				
			1 year	3 years	5 years	7 years	10 years
All	All	31,410	5.40 (5.15-5.66)	9.22 (8.88-9.57)	11.74 (11.34-12.16)	14.02 (13.54-14.53)	17.00 (16.29-17.74)
All cemented	All	6,938	5.83 (5.28-6.43)	8.95 (8.24-9.72)	11.26 (10.40-12.19)	13.15 (12.11-14.27)	16.18 (14.71-17.79)
	MoP	6,307	5.79 (5.22-6.42)	8.75 (8.02-9.55)	10.87 (9.99-11.82)	12.88 (11.79-14.05)	15.72 (14.20-17.38)
All uncemented	All	14,008	5.47 (5.10-5.87)	9.70 (9.19-10.24)	12.06 (11.46-12.69)	14.32 (13.60-15.08)	16.91 (15.85-18.04)
	MoP	3,910	5.74 (5.03-6.54)	9.83 (8.86-10.91)	11.59 (10.48-12.81)	14.50 (13.07-16.08)	*17.06 (15.02-19.35)*
	MoM	5,038	4.79 (4.23-5.43)	8.96 (8.17-9.82)	11.46 (10.53-12.46)	13.68 (12.58-14.87)	*16.68 (14.88-18.67)*
	CoP	1,632	6.34 (5.22-7.69)	11.46 (9.85-13.32)	13.49 (11.62-15.63)	*14.74 (12.64-17.16)*	*16.20 (13.65-19.18)*
	CoC	3,266	5.64 (4.89-6.51)	9.60 (8.58-10.74)	12.26 (11.04-13.61)	14.32 (12.87-15.93)	*16.99 (14.90-19.34)*
All hybrid	All	4,348	6.26 (5.55-7.05)	9.99 (9.05-11.02)	12.66 (11.52-13.92)	14.46 (13.10-15.96)	*16.35 (14.58-18.32)*
	MoP	2,633	6.65 (5.74-7.71)	9.99 (8.80-11.32)	12.36 (10.94-13.96)	13.57 (11.96-15.38)	*14.86 (12.95-17.02)*
Resurfacing	All	4,214	3.42 (2.91-4.02)	7.10 (6.33-7.95)	10.21 (9.25-11.26)	12.90 (11.75-14.15)	17.46 (15.71-19.39)
Unsure	All	1,289	6.31 (5.08-7.81)	9.65 (8.08-11.50)	12.37 (10.52-14.53)	15.61 (13.35-18.22)	*18.04 (15.17-21.38)*

*Note: Maximum interval was 12.8 years.

Table 3.18 (c) shows cumulative re-revision rates at 1, 3, 5, 7 and 10 years following the first revision for those with documented primary hip replacements within the NJR, broken down by fixation types and bearing surfaces.

The failure rates for resurfacings were comparatively low, but Figure 3.15 (b) on page 98 shows that after ten years the failure rate of re-revisions following resurfacing is becoming higher than alternatives.

3.3.10 Reasons for hip re-revision

Tables 3.19 (a) and (b) show a breakdown of the stated indications for the first revision and for any second revision (note the indications are not mutually exclusive). Table 3.19 (a) shows the indications for recorded revisions in the NJR and Table 3.19 (b) reports the indications for the first linked revision and the number and percentage of first linked revisions that were subsequently revised. The final column in Table 3.19 (b) reports the indications for all the second linked revisions i.e. 3,015 linked second revisions recorded aseptic loosening as an indication. It is interesting to note that both dislocation and infection are much more common indications for a second revision than first revision. This shows the increased risk of instability and infection following the first revision of a hip replacement compared to that of primary hip replacement.

Table 3.19 (a) Number of failures by indication for all revisions.

Reason for revision	All recorded revisions (%)
Aseptic loosening	50,375 (43.5)
Pain	19,541 (16.9)
Lysis	16,164 (14.0)
Implant wear	14,634 (12.6)
Dislocation/subluxation	16,646 (14.4)
Infection	15,923 (13.8)
Periprosthetic fracture	11,662 (10.1)
Malalignment	5,691 (4.9)
Implant fracture	3,787 (3.3)
Head/socket size mismatch	757 (0.7)
Other indication	8,170 (7.1)
Adverse reaction to particulate debris*	9,477 (8.2)

*Adverse reaction to particulate debris was only recorded using MDSv3 onwards and as such was only a potential reason for revision among a total of 95,209 revisions as opposed to 115,777 revisions for the other reasons.

Table 3.19 (b) Number of failures by indication for first linked revision and second linked re-revision.

	First linked revision		Second linked revision
Reason for revision	N	Subsequently re-revised, N(%)	N
Aseptic loosening	46,547	4,202 (9.0)	3,015
Pain	17,859	1,802 (10.1)	1,228
Lysis	15,097	1,320 (8.7)	731
Implant wear	13,774	1,169 (8.5)	634
Dislocation/subluxation	13,608	1,404 (10.3)	2,338
Infection	9,814	1,372 (14.0)	2,127
Periprosthetic fracture	10,339	944 (9.1)	1,042
Malalignment	5,138	479 (9.3)	454
Implant fracture	3,329	323 (9.7)	366
Head/socket size mismatch	682	83 (12.2)	57
Other indication	7,149	782 (10.9)	630
Adverse reaction to particulate debris*	8,289	693 (8.4)	532

*Adverse reaction to particulate debris was only recorded using MDSv3 onwards and as such was only a potential reason for revision among a total of 95,209 revisions as opposed to 115,777 revisions for the other reasons.

Tables 3.20 (a) and (b) show that the numbers of revisions and the relative proportion of revisions with a linked primary in the NJR increased with time. Approximately 50% of revisions performed in 2018 had a linked primary in the NJR. This is likely to reflect improved data capture over time, improved linkability of records and the longevity of hip replacements with a proportion of primaries being revised being performed before NJR data capture began or outside the coverage of the NJR.

Table 3.20 (a) Number of re-revisions by year.

Year of first revision in the NJR*	Number of first revisions	Number of first revisions (%) with the associated primary recorded in the NJR
2003	1,411	44 (3.1)
2004	2,641	143 (5.4)
2005	3,753	306 (8.2)
2006	4,499	462 (10.3)
2007	5,893	826 (14.0)
2008	6,333	1,158 (18.3)
2009	6,578	1,516 (23.0)
2010	7,105	1,952 (27.5)
2011	7,971	2,652 (33.3)
2012	9,038	3,337 (36.9)
2013	8,255	3,045 (36.9)
2014	8,101	3,092 (38.2)
2015	7,675	3,227 (42.0)
2016	7,219	3,180 (44.1)
2017	6,990	3,217 (46.0)
2018	6,453	3,253 (50.4)
Total	99,915	31,410 (31.4)

*First documented revision in the NJR.

Table 3.20 (b) Number of re-revisions by year, stage, and whether or not primary is in the NJR.

Year of first revision in the NJR*	Single stage		First documented stage of two-stage	
	Primary not in the NJR	Primary in the NJR	Primary not in the NJR	Primary in the NJR
2003	1,367	44	0	0
2004	2,289	124	209	19
2005	3,117	250	330	56
2006	3,658	375	379	87
2007	4,620	691	447	135
2008	4,705	955	470	203
2009	4,585	1,253	477	263
2010	4,742	1,722	411	230
2011	4,927	2,384	392	268
2012	5,325	3,010	376	327
2013	4,890	2,746	320	299
2014	4,661	2,796	348	296
2015	4,133	2,905	315	322
2016	3,800	2,903	239	277
2017	3,537	2,948	236	269
2018	2,986	3,010	214	243
All years	63,342	28,116	5,163	3,294

*First documented revision in the NJR.

3.3.11 90-day mortality after hip revision

The overall cumulative percentage mortality at 90 days after hip revision was lower in the cases with their primary hip replacement recorded in the NJR compared with the remainder (Kaplan-Meier estimates 1.20 (95% CI 1.09-1.33) versus 1.76 (1.67-1.87)), which may reflect the fact that this patient group were younger at the time of their first revision, median age of 69 (IQR 60-76) years compared to the group without primaries documented in the NJR who had a median age of 74 (IQR 65-80) years. The percentage of males was similar in both groups (44.0% versus 42.3% respectively).

3.3.12 Conclusions

As in previous annual reports, we have analysed implants by revision of the construct, rather than revision of a single component, as the mechanisms of failure (such as wear, adverse reaction to particulate debris and dislocation) are interdependent between different parts of the construct. We have also stratified revision by age and gender. The highest failure rates are among young women and the lowest among older women. When data on metal-on-metal is excluded, young women have similar revision rates to young men. Once again we must emphasise that implant survivorship is only one measure of success and cannot be used as an indication of satisfaction, relief of pain, improvement in function and greater

participation in society. The data clearly show that constructs fail at different rates depending on the age and gender of the recipients.

Overall the number of primary hip replacements recorded annually in the NJR continues to increase with 1,095,754 now recorded, of which 1,091,892 were available for analysis.

Since 2003 the types of implants utilised have changed dramatically and these changes continue. Between 2003 and 2007 cemented fixation was the most common, followed by uncemented fixation. Between 2008 and 2016 uncemented fixation was the most common followed by cemented fixation, with hybrid fixation increasing steadily since 2012.

As in 2017, hybrid fixation (31.2%) was more common in 2018 than cemented fixation (27.3%). Since 2011, the use of ceramic-on-ceramic bearings has declined whilst the use of ceramic-on-polyethylene bearings has increased at roughly the same rate, with ceramic-on-polyethylene bearings now being the second most commonly chosen bearing after metal-on-polyethylene.

Since the 12th Annual Report in 2015, we have presented data by age and gender comparing combinations of fixation and bearing. This assists clinicians and patients in choosing classes of prostheses that are the most appropriate for particular types of patients. For example, in males under 55 years of age, at ten years post-surgery, hybrid ceramic-on-polyethylene and ceramic-on-ceramic constructs have revision rates of less than 4%, whilst cemented metal-on-polyethylene constructs have revision rates of 6.29% (95% CI 4.99-7.92) and uncemented ceramic-on-ceramic bearings 4.64% (95% CI 4.22-5.11). In contrast, in women under 55 years, cemented ceramic-on-polyethylene constructs give excellent results with a 4.24% (95% CI 3.23-5.56) revision rate at ten years. However, cemented metal-on-polyethylene has a higher revision rate, whilst results with uncemented constructs with metal-on-polyethylene, ceramic-on-polyethylene and ceramic-on-ceramic are not statistically different from those achieved by cemented ceramic-on-polyethylene. For patients over 75 years old, all combinations except those with metal-on-metal bearings have good outcomes, with cemented and hybrid ceramic-on-polyethylene possibly having the lowest failure rates.

Both male and female patients aged over 75 years have a less than 5% risk of revision at 13 years. The 15-year mortality rate in men aged 75-79 years is 77.04% (95% CI 75.39-78.65) and in women aged 75-79 years is 66.27% (95% CI 65.10-67.43). This clearly shows that in older patients the vast majority of treatment strategies will last the rest of the patients' lives. Even in those aged 65 to 69 years at the time of surgery, 62% of males and 71% of females are still alive 15 years later.

We have examined head sizes (bearing diameters) with different fixation and bearing types and again these results are interesting. With metal-on-polyethylene and ceramic-on-polyethylene, large head sizes appear to be associated with higher failure rates particularly with 36mm heads used with cemented fixation and heads >36mm used with hybrid and uncemented fixation. Ceramic-on-ceramic bearings have lower failure rates with larger bearings as predicted by Alison Smith's flexible parametric survival models published in the Lancet in 2012[4].

With regard to specific branded stem/cup combinations, some of the best implant survivorships are still achieved by "mix and match" cemented hard-on-soft bearing constructs, although this practice remains contrary to MHRA and manufacturers' guidelines for usage.

It is encouraging that the most commonly used constructs by brand in cemented and hybrid fixation have good results. This does not hold true for uncemented fixation, but further breakdown by bearing type for commonly used uncemented implants shows that results are acceptable if metal-on-metal bearings are excluded.

[4] Smith AJ, Dieppe P, Vernon K, Porter M, Blom AW; National Joint Registry of England and Wales. Failure rates of stemmed metal-on-metal hip replacements: analysis of data from the National Joint Registry of England and Wales. Lancet. 2012 Mar 31;379(9822):1199-204.

Metal-on-metal stemmed and resurfacing implants continue to fail at higher than expected rates and their use is now extremely rare. The best performing brand of resurfacing has a failure rate of 9.91% (95% CI 8.47-11.58) at thirteen years. The use of metal-on-metal bearings has undoubtedly led to a large excess of revisions which would not have occurred if alternate bearings had been used. This has been modelled and published in the Journal of Bone and Joint Surgery. For every 100 MoM hip-resurfacing procedures, we estimate that there would be 7.8 excess revisions by ten years, and similarly for every 100 stemmed MoM THR procedures that there would be 15.9, which equates to 8,021 excess first revisions[5].

It is striking to note the high rates of revision for adverse soft tissue reaction to particulate debris in patients who have received metal-on-metal bearings. Analysis of stemmed metal-on-metal bearings by head size shows that 28mm heads have the best survivorship, but this is still poor compared to alternatives.

Revision rates by year of surgery for the entire cohort increased dramatically from 2003 to 2008 and then declined until 2013. This matches the use of resurfacing arthroplasty and stemmed metal-on-metal with the peak usage of these devices in 2008 corresponding with the highest failure rates by year of primary surgery. This demonstrates the profoundly negative effect metal-on-metal has had on hip replacement outcomes.

Consistent with results from previous years' reports, similar revision rates were observed for total hip replacement performed as a result of fractured neck of femur and those done for other causes. As expected, mortality rates were higher for the fractured neck of femur group.

The number of revision total hip replacements recorded in the NJR increased to a peak of 10,511 in 2012 and since then has declined steadily to 8,562 in 2017 and 7,889 in 2018. Please note that there may be a small number of late registrations for 2018 and thus the figure for this year may be revised upward slightly in the next annual report. Aseptic loosening is the most common reason for revision, accounting for nearly half of all cases, followed by pain and instability.

Risk of re-revision rate is strongly associated with time to first revision; 12.15% (95% CI 11.43-12.92%) of hips revised within a year of primary surgery are re-revised within three years. In contrast, when the primary lasts at least five years the re-revision rate is 6.81% (95% CI 6.31-7.34). Re-revision rates up to seven years appear to be independent of the fixation and bearing of the primary hip replacement.

[5] Hunt LP, Whitehouse MR, Beswick A, Porter ML, Howard P, Blom AW; Implications of Introducing New Technology: Comparative Survivorship Modeling of Metal-on-Metal Hip Replacements and Contemporary Alternatives in the National Joint Registry. J Bone Joint Surg Am. 2018 Feb 7;100(3):189-196.

Part 3

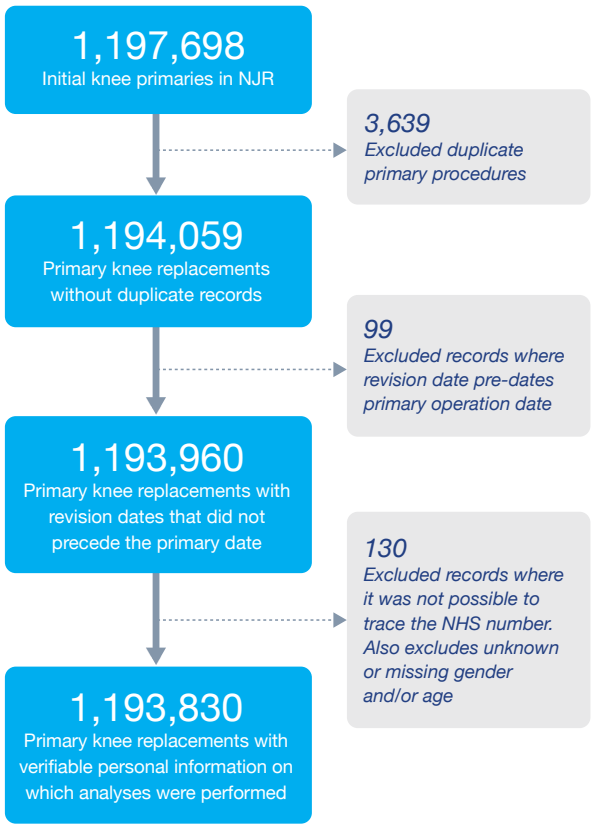
3.4 Outcomes after knee replacement

This section looks at revision and mortality outcomes for all primary knee operations performed between 1 April 2003 and 31 December 2018 (inclusive). Patients operated on at the beginning of the registry therefore had a potential 15.75 years of follow-up.

The outcomes of total and partial knee replacement procedures are discussed throughout this section, hereafter referred to as total (TKR) and unicompartmental (UKR) knee replacement. Brief details of the type of orthopaedic surgery involved for each form of replacement can be found in section 3.2. Of special note here, is that the NJR data collection process now distinguishes between medial and lateral unicondylar replacements, although this was not the case in the past.

Details of the patient cohort are given in Tables 3.1 and 3.2 of section 3.2. Figure 3.17 describes the data cleaning applied to produce the total of 1,193,830 primary knee procedures included in the analyses presented in this section.

Figure 3.17 Knee cohort flow diagram.



Over the lifetime of the registry, the 1,193,830 primary knee joint replacement procedures contributing to our analyses were carried out by a total of 3,289 unique consultant surgeons working across 466 units. Over the last three years (1 January 2016 to 31 December 2018), 308,961 primary knee procedures (representing 25.9% of the current registry) were performed by 1,937 consultant surgeons working across 408 units. Looking at caseload over this three-year period, the median number of primary procedures per consultant surgeon was 118 (IQR 39-229) and the median number of procedures per unit was 670 (IQR 318-1,016). A proportion of consultants will have just qualified over this period, some may have retired, and some surgeons may have periods of inactivity within the coverage of the NJR, therefore their apparent caseload would be lower.

Over this three-year period, there have been 274,495 primary total knee replacements performed by 1,925 surgeons (median=110 cases per surgeon; IQR 38-204) in 408 separate units (median=587 cases per unit; IQR 280-949). In the same time period, there have been 31,306 primary unicondylar knee procedures performed by 801 consultant surgeons (median=18 cases per surgeon; IQR 5-46) in 364 units (median=47 cases per unit; IQR 17-106).

The majority of primary knee replacements were carried out on women (females 56.7%; males 43.3%). The median age at primary operation was 69 (IQR 63-76) years and the overall range was 7-102 years. For unicompartmental primary knee replacements, patients were typically five (unicondylar; median age 64 years; IQR 57-71) and eleven years younger (patellofemoral; median age 58 years; IQR 50-67), compared to all knee replacements. Osteoarthritis was given as a documented indication for surgery in 1,162,349 procedures (97.4% of the cohort) and was the sole indication given in 1,148,855 (96.2%) primary knee procedures.

3.4.1 Overview of primary knee surgery

Table 3.21 **Number** and **percentage** of primary knee replacements by **fixation**, **constraint** and **bearing**.

Type of primary knee operation		Number of primary knee operations	Percentage of each constraint type used within each method of fixation	Percentage of all primary knee operations
Fixation method	Constraint and bearing type			
All types		1,193,830		100.0
Total knee replacement				
All cemented		1,016,337		85.1
Cemented and	unconstrained, fixed	685,560	67.5	57.4
	unconstrained, mobile	38,211	3.8	3.2
	posterior-stabilised, fixed	244,442	24.1	20.5
	posterior-stabilised, mobile	12,511	1.2	1.0
	constrained, condylar	9,797	1.0	0.8
	monobloc polyethylene tibia	16,218	1.6	1.4
	bearing type unknown	9,598	0.9	0.8
All uncemented		45,057		3.8
Hybrid		9,479		0.8
Uncemented/ hybrid and	unconstrained, fixed	23,278	42.7	1.9
	unconstrained, mobile	26,165	48.0	2.2
	posterior-stabilised, fixed	3,832	7.0	0.3
	other constraint	655	1.2	0.1
	bearing type unknown	606	1.1	0.1
Unicompartmental knee replacement				
Unicondylar		108,476		9.1
Unicondylar and	fixed	38,604	35.6	3.2
	mobile	68,988	63.6	5.8
	bearing type unknown	884	0.8	0.1
Patellofemoral		14,434		1.2
Unclassified		47		<0.01

Table 3.21 shows the breakdown of cases by type of knee replacement, the method of fixation, constraint and bearing used. A breakdown within each method of fixation of the percentage of constraint and bearing types used is shown in a separate column. Cemented TKR is the most commonly performed type of knee replacement (85.1% of all primary knee replacements). A further 4.6% were either all uncemented or hybrid TKRs. Most UKRs were unicondylar (9.1% of the total) with the remainder being patellofemoral (1.2%).

More than half of all operations (57.4%) were TKRs which were all cemented and unconstrained (cruciate retaining) with a fixed bearing, followed by 20.5% which were all cemented and posterior stabilised with a fixed bearing. Within each method of fixation, it can be seen that uncemented/hybrid prostheses are mostly unconstrained but almost equally likely to have a mobile or fixed bearing. Approximately two-thirds (67.5%) of cemented TKRs are unconstrained and have a fixed bearing. Unicondylar knee surgery typically involves the use of a mobile bearing (63.6%). A number of primary knee replacements could not be classified according to their bearing/constraint (approximately 1% of the total cohort).

Table 3.22 Percentage* of primary knee replacements by fixation, constraint, bearing and calendar year.

Fixation/bearing/ constraint	2004 n= 41,709	2005 n= 42,561	2006 n= 50,518	2007 n= 67,194	2008 n= 74,595	2009 n= 76,686	2010 n= 79,274	2011 n= 82,857	2012 n= 86,693	2013 n= 86,387	2014 n= 96,341	2015 n=100,054	2016 n=104,590	2017 n=105,278	2018 *n= 99,093*
Total knee replacement															
All cemented	**81.0**	**81.7**	**81.3**	**81.9**	**81.9**	**82.6**	**84.0**	**85.4**	**86.7**	**87.7**	**87.4**	**87.3**	**87.1**	**86.6**	*85.9*
Cemented and															
unconstrained fixed	53.0	52.9	50.6	50.6	51.4	53.0	54.4	56.6	59.0	59.7	60.7	61.5	61.9	61.4	*60.8*
unconstrained mobile	4.2	5.4	6.5	6.5	5.8	4.8	4.1	3.0	2.4	2.2	2.0	1.7	1.8	1.6	*1.7*
posterior-stabilised fixed	20.7	19.6	19.8	20.0	20.7	21.1	21.6	21.4	21.0	21.1	20.5	20.2	19.7	19.9	*19.8*
posterior-stabilised mobile	1.0	1.6	1.9	1.6	1.4	1.4	1.4	1.2	1.1	1.2	1.0	0.8	0.6	0.4	*0.3*
constrained condylar	0.4	0.4	0.3	0.3	0.3	0.3	0.4	0.4	0.6	0.9	1.1	1.2	1.4	1.4	*1.6*
monobloc polyethlene tibia	0.3	0.4	0.6	0.9	0.8	0.7	1.0	1.6	2.0	2.2	1.9	1.5	1.5	1.6	*1.6*
bearing/constraint unknown	1.5	1.4	1.6	1.9	1.5	1.2	1.2	1.2	0.6	0.5	0.3	0.3	0.3	0.3	*0.2*
All uncemented	**6.6**	**6.2**	**6.5**	**6.5**	**6.2**	**5.7**	**4.7**	**4.1**	**3.3**	**2.5**	**2.6**	**2.3**	**2.0**	**2.0**	*1.8*
Uncemented and															
unconstrained fixed	2.4	2.2	2.4	2.9	2.7	2.6	1.8	1.4	1.0	0.7	0.6	0.7	0.8	0.8	*0.8*
unconstrained mobile	3.3	3.3	3.4	3.2	3.1	2.7	2.6	2.4	2.0	1.6	1.6	1.4	1.1	1.0	*0.8*
posterior-stabilised fixed	0.6	0.5	0.5	0.4	0.4	0.3	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	*0.2*
other constraint	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	*<0.1*
constraint unknown	0.3	0.2	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	*<0.1*
Hybrid	**2.8**	**2.4**	**1.7**	**1.4**	**1.3**	**1.2**	**0.9**	**0.5**	**0.4**	**0.4**	**0.4**	**0.4**	**0.5**	**0.2**	*0.2*
Hybrid and															
unconstrained fixed	2.3	1.9	1.2	1.1	1.1	1.0	0.7	0.3	0.2	0.2	0.1	0.1	0.1	0.1	*0.1*
unconstrained mobile	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.1	*0.1*
posterior-stabilised fixed	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	*0.1*
other constraint	<0.1	0.2	0.2	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	*<0.1*
constraint unknown	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	*<0.1*
Unicompartmental knee replacement															
Unicondylar	**8.5**	**8.7**	**9.3**	**8.9**	**9.1**	**9.0**	**9.0**	**8.6**	**8.3**	**8.1**	**8.5**	**8.9**	**9.3**	**10.1**	*11.1*
Unicondylar and															
fixed	1.7	2.1	2.3	2.0	2.1	2.3	2.7	2.6	3.0	3.3	3.5	3.7	4.1	4.5	*5.5*
mobile	6.7	6.5	6.9	6.7	6.8	6.6	6.3	5.8	5.2	4.8	5.0	5.2	5.3	5.6	*5.6*
constraint unknown	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	*<0.1*
Patellofemoral	**1.0**	**1.0**	**1.1**	**1.4**	**1.5**	**1.5**	**1.4**	**1.5**	**1.4**	**1.2**	**1.1**	**1.1**	**1.1**	**1.1**	*0.9*
Unclassified	**0.1**	**<0.1**				**0**									*0*
All types	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	*100*

*Percentage of all primary operations in a particular year which used one of the five fixation methods: cemented, uncemented, hybrid, patellofemoral or unicondylar. Percentages shown represent percentage of total procedures.
Note: Data from 2003 has been included in 2004 since 2003 was not a complete year. Blue italics indicate the data is provisional and likely to increase due to late entry of the data.

Table 3.22 shows the annual rates for the usage of primary knee replacements. Overall, more than 80% of all primaries utilised all cemented fixation and since 2004, the share of all implant replacements of this type has increased by about 6%. The main decline in the type of primary knee replacements carried out has been in the use of all uncemented and hybrid total knee replacements over time (now 2% of all knee replacements). Usage of each implant of this type has decreased proportionally to less than a third of those figures reported for 2003 (when they were 9.4% of all knee replacements).

Figure 3.18 Fixation by year of procedure in primary knee replacement.

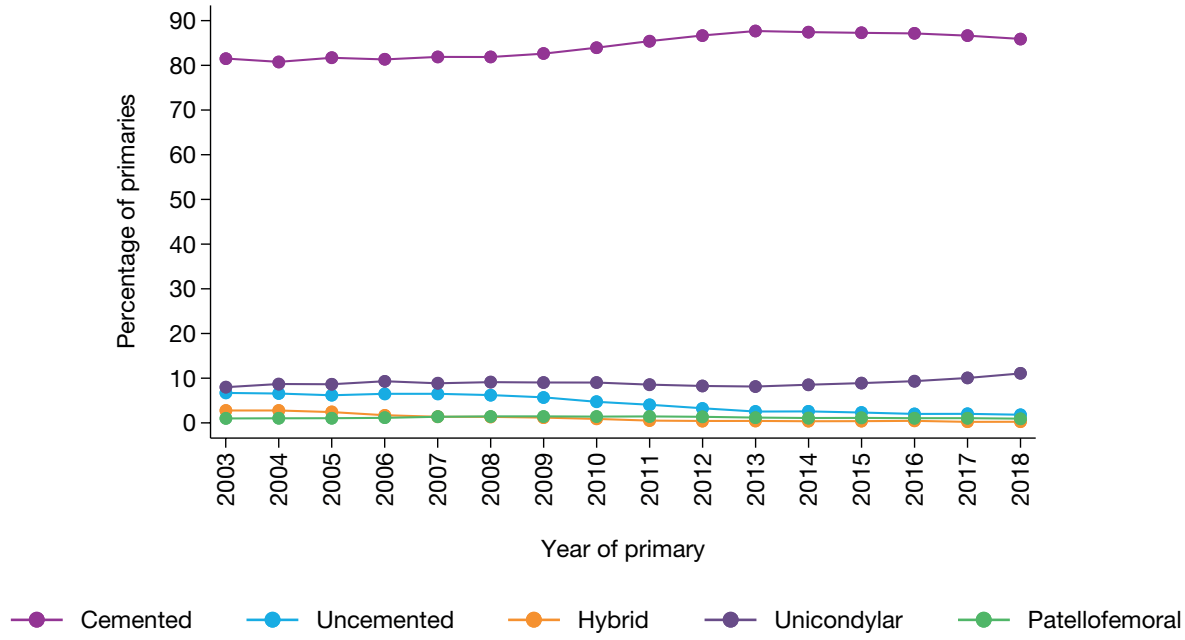


Figure 3.18 illustrates the temporal changes in fixation highlighting the dominance of cemented TKR primaries.

Table 3.23 Age at primary knee replacement by **fixation**, **constraint** and **bearing** type.

Fixation	Constraint and bearing type	N	Age of patient (years)		Percentage (%) male[3]
			Median (IQR)[1]	Mean (SD)[2]	
All types		**1,193,830**	**69 (63-76)**	**68.9 (9.6)**	**43.3**
All cemented		**1,016,337**	**70 (64-76)**	**69.7 (9.3)**	**42.3**
Cemented and	unconstrained, fixed	685,560	70 (64-76)	69.6 (9.2)	42.8
	unconstrained, mobile	38,211	69 (62-76)	68.5 (9.6)	42.2
	posterior-stabilised, fixed	244,442	70 (64-77)	69.8 (9.4)	41.1
	posterior-stabilised, mobile	12,511	66 (60-74)	66.4 (10.1)	44.8
	constrained, condylar	9,797	70 (63-78)	69.9 (10.6)	36.2
	bearing type unknown	9,598	70 (63-77)	69.4 (10.5)	41.6
	monobloc polyethylene tibia	16,218	74 (69-79)	73.5 (8.2)	40.7
All uncemented		**45,057**	**69 (62-75)**	**68.2 (9.6)**	**48.4**
Hybrid		**9,479**	**69 (62-76)**	**68.5 (9.9)**	**44.6**
Uncemented/hybrid and	unconstrained, fixed	23,278	69 (62-75)	68.4 (9.7)	48.6
	unconstrained, mobile	26,165	69 (62-75)	68.5 (9.3)	45.9
	posterior-stabilised, fixed	3,832	67 (59-74)	66.6 (10.6)	52.0
	other type	655	67 (60-74)	66.4 (10.0)	64.4
	bearing type unknown	606	68 (61-76)	67.5 (10.4)	48.3
Unicondylar		**108,476**	**64 (57-71)**	**63.8 (9.7)**	**53.4**
Unicondylar and	fixed	38,604	63 (56-70)	63.0 (10.0)	54.4
	mobile	68,988	64 (57-71)	64.2 (9.5)	52.9
	bearing type unknown	884	63 (56-70)	62.7 (10.1)	49.3
Patellofemoral		**14,434**	**58 (50-67)**	**58.8 (11.6)**	**22.5**
Unclassified		**47**	**69 (59-77)**	**68.4 (10.8)**	**46.8**

[1]IQR = Interquartile range - age of middle 50% of patients at time of primary knee operation.
[2]SD = Standard deviation.
[3]The percentage male figures are based on a total number of 1,193,830 primary knee replacements.

Table 3.23 shows the age and gender distribution of patients undergoing primary knee replacement. The median age of a person receiving a cemented TKR was 70 years (IQR 64-76 years). Patients receiving UKRs were typically six (unicondylar; median age 64 years; IQR 57-71) and twelve years younger (patellofemoral; median age 58 years; IQR 50-67 compared to all knee replacements).

Over all operation types, a higher percentage of females (56.7%) than males have had a knee replacement.

Women are also more likely to have a primary TKR; 57.7%, 51.6% and 55.4% of cemented, uncemented and hybrid type procedures respectively are carried out on female patients. Conversely, unicondylar surgery is performed on a higher proportion of males (53.4%). Patellofemoral surgery is predominantly carried out on females (77.5% of patients) who are typically younger than a TKR or unicondylar patient with a median age at operation of 58.

Table 3.24 Primary knee replacement patient **demographics**.

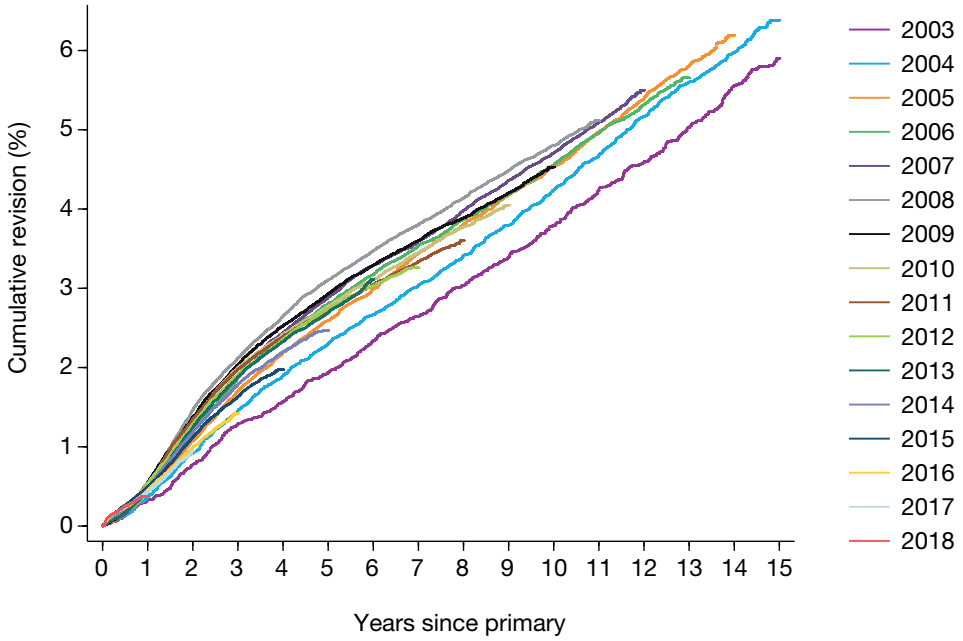
	Males N (%)		Females N (%)		All N (%)	
Total	**517,099**		**676,731**		**1,193,830**	
ASA 1	71,212 (13.8)		70,906 (10.5)		142,118 (11.9)	
ASA 2	363,434 (70.3)		495,833 (73.3)		859,267 (72.0)	
ASA 3	80,565 (15.6)		107,896 (15.9)		188,461 (15.8)	
ASA 4	1,832 (0.4)		2,016 (0.3)		3,848 (0.3)	
ASA 5	56 (<0.1)		80 (<0.1)		136 (<0.1)	
Osteoarthritis as a reason for primary	507,482 (98.1)		654,867 (96.8)		1,162,349 (97.4)	
Osteoarthritis as the sole reason for primary	501,332 (97.0)		647,523 (95.7)		1,148,855 (96.2)	
Age	Mean (SD) 68.6 (9.3)	Median (IQR) 69 (62-75)	Mean (SD) 69.2 (9.8)	Median (IQR) 70 (63-76)	Mean (SD) 68.9 (9.6)	Median (IQR) 69 (63-76)

Note: Percentages in this table are calculated by column.

Table 3.24 shows the ASA grade and reason for knee replacement by gender for all primary knee replacements. A greater number of females than males undergo knee replacement and ASA 2 is the most common ASA grade. Only a small number of patients with a grade greater than ASA 3 undergo knee replacement. The majority of cases are performed for osteoarthritis; 1,148,855 (96.2%) of all 1,193,830 knee replacements with a reason for primary surgery recorded in the NJR are performed for osteoarthritis as the sole indication.

3.4.2 First revision after primary knee surgery

Figure 3.19 (a) KM estimates of cumulative **revision** by **year**, in primary knee replacements.



A total of 33,292 first revisions of a knee prosthesis have been linked to NJR primary knee replacement surgery records of operations undertaken between 2003 and 2018. Figures 3.19 (a) and (b) illustrate temporal changes in the overall revision rates using Kaplan-Meier estimates; procedures have been grouped by the year of the primary operation. Figure 3.19 (a) plots each Kaplan-Meier survival curve with a common origin, i.e. time zero is equal to the year of operation. This illustrates that there was a small increase in revision rates up until 2008 followed by a small decline.

Figure 3.19 (b) shows the same curves plotted against calendar time, where the origin of each curve is the year of operation. Figure 3.19 (b) separates each year allowing changes in failure rates to be clearly identified. In addition, the revision rates at 1, 3, 5, 7 and 10 years have been highlighted. If revision rates and timing of revision rates were static across time, we would expect all failure curves to be the same shape and equally spaced; a departure from this indicates a change in the number and timing of revision procedures. The cumulative probability of a joint being revised at three and five years increased for each operative year group between 2003 and 2008; the probability of being revised at three and five years reduced for operations performed between 2009 and 2018. From the peak in 2008, the yearly survivorship curves are less divergent, i.e. a slowing in the increasing trend.

Possible reasons for a peak in the probability of revision in the 2008 cohort are: 1) the registry was not capturing the full range and number of operations taking place in units in England and Wales until 2008, and 2) there could be bias in terms of the general overall health, risk of revision, and other key characteristics of the patients on record in the NJR in the early years. Given similar, more marked, patterns are observed in primary hip replacements and the start of the reduction coincides with the period where clinician feedback and performance analyses were introduced, it is likely that these patterns represent improved survivorship as a result of clinician feedback and adoption of evidence-based practice.

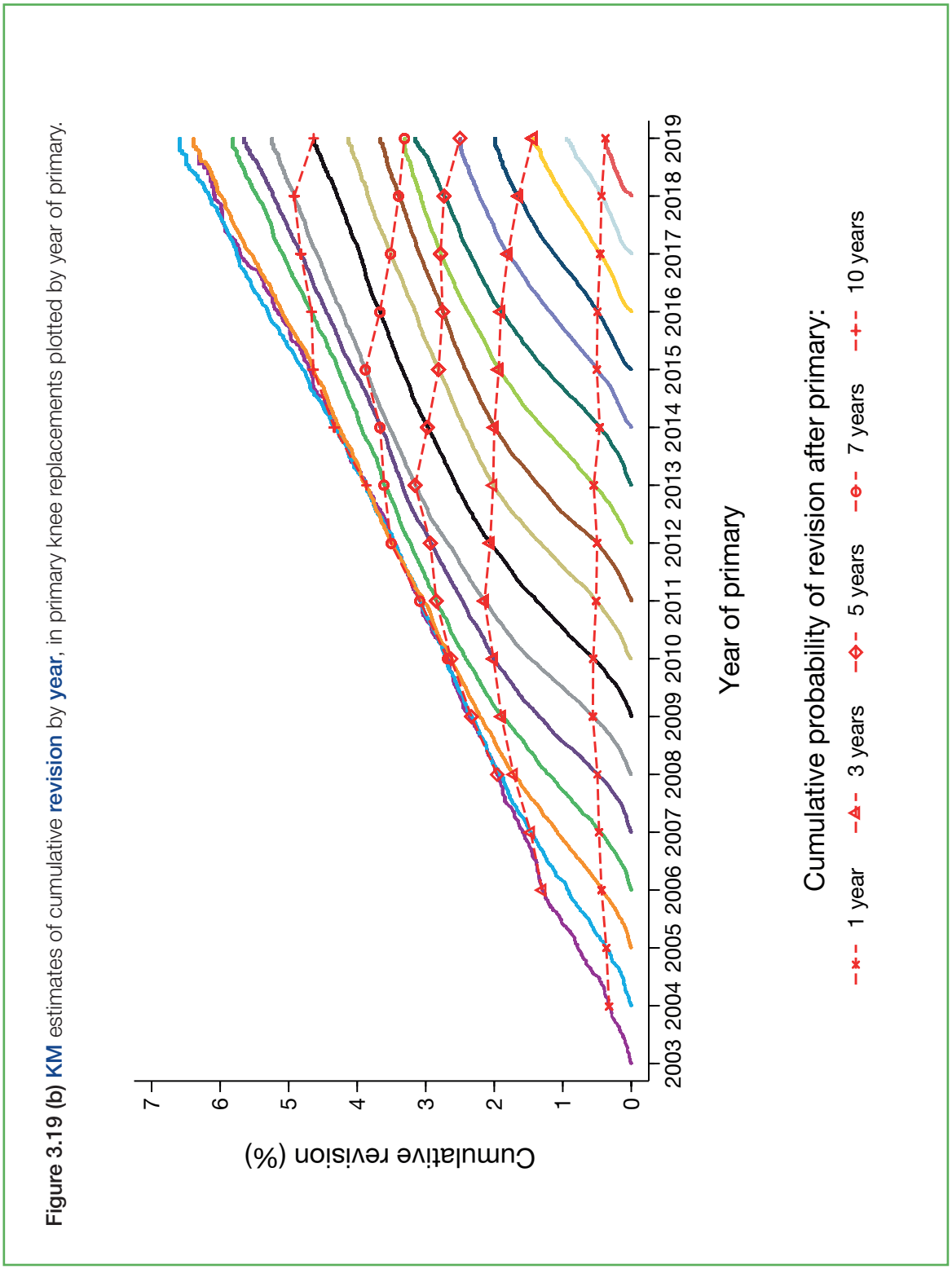


Figure 3.19 (b) KM estimates of cumulative **revision** by **year**, in primary knee replacements plotted by year of primary.

Table 3.25 KM estimates of cumulative **revision** (95% CI) by **fixation**, **constraint** and **bearing**, in primary knee replacements.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

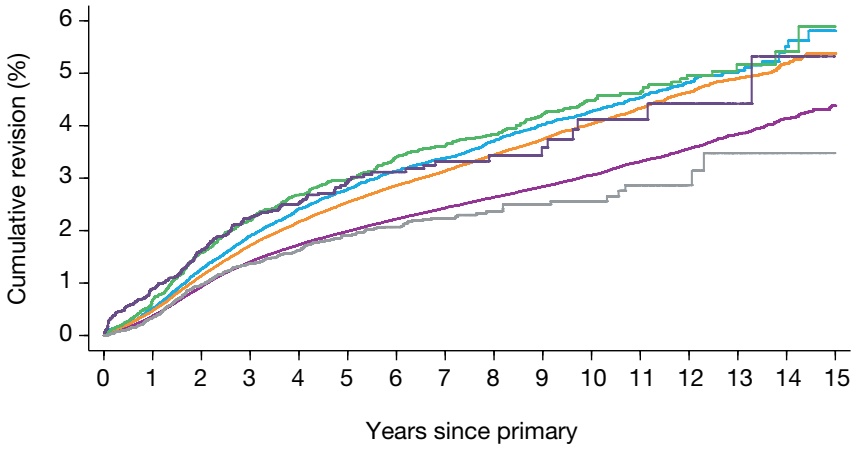
Fixation/constraint/ bearing type	N	Time since primary					
		1 year	3 years	5 years	10 years	13 years	15 years
All types	**1,193,830**	**0.49 (0.48-0.50)**	**1.82 (1.80-1.85)**	**2.66 (2.63-2.69)**	**4.37 (4.32-4.43)**	**5.59 (5.51-5.68)**	**6.41 (6.26-6.57)**
Unclassified	**47**	*0.00*	*0.00*	*0.00*	*2.56 (0.37-16.84)*	*2.56 (0.37-16.84)*	
All cemented	**1,016,337**	**0.41 (0.40-0.43)**	**1.53 (1.50-1.55)**	**2.19 (2.16-2.23)**	**3.41 (3.36-3.46)**	**4.22 (4.14-4.30)**	**4.74 (4.61-4.88)**
unconstrained, fixed	685,560	0.37 (0.36-0.39)	1.41 (1.38-1.44)	1.99 (1.95-2.03)	3.06 (3.00-3.12)	3.84 (3.75-3.94)	4.38 (4.21-4.56)
unconstrained, mobile	38,211	0.52 (0.45-0.59)	1.90 (1.76-2.05)	2.79 (2.61-2.97)	4.27 (4.03-4.52)	5.06 (4.74-5.40)	*5.81 (5.19-6.50)*
posterior-stabilised, fixed	244,442	0.47 (0.44-0.50)	1.72 (1.66-1.77)	2.54 (2.47-2.62)	4.04 (3.93-4.15)	4.90 (4.74-5.08)	5.38 (5.13-5.64)
posterior-stabilised, mobile	12,511	0.68 (0.55-0.85)	2.20 (1.95-2.48)	2.97 (2.68-3.31)	4.49 (4.06-4.95)	5.17 (4.60-5.81)	*5.89 (4.80-7.23)*
constrained condylar	9,797	0.89 (0.72-1.11)	2.25 (1.93-2.62)	2.94 (2.53-3.42)	4.12 (3.33-5.09)	*4.42 (3.48-5.61)*	*5.32 (3.62-7.80)*
monobloc polyethylene tibia	16,218	0.34 (0.26-0.45)	1.37 (1.19-1.59)	1.91 (1.68-2.18)	2.56 (2.22-2.96)	*3.48 (2.62-4.62)*	*3.48 (2.62-4.62)*
bearing type unknown	9,598	0.79 (0.63-0.99)	2.41 (2.11-2.75)	3.41 (3.04-3.81)	5.20 (4.70-5.76)	6.31 (5.60-7.11)	*6.31 (5.60-7.11)*
All uncemented	**45,057**	**0.57 (0.50-0.64)**	**2.09 (1.96-2.24)**	**2.88 (2.72-3.05)**	**4.15 (3.94-4.38)**	**5.27 (4.95-5.62)**	**6.16 (5.60-6.78)**
unconstrained, fixed	16,949	0.62 (0.51-0.76)	2.31 (2.09-2.56)	3.03 (2.76-3.32)	4.27 (3.92-4.64)	5.41 (4.89-5.99)	*5.91 (5.20-6.72)*
unconstrained, mobile	24,120	0.52 (0.44-0.63)	1.92 (1.75-2.11)	2.71 (2.50-2.93)	3.85 (3.57-4.15)	4.79 (4.38-5.24)	*5.95 (5.11-6.92)*
posterior-stabilised, fixed	3,251	0.57 (0.36-0.91)	2.31 (1.82-2.92)	3.34 (2.72-4.09)	5.93 (4.97-7.08)	*8.35 (6.78-10.26)*	*9.77 (7.37-12.91)*
other constraint	260	*0.78 (0.20-3.10)*	*2.46 (1.11-5.40)*	*2.92 (1.40-6.03)*	*2.92 (1.40-6.03)*		
bearing type unknown	477	0.63 (0.20-1.95)	1.54 (0.74-3.21)	3.27 (1.95-5.46)	*4.55 (2.87-7.19)*	*4.98 (3.17-7.80)*	
Hybrid	**9,479**	**0.56 (0.43-0.73)**	**1.80 (1.55-2.10)**	**2.46 (2.15-2.81)**	**3.60 (3.20-4.05)**	**4.18 (3.69-4.74)**	*4.37 (3.82-4.99)*
unconstrained, fixed	6,329	0.48 (0.34-0.69)	1.64 (1.35-1.99)	2.23 (1.88-2.64)	3.20 (2.76-3.71)	3.77 (3.23-4.39)	*3.99 (3.39-4.70)*
unconstrained, mobile	2,045	0.90 (0.57-1.42)	1.74 (1.24-2.44)	2.34 (1.71-3.21)	3.54 (2.56-4.89)	*3.97 (2.78-5.68)*	*3.97 (2.78-5.68)*
posterior-stabilised, fixed	581	0.18 (0.03-1.29)	2.62 (1.53-4.46)	4.23 (2.74-6.48)	*6.21 (4.27-8.97)*	*6.92 (4.69-10.15)*	
other constraint	395	0.26 (0.04-1.81)	2.09 (1.05-4.13)	2.96 (1.65-5.29)	*4.57 (2.75-7.56)*	*5.90 (3.27-10.51)*	
bearing type unknown	129	*1.55 (0.39-6.06)*	*6.45 (3.27-12.48)*	*6.45 (3.27-12.48)*	*10.98 (6.32-18.71)*	*10.98 (6.32-18.71)*	
Unicondylar	**108,476**	**1.07 (1.01-1.13)**	**3.90 (3.78-4.03)**	**5.95 (5.79-6.11)**	**11.11 (10.83-11.40)**	**15.22 (14.76-15.69)**	**17.99 (17.15-18.87)**
fixed	38,604	0.71 (0.62-0.80)	3.43 (3.23-3.64)	5.36 (5.09-5.65)	9.74 (9.24-10.27)	13.47 (12.59-14.40)	*15.62 (14.09-17.31)*
mobile	68,988	1.27 (1.18-1.35)	4.15 (3.99-4.31)	6.25 (6.04-6.45)	11.63 (11.30-11.98)	15.90 (15.35-16.46)	18.86 (17.87-19.89)
bearing type unknown	884	0.80 (0.38-1.67)	4.23 (3.07-5.81)	5.98 (4.57-7.82)	12.77 (10.41-15.61)	*14.40 (11.66-17.71)*	*14.40 (11.66-17.71)*
Patellofemoral	**14,434**	**1.15 (0.98-1.34)**	**6.02 (5.62-6.46)**	**9.82 (9.28-10.38)**	**18.86 (17.95-19.81)**	**23.47 (22.14-24.86)**	*26.93 (24.28-29.80)*

Note: Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Table 3.25 shows Kaplan-Meier estimates of the cumulative percentage probability of first revision, for any cause, for the cohort of all primary knee replacements. This is broken down for TKR by knee fixation type (cemented, uncemented or hybrid) and sub-divided further within each fixation type by the constraint (unconstrained, posterior-stabilised or constrained condylar) and bearing mobility (fixed or mobile) and for UKR, by bearing mobility (fixed or mobile). The table shows updated estimates at 1, 3, 5, 10, 13 and 15 years from the primary operation together with 95% Confidence Intervals (95% CI). Results at 15 years have been added, but in general, the group sizes are too small for meaningful sub-division, hence many of these estimates are shown in blue italics, indicating that fewer than 250 cases remained at risk. Kaplan-Meier estimates are not shown at all when the numbers at risk fell below ten.

Further revisions in these groups would be highly unlikely and, when they do occur, they may appear to have a disproportionate impact on the Kaplan-Meier estimate, i.e. the step upwards may seem steeper. Furthermore, the upper 95% CI at these time points may be underestimated. Although a number of statistical methods have been proposed to deal with this, they typically give different values and, as yet, there is no clear consensus for the large datasets we have here.

Figure 3.20 (a) KM estimates of cumulative **revision** in **primary total cemented** knee replacements by **constraint** and **bearing**.

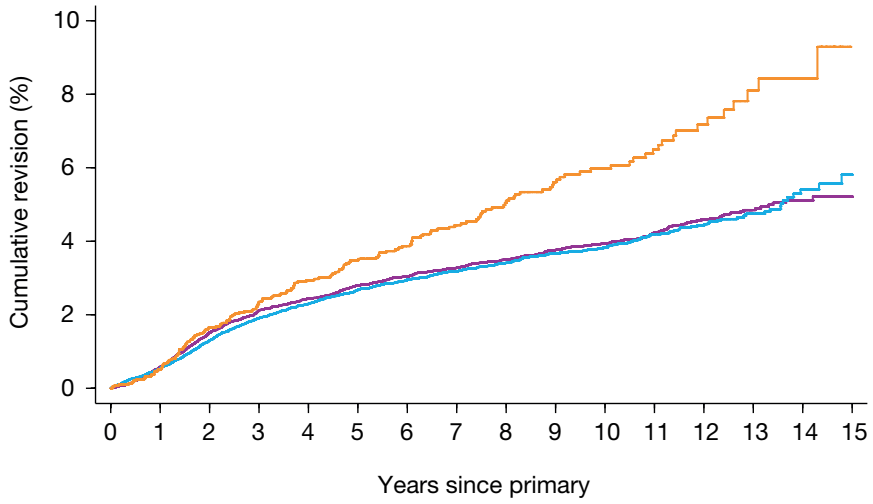


Number at risk

Unconstrained, fixed	685,560	616,702	542,345	468,663	399,752	335,494	279,169	225,660	178,154	136,442	99,615	68,103	42,603	25,049	11,358	3,370
Unconstrained, mobile	38,211	36,016	33,625	31,113	28,689	26,235	23,753	21,188	18,393	15,053	11,618	7,914	4,610	2,330	862	243
Posterior–stabilised, fixed	244,442	221,257	196,315	171,910	148,510	126,099	105,971	86,733	68,823	52,570	38,152	25,736	15,960	9,317	4,362	1,334
Posterior–stabilised, mobile	12,511	12,018	11,327	10,536	9,589	8,517	7,366	6,344	5,285	4,204	3,209	2,331	1,421	753	276	81
Constrained, condylar	9,797	7,969	6,329	4,776	3,472	2,398	1,668	1,187	864	624	462	336	205	125	59	19
Monobloc polyethylene tibia	16,218	14,431	12,437	10,653	8,938	7,005	5,143	3,543	2,393	1,704	1,204	729	363	170	67	27

Figures 3.20 (a) to 3.20 (c) illustrate the differences in revision rates between the types of knee replacement, fixation and constraint. It is worth noting the different vertical scales between the three figures. The results show the lowest revision rates for cemented unconstrained fixed bearing TKR and cemented TKR with monobloc polyethylene tibias. The revision rates in cemented TKRs that are posterior-stabilised and those that have mobile bearings remain higher. The revision rates for UKRs remain substantially higher than for TKR, this is most marked in the patellofemoral replacement group.

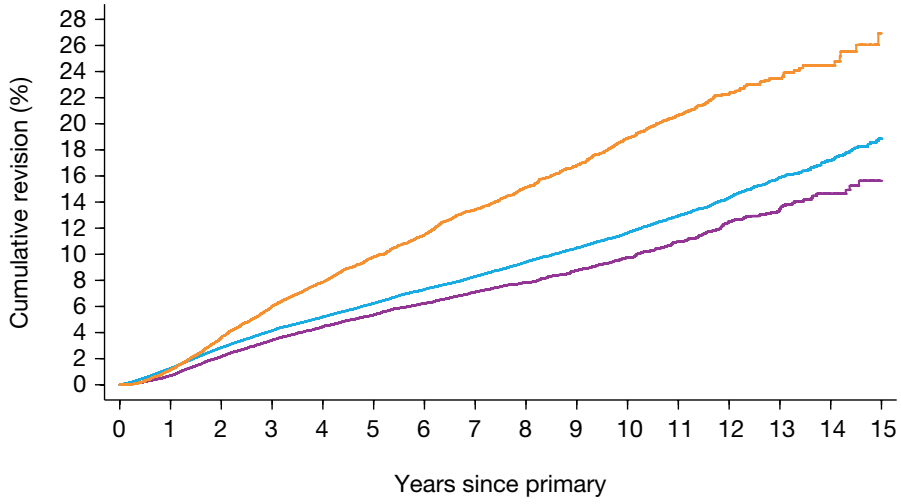
Figure 3.20 (b) KM estimates of cumulative **revision** in **primary total uncemented/hybrid** knee replacements by **constraint** and **bearing**.



Number at risk

Unconstrained, fixed	23,278	21,955	20,586	19,247	18,068	16,927	15,709	14,284	12,594	10,550	8,038	5,659	3,565	2,211	1,066	326
Unconstrained, mobile	26,165	24,904	23,258	21,369	19,319	17,201	15,313	13,165	10,986	8,872	6,885	4,794	3,062	1,762	811	237
Posterior–stabilised, fixed	3,832	3,528	3,223	2,982	2,703	2,359	2,101	1,864	1,625	1,373	1,071	795	521	299	141	51

Figure 3.20 (c) KM estimates of cumulative **revision** in **primary unicondylar or patellofemoral** knee replacements by **constraint** and **bearing**.



Number at risk

Unicondylar, fixed	38,604	32,833	27,561	22,888	18,915	15,378	12,456	9,887	7,756	5,787	4,254	2,926	1,840	980	410	106
Unicondylar, mobile	68,988	62,377	55,272	48,807	42,935	37,524	32,872	28,080	23,147	18,386	13,754	9,467	5,947	3,434	1,612	473
Patellofemoral	14,434	13,286	11,793	10,377	9,058	7,833	6,731	5,503	4,372	3,363	2,429	1,573	917	532	239	74

Figure 3.21 (a) shows that the chance of revision after primary cemented TKR is far higher in younger patient cohorts and that men were slightly more likely, overall, to have a first revision compared to women of comparable grouped age, if they were under the age of 70 when they underwent primary surgery.

Figure 3.21 (a) KM estimates of cumulative **revision** in **primary total** knee replacements by **gender** and **age**.

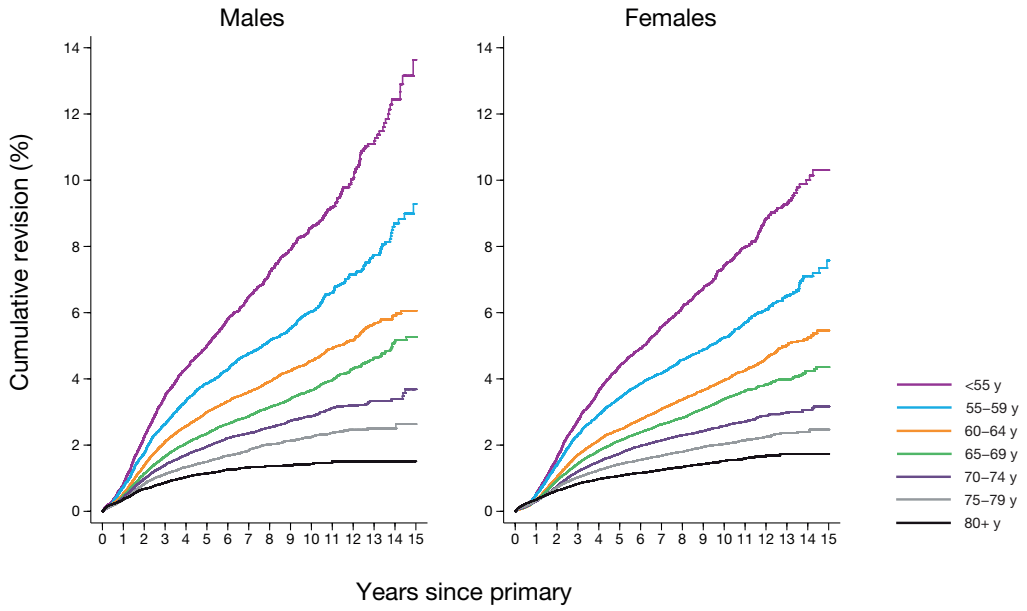


Figure 3.21 (b) shows that the risk of revision of primary unicondylar knee replacement is, again, substantially higher for younger patient cohorts but that there are less marked differences in younger patients in the risk of revision according to gender. The risk of revision appears to be higher in females over the age of 75 compared to males. The risk of revision is higher in all age groups than it is for cemented TKR.

Figure 3.21 (b) KM estimates of cumulative **revision** in **primary unicondylar** knee replacements by **gender** and **age**.

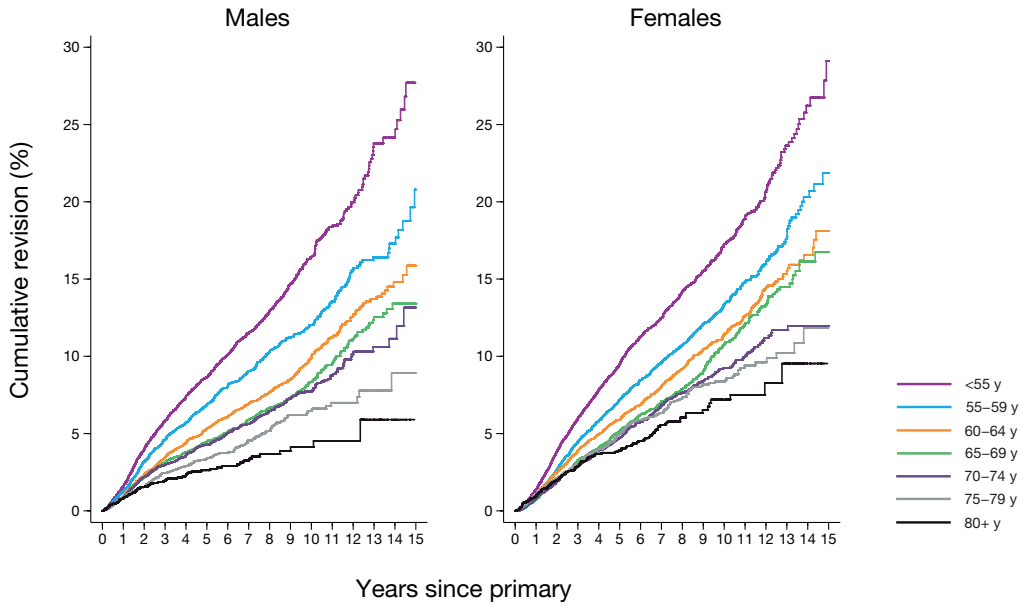


Table 3.26 (overleaf) shows gender and age stratified Kaplan-Meier estimates of the cumulative percentage probability of first revision, for any cause, firstly for all cases combined, then by knee fixation/constraint/bearing sub-divisions. Estimates are shown, along with 95% CIs, for males and females within each of four age bands, <55, 55-64, 65-74 and 75+ years for revision rate at 1, 3, 5, 10, 13 and 15 years after the primary operation. These refine results reported in earlier reports, but now with larger numbers of cases and therefore generally narrower confidence intervals.

Table 3.26 KM estimates of cumulative **revision** (95% CI) by **gender**, **age**, **fixation**, **constraint** and **bearing**, in primary knee replacements.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

Fixation/constraint/ bearing type	Age at primary (years)	Males							Females						
		n	Time since primary						n	Time since primary					
			1 year	3 years	5 years	10 years	13 years	15 years		1 year	3 years	5 years	10 years	13 years	15 years
All types	<55	36,953	1.06 (0.96-1.17)	4.31 (4.09-4.54)	6.29 (6.01-6.58)	10.96 (10.50-11.43)	14.82 (14.04-15.64)	*17.48 (16.10-18.97)*	52,678	0.77 (0.70-0.85)	3.79 (3.62-3.98)	6.02 (5.79-6.26)	10.65 (10.26-11.05)	13.49 (12.90-14.10)	15.54 (14.53-16.62)
All cemented	<55	24,479	0.82 (0.72-0.95)	3.51 (3.27-3.77)	5.03 (4.73-5.36)	8.59 (8.09-9.12)	11.19 (10.37-12.06)	*13.64 (12.06-15.41)*	35,389	0.55 (0.48-0.64)	2.76 (2.57-2.95)	4.40 (4.16-4.66)	7.44 (7.04-7.86)	9.27 (8.67-9.90)	*10.31 (9.46-11.23)*
unconstrained, fixed	<55	15,789	0.77 (0.64-0.92)	3.18 (2.89-3.49)	4.44 (4.08-4.82)	7.79 (7.18-8.46)	10.60 (9.53-11.79)	*13.20 (11.03-15.74)*	23,134	0.48 (0.39-0.58)	2.37 (2.16-2.59)	3.90 (3.61-4.21)	6.63 (6.15-7.14)	8.46 (7.71-9.29)	*9.88 (8.71-11.19)*
unconstrained, mobile	<55	1,338	1.00 (0.58-1.71)	4.43 (3.42-5.74)	6.15 (4.92-7.66)	8.85 (7.24-10.79)	*12.02 (9.34-15.39)*	*15.48 (10.68-22.14)*	1,671	0.62 (0.33-1.15)	2.95 (2.21-3.93)	5.13 (4.10-6.41)	7.80 (6.40-9.50)	*8.92 (7.21-11.01)*	*9.96 (7.53-13.12)*
posterior-stabilised, fixed	<55	5,894	0.75 (0.55-1.01)	3.86 (3.36-4.43)	5.93 (5.27-6.67)	10.37 (9.26-11.60)	*13.02 (11.34-14.93)*	*14.07 (11.93-16.55)*	8,616	0.56 (0.42-0.75)	3.26 (2.87-3.70)	5.02 (4.51-5.59)	9.02 (8.14-10.00)	11.60 (10.26-13.11)	*12.01 (10.48-13.74)*
posterior-stabilised, mobile	<55	681	1.33 (0.70-2.55)	4.41 (3.08-6.28)	5.72 (4.17-7.81)	*8.71 (6.57-11.51)*	*8.71 (6.57-11.51)*		767	1.46 (0.81-2.62)	4.86 (3.53-6.68)	6.14 (4.62-8.14)	8.78 (6.74-11.40)	*8.78 (6.74-11.40)*	
constrained condylar	<55	315	2.28 (1.09-4.73)	*4.87 (2.84-8.30)*	*7.14 (4.28-11.78)*	*7.14 (4.28-11.78)*			475	0.69 (0.22-2.12)	*2.12 (1.06-4.22)*	*2.65 (1.35-5.19)*	*4.92 (1.87-12.63)*	*4.92 (1.87-12.63)*	
monobloc polyethylene tibia	<55	144	*0.72 (0.10-5.00)*	*5.31 (2.56-10.83)*	*5.31 (2.56-10.83)*	*8.21 (4.20-15.72)*	*8.21 (4.20-15.72)*		238	*0.89 (0.22-3.52)*	*4.07 (2.05-8.00)*	*5.46 (2.95-9.99)*	*6.31 (3.49-11.26)*		
bearing type unknown	<55	318	1.61 (0.67-3.82)	4.68 (2.80-7.78)	*7.76 (5.17-11.57)*	*13.72 (9.75-19.13)*	*15.83 (11.22-22.06)*		488	1.86 (0.97-3.55)	6.94 (4.95-9.67)	10.31 (7.82-13.54)	*14.07 (10.91-18.05)*	*15.47 (11.93-19.95)*	
All uncemented	<55	1,795	0.75 (0.43-1.28)	4.19 (3.31-5.29)	5.91 (4.83-7.22)	8.96 (7.47-10.72)	*12.72 (10.24-15.75)*	*15.08 (11.35-19.90)*	1,889	0.76 (0.45-1.29)	4.02 (3.18-5.06)	5.85 (4.81-7.11)	8.44 (7.08-10.06)	*10.09 (8.38-12.12)*	*10.80 (8.71-13.36)*
unconstrained, fixed	<55	746	0.97 (0.46-2.02)	4.61 (3.24-6.53)	6.29 (4.62-8.53)	*9.05 (6.86-11.89)*	*15.24 (10.58-21.68)*		716	1.02 (0.49-2.13)	3.27 (2.14-4.98)	4.61 (3.20-6.63)	*7.43 (5.42-10.15)*	*9.17 (6.54-12.80)*	*9.17 (6.54-12.80)*
unconstrained, mobile	<55	802	0.77 (0.34-1.70)	4.10 (2.88-5.81)	5.88 (4.35-7.91)	*8.91 (6.82-11.60)*	*9.89 (7.51-12.98)*	*14.75 (8.99-23.70)*	961	0.64 (0.29-1.41)	3.93 (2.84-5.44)	5.99 (4.58-7.81)	8.21 (6.42-10.47)	*9.74 (7.54-12.55)*	
posterior-stabilised, fixed	<55	212	*0*	*2.67 (1.12-6.30)*	*3.93 (1.89-8.09)*	*8.96 (4.78-16.48)*	*18.54 (9.61-34.04)*		185	*0.56 (0.08-3.88)*	*7.08 (4.08-12.14)*	*9.83 (6.12-15.58)*	*14.08 (9.11-21.42)*	*16.68 (10.41-26.15)*	
other constraint	<55	19	*0*	*5.56 (0.80-33.36)*	*11.46 (2.99-38.61)*				5						
bearing type unknown	<55	16	*0*	*7.14 (1.04-40.92)*	*7.14 (1.04-40.92)*				22	*0*	*5.00 (0.72-30.53)*	*5.00 (0.72-30.53)*	*5.00 (0.72-30.53)*		
Hybrid	<55	363	0.83 (0.27-2.56)	3.47 (1.98-6.02)	5.97 (3.89-9.11)	*8.30 (5.68-12.05)*	*10.31 (6.88-15.30)*		443	0.46 (0.12-1.82)	2.71 (1.51-4.84)	4.90 (3.15-7.58)	*8.15 (5.71-11.57)*	*8.92 (6.20-12.76)*	*10.58 (6.87-16.10)*
unconstrained, fixed	<55	208	*0.96 (0.24-3.79)*	*2.97 (1.35-6.50)*	*5.57 (3.12-9.84)*	*6.68 (3.93-11.23)*	*9.50 (5.49-16.18)*		265	0.77 (0.19-3.03)	*3.56 (1.87-6.73)*	*5.21 (3.06-8.81)*	*7.12 (4.47-11.24)*	*8.23 (5.10-13.13)*	*10.41 (5.98-17.79)*
unconstrained, mobile	<55	69	*0*	*3.03 (0.77-11.58)*	*5.01 (1.62-14.89)*	*16.38 (6.56-37.58)*			100	*0*	*0*	*1.92 (0.27-12.88)*	*9.31 (2.94-27.40)*		
posterior-stabilised, fixed	<55	42	*0*	*0*	*3.03 (0.43-19.63)*	*6.26 (1.60-22.82)*			45	*0*	*2.38 (0.34-15.72)*	*7.26 (2.40-20.85)*	*9.77 (3.78-23.98)*		

Note: Total sample on which results are based is 1,193,830 primary knee replacements. Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Table 3.26 (continued)

Fixation/constraint/ bearing type	Age at primary (years)	Males							Females						
			Time since primary							Time since primary					
		n	1 year	3 years	5 years	10 years	13 years	15 years	n	1 year	3 years	5 years	10 years	13 years	15 years
other constraint	<55	33	*0*	*9.09 (3.03-25.59)*	*12.12 (4.73-29.14)*	*12.12 (4.73-29.14)*			24	*0*	*0*	*4.35 (0.62-27.07)*	*13.26 (4.48-35.73)*		
bearing type unknown	<55	11							9						
Unicondylar	**<55**	**9,254**	**1.60 (1.36-1.89)**	**5.84 (5.34-6.39)**	**8.67 (8.03-9.36)**	**16.42 (15.29-17.62)**	**23.78 (21.60-26.15)**	*27.71 (24.07-31.78)*	**10,442**	**1.42 (1.20-1.67)**	**6.01 (5.53-6.53)**	**9.53 (8.89-10.21)**	**17.29 (16.22-18.42)**	**23.63 (21.77-25.62)**	*29.12 (25.15-33.57)*
fixed	<55	4,043	1.25 (0.94-1.66)	4.90 (4.21-5.71)	7.63 (6.70-8.70)	14.26 (12.45-16.32)	*19.76 (16.61-23.42)*		4,156	0.89 (0.64-1.25)	5.54 (4.80-6.38)	8.48 (7.50-9.58)	16.43 (14.52-18.55)	*20.67 (17.77-23.97)*	*23.02 (18.96-27.79)*
mobile	<55	5,119	1.86 (1.52-2.28)	6.47 (5.79-7.23)	9.36 (8.51-10.30)	17.61 (16.19-19.15)	*25.71 (22.95-28.74)*	*30.77 (26.19-35.95)*	6,188	1.77 (1.47-2.14)	6.34 (5.72-7.03)	10.15 (9.33-11.04)	17.85 (16.56-19.24)	*25.12 (22.78-27.65)*	*31.76 (26.65-37.57)*
bearing type unknown	<55	92	*2.17 (0.55-8.41)*	*9.08 (4.64-17.35)*	*11.52 (6.36-20.38)*	*19.81 (11.99-31.72)*			98	*1.02 (0.14-7.02)*	*5.21 (2.20-12.07)*	*9.65 (5.14-17.74)*	*15.55 (8.84-26.55)*		
Patellofemoral	**<55**	**1,059**	**2.50 (1.70-3.68)**	**10.09 (8.29-12.24)**	**15.30 (12.99-17.97)**	*24.12 (20.69-28.02)*	*31.24 (26.06-37.16)*		**4,513**	**1.00 (0.74-1.35)**	**6.75 (5.99-7.59)**	**10.60 (9.61-11.68)**	**21.17 (19.43-23.05)**	*25.24 (22.74-27.97)*	*30.24 (24.87-36.46)*
All types	**55-64**	**129,329**	**0.70 (0.66-0.75)**	**2.58 (2.49-2.68)**	**3.78 (3.66-3.90)**	**6.13 (5.95-6.31)**	**7.98 (7.70-8.27)**	**9.16 (8.67-9.66)**	**155,063**	**0.49 (0.46-0.53)**	**2.29 (2.21-2.38)**	**3.43 (3.33-3.54)**	**5.72 (5.57-5.89)**	**7.36 (7.11-7.61)**	**8.51 (8.08-8.95)**
All cemented	**55-64**	**100,592**	**0.62 (0.57-0.67)**	**2.30 (2.20-2.40)**	**3.30 (3.18-3.43)**	**5.05 (4.87-5.24)**	**6.38 (6.10-6.68)**	**7.20 (6.74-7.69)**	**127,283**	**0.41 (0.37-0.45)**	**1.94 (1.86-2.03)**	**2.83 (2.73-2.94)**	**4.44 (4.29-4.60)**	**5.59 (5.35-5.84)**	**6.26 (5.87-6.68)**
unconstrained, fixed	55-64	68,572	0.53 (0.47-0.58)	2.11 (1.99-2.23)	3.01 (2.87-3.16)	4.49 (4.28-4.71)	5.92 (5.57-6.30)	6.77 (6.19-7.40)	86,280	0.38 (0.34-0.42)	1.80 (1.70-1.90)	2.55 (2.43-2.67)	3.94 (3.77-4.13)	5.06 (4.77-5.36)	5.92 (5.40-6.49)
unconstrained, mobile	55-64	4,435	0.78 (0.56-1.09)	2.72 (2.27-3.25)	3.81 (3.26-4.44)	5.94 (5.20-6.79)	6.52 (5.68-7.49)	*9.25 (6.47-13.15)*	5,319	0.54 (0.37-0.78)	2.29 (1.91-2.75)	3.39 (2.91-3.94)	5.18 (4.53-5.91)	6.52 (5.57-7.61)	*7.11 (5.72-8.82)*
posterior-stabilised, fixed	55-64	23,156	0.79 (0.68-0.91)	2.68 (2.47-2.92)	3.97 (3.69-4.26)	6.29 (5.87-6.74)	7.71 (7.10-8.38)	*8.23 (7.45-9.08)*	30,180	0.44 (0.37-0.53)	2.22 (2.05-2.41)	3.40 (3.18-3.65)	5.40 (5.06-5.76)	6.45 (5.97-6.98)	*6.76 (6.16-7.41)*
posterior-stabilised, mobile	55-64	1,839	0.83 (0.50-1.37)	2.48 (1.85-3.32)	2.99 (2.28-3.90)	4.97 (3.91-6.30)	*5.37 (4.21-6.85)*	*5.37 (4.21-6.85)*	2,084	0.39 (0.19-0.77)	1.86 (1.35-2.56)	3.15 (2.45-4.04)	4.97 (4.01-6.15)	*6.44 (4.79-8.62)*	*6.44 (4.79-8.62)*
constrained condylar	55-64	865	0.75 (0.34-1.66)	2.11 (1.24-3.57)	*3.39 (2.06-5.54)*	*3.39 (2.06-5.54)*	*3.39 (2.06-5.54)*		1,195	0.72 (0.36-1.45)	2.48 (1.63-3.78)	2.48 (1.63-3.78)	*6.23 (3.44-11.16)*	*7.91 (4.25-14.47)*	
monobloc polyethylene tibia	55-64	780	0.83 (0.37-1.84)	2.17 (1.28-3.65)	3.92 (2.57-5.94)	*5.26 (3.42-8.03)*	*5.26 (3.42-8.03)*		1,035	0.30 (0.10-0.93)	1.69 (1.00-2.85)	2.75 (1.76-4.28)	*4.41 (2.78-6.97)*	*7.87 (4.44-13.76)*	
bearing type unknown	55-64	945	1.50 (0.89-2.52)	4.19 (3.07-5.71)	5.14 (3.87-6.81)	7.40 (5.71-9.57)	*9.14 (6.97-11.95)*	*9.14 (6.97-11.95)*	1,190	0.94 (0.52-1.69)	3.17 (2.30-4.37)	4.43 (3.37-5.83)	7.18 (5.72-8.99)	*8.59 (6.60-11.13)*	*8.59 (6.60-11.13)*
All uncemented	**55-64**	**6,025**	**0.61 (0.44-0.85)**	**2.25 (1.89-2.67)**	**3.28 (2.83-3.80)**	**5.26 (4.63-5.97)**	**6.80 (5.87-7.88)**	*7.22 (6.15-8.47)*	**5,828**	**0.60 (0.43-0.84)**	**2.45 (2.07-2.90)**	**3.57 (3.10-4.11)**	**5.29 (4.66-5.99)**	**6.54 (5.71-7.50)**	*8.65 (6.74-11.07)*
unconstrained, fixed	55-64	2,353	0.48 (0.27-0.87)	2.47 (1.89-3.23)	3.53 (2.80-4.44)	5.95 (4.91-7.21)	*6.93 (5.60-8.56)*	*8.12 (6.19-10.62)*	2,146	0.68 (0.40-1.14)	2.68 (2.05-3.50)	3.49 (2.75-4.41)	5.28 (4.31-6.47)	*6.59 (5.32-8.15)*	*8.45 (5.95-11.93)*
unconstrained, mobile	55-64	2,976	0.55 (0.34-0.90)	2.09 (1.62-2.69)	3.17 (2.57-3.92)	4.47 (3.69-5.40)	*6.42 (5.10-8.07)*	*6.42 (5.10-8.07)*	3,192	0.54 (0.34-0.87)	2.32 (1.83-2.92)	3.58 (2.95-4.33)	5.05 (4.24-6.02)	5.86 (4.85-7.07)	*8.57 (5.74-12.71)*
posterior-stabilised, fixed	55-64	574	1.06 (0.48-2.35)	1.81 (0.98-3.33)	2.23 (1.27-3.90)	*6.41 (4.23-9.66)*	*8.44 (5.33-13.24)*		397	0.78 (0.25-2.39)	2.93 (1.64-5.24)	4.47 (2.76-7.21)	*8.05 (5.46-11.80)*	*12.62 (8.09-19.41)*	

Note: Total sample on which results are based is 1,193,830 primary knee replacements. Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Table 3.26 (continued)

Fixation/constraint/ bearing type	Age at primary (years)	Males							Females						
		n	Time since primary						n	Time since primary					
			1 year	3 years	5 years	10 years	13 years	15 years		1 year	3 years	5 years	10 years	13 years	15 years
other constraint	55-64	49	*2.13 (0.30-14.16)*	*4.40 (1.12-16.50)*	*4.40 (1.12-16.50)*				25	*0*	*0*	*0*			
bearing type unknown	55-64	73	*2.74 (0.69-10.51)*	*4.19 (1.37-12.44)*	*7.36 (3.12-16.83)*	*7.36 (3.12-16.83)*	*7.36 (3.12-16.83)*		68	*0*	*0*	*1.72 (0.24-11.62)*	*1.72 (0.24-11.62)*	*1.72 (0.24-11.62)*	
Hybrid	**55-64**	**1,073**	**0.47 (0.20-1.14)**	**1.85 (1.18-2.88)**	**3.13 (2.21-4.42)**	**4.84 (3.59-6.51)**	*7.04 (5.16-9.57)*	*7.04 (5.16-9.57)*	**1,259**	**0.56 (0.27-1.18)**	**2.27 (1.56-3.29)**	**3.14 (2.28-4.34)**	**4.44 (3.34-5.89)**	*4.67 (3.51-6.22)*	*4.67 (3.51-6.22)*
unconstrained, fixed	55-64	675	0.30 (0.08-1.20)	1.53 (0.82-2.82)	2.95 (1.89-4.59)	4.11 (2.79-6.05)	*5.63 (3.83-8.23)*	*5.63 (3.83-8.23)*	801	0.88 (0.42-1.84)	2.58 (1.67-3.97)	3.40 (2.32-4.95)	4.79 (3.45-6.62)	*5.09 (3.67-7.04)*	*5.09 (3.67-7.04)*
unconstrained, mobile	55-64	223	*0.90 (0.23-3.56)*	*0.90 (0.23-3.56)*	*1.62 (0.51-5.09)*	*1.62 (0.51-5.09)*	*4.51 (1.21-16.05)*		311	0	*1.45 (0.54-3.84)*	*1.99 (0.82-4.81)*	*1.99 (0.82-4.81)*	*1.99 (0.82-4.81)*	
posterior-stabilised, fixed	55-64	80	*0*	*2.84 (0.72-10.88)*	*4.33 (1.42-12.85)*	*8.45 (3.53-19.53)*			82	*0*	*2.58 (0.65-9.93)*	*5.36 (2.05-13.68)*	*8.47 (3.88-17.95)*		
other constraint	55-64	75	*1.33 (0.19-9.09)*	*5.37 (2.05-13.68)*	*6.90 (2.92-15.81)*	*11.42 (5.40-23.27)*			54	*0*	*1.96 (0.28-13.11)*	*1.96 (0.28-13.11)*	*1.96 (0.28-13.11)*		
bearing type unknown	55-64	20	*0*	*5.26 (0.76-31.88)*	*5.26 (0.76-31.88)*				11	*0*	*0*				
Unicondylar	**55-64**	**20,612**	**1.10 (0.96-1.26)**	**3.97 (3.69-4.28)**	**6.01 (5.64-6.39)**	**10.84 (10.25-11.47)**	**14.86 (13.92-15.86)**	*18.08 (16.09-20.27)*	**17,245**	**0.99 (0.85-1.16)**	**4.18 (3.87-4.52)**	**6.52 (6.11-6.96)**	**12.36 (11.68-13.07)**	**16.60 (15.53-17.72)**	*20.00 (18.20-21.95)*
fixed	55-64	7,526	0.58 (0.43-0.79)	2.87 (2.47-3.33)	5.05 (4.47-5.71)	9.08 (8.05-10.22)	*14.13 (12.10-16.47)*	*17.97 (13.55-23.63)*	5,985	0.69 (0.50-0.95)	3.95 (3.43-4.55)	6.05 (5.36-6.83)	11.19 (9.96-12.57)	*14.73 (12.79-16.92)*	*18.71 (14.96-23.27)*
mobile	55-64	12,917	1.38 (1.19-1.61)	4.54 (4.17-4.95)	6.53 (6.07-7.02)	11.58 (10.86-12.35)	15.36 (14.29-16.50)	*18.49 (16.28-20.95)*	11,105	1.16 (0.97-1.38)	4.31 (3.93-4.73)	6.78 (6.28-7.32)	12.92 (12.11-13.78)	17.46 (16.19-18.81)	*20.75 (18.71-22.98)*
bearing type unknown	55-64	169	*1.78 (0.58-5.40)*	*5.38 (2.84-10.09)*	*6.02 (3.28-10.90)*	*13.07 (8.45-19.92)*	*13.07 (8.45-19.92)*		155	*0*	*3.37 (1.42-7.92)*	*4.08 (1.86-8.87)*	*7.28 (3.77-13.82)*	*7.28 (3.77-13.82)*	
Patellofemoral	**55-64**	**1,022**	**2.03 (1.32-3.13)**	**6.02 (4.65-7.77)**	**10.94 (8.97-13.32)**	*23.04 (19.37-27.28)*	*32.68 (26.28-40.16)*		**3,442**	**0.91 (0.63-1.29)**	**5.48 (4.73-6.36)**	**9.56 (8.51-10.72)**	**18.22 (16.53-20.07)**	*23.55 (21.00-26.36)*	*25.20 (21.89-28.92)*
All types	**65-74**	**205,760**	**0.51 (0.48-0.54)**	**1.71 (1.66-1.78)**	**2.40 (2.33-2.48)**	**3.79 (3.67-3.91)**	**4.81 (4.62-5.00)**	**5.39 (5.10-5.70)**	**253,787**	**0.36 (0.34-0.39)**	**1.50 (1.45-1.55)**	**2.21 (2.15-2.28)**	**3.58 (3.47-3.68)**	**4.29 (4.15-4.44)**	**4.73 (4.51-4.97)**
All cemented	**65-74**	**175,118**	**0.45 (0.42-0.48)**	**1.53 (1.47-1.60)**	**2.16 (2.08-2.23)**	**3.26 (3.15-3.38)**	**4.00 (3.82-4.18)**	**4.50 (4.20-4.82)**	**225,702**	**0.32 (0.30-0.35)**	**1.32 (1.27-1.37)**	**1.94 (1.87-2.00)**	**2.97 (2.87-3.07)**	**3.46 (3.33-3.60)**	**3.74 (3.55-3.94)**
unconstrained, fixed	65-74	121,055	0.42 (0.39-0.46)	1.40 (1.33-1.47)	1.97 (1.88-2.06)	2.87 (2.74-3.01)	3.61 (3.39-3.83)	4.06 (3.70-4.45)	152,476	0.27 (0.24-0.29)	1.21 (1.15-1.27)	1.73 (1.66-1.81)	2.69 (2.57-2.81)	3.13 (2.98-3.30)	3.37 (3.16-3.60)
unconstrained, mobile	65-74	6,260	0.46 (0.32-0.67)	1.86 (1.54-2.24)	2.64 (2.25-3.10)	4.15 (3.60-4.78)	4.47 (3.86-5.17)	*4.84 (3.96-5.91)*	8,083	0.43 (0.31-0.60)	1.72 (1.45-2.04)	2.48 (2.14-2.88)	3.90 (3.43-4.43)	4.53 (3.95-5.20)	*4.53 (3.95-5.20)*
posterior-stabilised, fixed	65-74	40,510	0.51 (0.45-0.59)	1.77 (1.64-1.92)	2.50 (2.33-2.68)	4.06 (3.80-4.35)	4.89 (4.51-5.31)	5.56 (4.92-6.27)	55,098	0.41 (0.36-0.47)	1.48 (1.37-1.59)	2.28 (2.14-2.43)	3.41 (3.20-3.62)	3.99 (3.71-4.29)	4.44 (3.99-4.95)
posterior-stabilised, mobile	65-74	1,979	0.52 (0.28-0.96)	1.95 (1.41-2.69)	2.79 (2.11-3.67)	3.60 (2.72-4.74)	*4.70 (3.44-6.41)*	*4.70 (3.44-6.41)*	2,350	0.65 (0.39-1.07)	2.03 (1.52-2.71)	2.63 (2.03-3.41)	3.94 (3.07-5.06)	*4.43 (3.38-5.78)*	*4.43 (3.38-5.78)*

Note: Total sample on which results are based is 1,193,830 primary knee replacements. Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Table 3.26 (continued)

Fixation/constraint/ bearing type	Age at primary (years)	Males							Females						
		n	Time since primary						n	Time since primary					
			1 year	3 years	5 years	10 years	13 years	15 years		1 year	3 years	5 years	10 years	13 years	15 years
constrained condylar	65-74	1,295	0.77 (0.40-1.48)	2.75 (1.87-4.05)	3.95 (2.75-5.66)	*5.74 (3.62-9.04)*	*5.74 (3.62-9.04)*		2,190	0.88 (0.55-1.39)	2.42 (1.78-3.29)	3.15 (2.33-4.26)	*3.34 (2.46-4.53)*	*3.34 (2.46-4.53)*	
monobloc polyethylene tibia	65-74	2,455	0.13 (0.04-0.41)	1.51 (1.06-2.15)	2.03 (1.47-2.81)	*2.39 (1.73-3.31)*	*3.07 (1.86-5.03)*		3,668	0.35 (0.20-0.62)	1.63 (1.24-2.15)	2.24 (1.75-2.88)	2.74 (2.11-3.56)	*3.22 (2.23-4.66)*	
bearing type unknown	65-74	1,564	0.78 (0.44-1.37)	2.70 (1.99-3.66)	3.23 (2.44-4.28)	4.62 (3.57-5.96)	*5.28 (3.93-7.07)*	*5.28 (3.93-7.07)*	1,837	0.50 (0.26-0.95)	1.38 (0.93-2.06)	2.42 (1.78-3.29)	3.74 (2.84-4.92)	*4.23 (3.16-5.65)*	*4.23 (3.16-5.65)*
All uncemented	**65-74**	**8,559**	**0.58 (0.44-0.77)**	**1.82 (1.55-2.14)**	**2.39 (2.06-2.76)**	**3.49 (3.05-4.00)**	**4.55 (3.81-5.43)**	*5.25 (4.23-6.51)*	**8,534**	**0.49 (0.36-0.66)**	**2.27 (1.96-2.62)**	**3.00 (2.63-3.41)**	**3.89 (3.45-4.39)**	**4.42 (3.88-5.03)**	*4.95 (4.08-6.00)*
unconstrained, fixed	65-74	3,285	0.60 (0.38-0.94)	2.27 (1.79-2.87)	2.91 (2.35-3.60)	3.98 (3.26-4.86)	*4.70 (3.63-6.08)*	*4.70 (3.63-6.08)*	3,007	0.48 (0.28-0.81)	2.68 (2.14-3.35)	3.22 (2.62-3.97)	3.96 (3.25-4.82)	4.55 (3.67-5.64)	*4.55 (3.67-5.64)*
unconstrained, mobile	65-74	4,524	0.52 (0.35-0.78)	1.52 (1.19-1.94)	1.92 (1.53-2.39)	3.03 (2.47-3.72)	4.44 (3.38-5.82)	*5.53 (3.90-7.82)*	4,936	0.53 (0.36-0.78)	2.06 (1.69-2.51)	2.90 (2.45-3.45)	3.85 (3.27-4.53)	4.27 (3.60-5.07)	*4.61 (3.72-5.70)*
posterior-stabilised, fixed	65-74	590	0.89 (0.37-2.12)	1.88 (1.01-3.47)	2.61 (1.52-4.48)	*3.31 (1.97-5.54)*	*4.00 (2.32-6.83)*		484	0.21 (0.03-1.46)	2.17 (1.13-4.13)	2.98 (1.70-5.21)	*4.24 (2.53-7.07)*	*5.00 (2.95-8.41)*	
other constraint	65-74	79	*1.27 (0.18-8.65)*	*2.58 (0.65-9.94)*	*2.58 (0.65-9.94)*				29	*0*	*0*	*0*			
bearing type unknown	65-74	81	*0*	*0*	*5.32 (2.03-13.56)*	*9.05 (4.05-19.53)*	*9.05 (4.05-19.53)*		78	*0*	*1.41 (0.20-9.58)*	*1.41 (0.20-9.58)*	*3.55 (0.87-13.87)*	*6.39 (2.01-19.31)*	
Hybrid	**65-74**	**1,653**	**0.55 (0.29-1.06)**	**1.92 (1.35-2.74)**	**2.22 (1.59-3.10)**	**3.22 (2.38-4.33)**	*3.43 (2.53-4.64)*	*3.43 (2.53-4.64)*	**1,893**	**0.53 (0.29-0.99)**	**1.72 (1.21-2.43)**	**1.91 (1.37-2.66)**	**2.67 (1.99-3.59)**	**3.01 (2.22-4.07)**	*3.34 (2.39-4.67)*
unconstrained, fixed	65-74	1,177	0.26 (0.08-0.80)	1.61 (1.02-2.54)	1.90 (1.24-2.90)	2.79 (1.92-4.05)	*3.06 (2.09-4.47)*	*3.06 (2.09-4.47)*	1,283	0.32 (0.12-0.84)	1.28 (0.79-2.09)	1.28 (0.79-2.09)	2.15 (1.46-3.17)	2.57 (1.73-3.81)	*2.96 (1.92-4.55)*
unconstrained, mobile	65-74	296	1.39 (0.52-3.66)	*2.17 (0.98-4.78)*	*2.73 (1.29-5.72)*	*3.51 (1.70-7.16)*	*3.51 (1.70-7.16)*		446	1.36 (0.61-3.01)	2.90 (1.65-5.06)	*3.73 (2.19-6.33)*	*4.26 (2.52-7.15)*	*4.26 (2.52-7.15)*	
posterior-stabilised, fixed	65-74	90	*1.16 (0.16-7.97)*	*3.68 (1.20-10.99)*	*3.68 (1.20-10.99)*	*5.87 (2.15-15.50)*			99	*0*	*1.22 (0.17-8.34)*	*2.52 (0.64-9.71)*	*2.52 (0.64-9.71)*	*2.52 (0.64-9.71)*	
other constraint	65-74	67	*0*	*0*	*0*	*0*			43	*0*	*0*	*0*	*0*		
bearing type unknown	65-74	23	*4.35 (0.62-27.07)*	*14.60 (4.89-39.15)*	*14.60 (4.89-39.15)*				22	*0*	*9.52 (2.47-33.00)*	*9.52 (2.47-33.00)*			
Unicondylar	**65-74**	**19,713**	**0.94 (0.81-1.09)**	**3.10 (2.85-3.38)**	**4.42 (4.10-4.77)**	**8.10 (7.53-8.70)**	**11.79 (10.78-12.89)**	*13.22 (11.72-14.89)*	**15,532**	**0.79 (0.66-0.95)**	**3.11 (2.82-3.42)**	**4.98 (4.60-5.41)**	**10.09 (9.39-10.83)**	**13.26 (12.22-14.37)**	*14.65 (13.24-16.20)*
fixed	65-74	6,621	0.71 (0.53-0.96)	3.12 (2.67-3.64)	4.43 (3.86-5.10)	6.81 (5.89-7.87)	*10.75 (8.61-13.39)*	*11.67 (9.04-15.01)*	5,063	0.41 (0.26-0.65)	2.48 (2.03-3.03)	3.91 (3.28-4.64)	7.22 (6.06-8.58)	*9.12 (7.52-11.04)*	*9.90 (7.83-12.49)*
mobile	65-74	12,969	1.06 (0.89-1.26)	3.11 (2.81-3.46)	4.43 (4.04-4.85)	8.50 (7.82-9.23)	12.10 (10.97-13.35)	*13.70 (11.94-15.70)*	10,333	0.98 (0.80-1.19)	3.41 (3.05-3.81)	5.46 (4.98-5.99)	11.03 (10.19-11.93)	14.53 (13.29-15.87)	*16.08 (14.40-17.94)*
bearing type unknown	65-74	123	*0*	*1.66 (0.42-6.48)*	*3.44 (1.30-8.92)*	*6.41 (3.10-13.04)*			136	*0*	*2.35 (0.76-7.11)*	*4.02 (1.69-9.40)*	*12.03 (6.91-20.49)*	*14.23 (8.20-24.05)*	
Patellofemoral	**65-74**	**710**	**2.05 (1.22-3.44)**	**7.02 (5.25-9.37)**	**10.47 (8.18-13.36)**	*20.18 (16.10-25.13)*	*20.18 (16.10-25.13)*		**2,119**	**0.89 (0.56-1.41)**	**5.33 (4.41-6.45)**	**8.36 (7.16-9.75)**	**17.16 (15.08-19.49)**	*21.63 (18.79-24.84)*	*26.87 (20.45-34.82)*

Note: Total sample on which results are based is 1,193,830 primary knee replacements. Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Table 3.26 (continued)

Fixation/constraint/ bearing type	Age at primary (years)	Males							Females						
		n	Time since primary						n	Time since primary					
			1 year	3 years	5 years	10 years	13 years	15 years		1 year	3 years	5 years	10 years	13 years	15 years
All types	**75+**	**145,057**	**0.40 (0.37-0.44)**	**1.11 (1.05-1.17)**	**1.48 (1.41-1.55)**	**2.19 (2.08-2.30)**	**2.47 (2.31-2.64)**	**2.63 (2.36-2.92)**	**215,203**	**0.38 (0.35-0.40)**	**1.04 (0.99-1.08)**	**1.42 (1.37-1.48)**	**2.07 (1.99-2.16)**	**2.48 (2.34-2.62)**	**2.62 (2.43-2.82)**
All cemented	**75+**	**129,705**	**0.37 (0.33-0.40)**	**1.02 (0.96-1.08)**	**1.35 (1.28-1.43)**	**1.94 (1.83-2.05)**	**2.16 (2.00-2.32)**	*2.26 (2.02-2.54)*	**198,069**	**0.34 (0.32-0.37)**	**0.94 (0.90-0.99)**	**1.27 (1.21-1.33)**	**1.81 (1.73-1.89)**	**2.10 (1.98-2.24)**	**2.18 (2.02-2.36)**
unconstrained, fixed	75+	88,159	0.35 (0.31-0.39)	0.98 (0.91-1.05)	1.27 (1.18-1.35)	1.83 (1.70-1.97)	1.99 (1.83-2.17)	*1.99 (1.83-2.17)*	130,095	0.31 (0.28-0.34)	0.90 (0.84-0.95)	1.19 (1.12-1.26)	1.71 (1.61-1.82)	1.92 (1.79-2.07)	1.92 (1.79-2.07)
unconstrained, mobile	75+	4,089	0.38 (0.23-0.63)	1.00 (0.73-1.38)	1.64 (1.25-2.13)	2.01 (1.56-2.60)	*2.56 (1.61-4.07)*	*2.56 (1.61-4.07)*	7,016	0.44 (0.31-0.63)	1.01 (0.79-1.29)	1.44 (1.16-1.78)	1.94 (1.58-2.37)	2.60 (1.92-3.50)	*2.60 (1.92-3.50)*
posterior-stabilised, fixed	75+	30,891	0.40 (0.33-0.48)	1.11 (0.99-1.25)	1.52 (1.37-1.69)	2.21 (1.98-2.48)	2.55 (2.21-2.93)	*2.96 (2.20-3.99)*	50,097	0.37 (0.32-0.43)	1.02 (0.92-1.11)	1.41 (1.30-1.53)	2.01 (1.84-2.18)	2.31 (2.07-2.58)	*2.63 (2.16-3.19)*
posterior-stabilised, mobile	75+	1,111	0.65 (0.31-1.36)	1.58 (0.97-2.56)	1.73 (1.07-2.78)	*2.13 (1.34-3.38)*	*2.13 (1.34-3.38)*		1,700	0.54 (0.28-1.03)	1.00 (0.61-1.63)	1.42 (0.93-2.19)	1.78 (1.18-2.69)	*2.49 (1.33-4.65)*	
constrained condylar	75+	1,075	1.04 (0.56-1.93)	1.98 (1.20-3.25)	*1.98 (1.20-3.25)*	*2.81 (1.43-5.49)*			2,387	0.89 (0.57-1.38)	1.50 (1.03-2.18)	1.98 (1.37-2.88)	*2.27 (1.51-3.40)*	*2.27 (1.51-3.40)*	
monobloc polyethylene tibia	75+	3,217	0.27 (0.13-0.53)	1.10 (0.76-1.58)	1.39 (0.99-1.95)	*1.64 (1.17-2.30)*			4,681	0.39 (0.24-0.63)	0.81 (0.57-1.13)	1.12 (0.82-1.54)	1.61 (1.13-2.31)	*1.61 (1.13-2.31)*	
bearing type unknown	75+	1,163	0.09 (0.01-0.62)	0.67 (0.32-1.40)	1.05 (0.56-1.95)	*1.87 (1.06-3.29)*	*1.87 (1.06-3.29)*		2,093	0.63 (0.37-1.08)	1.29 (0.87-1.90)	1.81 (1.29-2.54)	2.47 (1.80-3.40)	*4.37 (2.49-7.60)*	*4.37 (2.49-7.60)*
All uncemented	**75+**	**5,439**	**0.48 (0.32-0.71)**	**1.31 (1.03-1.68)**	**1.76 (1.42-2.19)**	**2.33 (1.90-2.87)**	*2.33 (1.90-2.87)*	*2.33 (1.90-2.87)*	**6,988**	**0.56 (0.40-0.76)**	**1.30 (1.05-1.61)**	**1.61 (1.32-1.95)**	**1.95 (1.62-2.36)**	**2.96 (2.20-3.97)**	*3.30 (2.36-4.59)*
unconstrained, fixed	75+	2,072	0.56 (0.31-1.00)	1.17 (0.77-1.78)	1.66 (1.15-2.38)	2.06 (1.45-2.92)	*2.06 (1.45-2.92)*		2,624	0.75 (0.48-1.17)	1.50 (1.09-2.06)	1.85 (1.38-2.48)	1.85 (1.38-2.48)	*3.25 (1.98-5.33)*	
unconstrained, mobile	75+	2,925	0.49 (0.29-0.83)	1.33 (0.95-1.84)	1.72 (1.27-2.32)	2.30 (1.73-3.06)	*2.30 (1.73-3.06)*		3,804	0.43 (0.26-0.70)	1.21 (0.90-1.63)	1.41 (1.07-1.87)	1.92 (1.47-2.52)	*2.36 (1.74-3.19)*	*3.00 (1.85-4.84)*
posterior-stabilised, fixed	75+	344	0	*2.24 (1.01-4.92)*	*3.10 (1.56-6.13)*	*4.45 (2.36-8.30)*	*4.45 (2.36-8.30)*		465	0.44 (0.11-1.76)	0.95 (0.36-2.52)	*2.11 (0.99-4.48)*	*3.71 (1.94-7.04)*	*6.63 (2.62-16.27)*	*6.63 (2.62-16.27)*
other constraint	75+	43	*0*	*2.50 (0.36-16.45)*	*2.50 (0.36-16.45)*				11	*0*	*0*				
bearing type unknown	75+	55	*0*	*0*	*0*	*2.94 (0.42-19.10)*			84	*1.20 (0.17-8.25)*	*1.20 (0.17-8.25)*	*1.20 (0.17-8.25)*	*1.20 (0.17-8.25)*	*1.20 (0.17-8.25)*	
Hybrid	**75+**	**1,138**	**0.45 (0.19-1.09)**	**0.94 (0.51-1.75)**	**1.35 (0.78-2.34)**	**1.99 (1.18-3.35)**	*1.99 (1.18-3.35)*		**1,657**	**0.68 (0.38-1.23)**	**1.34 (0.88-2.06)**	**1.58 (1.06-2.36)**	**2.12 (1.46-3.07)**	*2.12 (1.46-3.07)*	*2.12 (1.46-3.07)*
unconstrained, fixed	75+	802	0.39 (0.13-1.21)	0.94 (0.45-1.96)	1.47 (0.79-2.72)	*2.24 (1.27-3.93)*	*2.24 (1.27-3.93)*		1,118	0.64 (0.30-1.33)	1.21 (0.70-2.07)	1.53 (0.94-2.49)	2.07 (1.33-3.22)	*2.07 (1.33-3.22)*	*2.07 (1.33-3.22)*
unconstrained, mobile	75+	203	*0.99 (0.25-3.89)*	*0.99 (0.25-3.89)*	*0.99 (0.25-3.89)*	*0.99 (0.25-3.89)*			397	1.05 (0.40-2.78)	1.37 (0.57-3.28)	*1.37 (0.57-3.28)*	*2.30 (0.89-5.83)*		
posterior-stabilised, fixed	75+	62	*0*	*2.17 (0.31-14.45)*	*2.17 (0.31-14.45)*	*2.17 (0.31-14.45)*			81	*0*	*4.64 (1.52-13.74)*	*4.64 (1.52-13.74)*	*4.64 (1.52-13.74)*		

Note: Total sample on which results are based is 1,193,830 primary knee replacements. Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Table 3.26 (continued)

Fixation/constraint/ bearing type	Age at primary (years)	Males							Females						
		n	Time since primary						n	Time since primary					
			1 year	3 years	5 years	10 years	13 years	15 years		1 year	3 years	5 years	10 years	13 years	15 years
other constraint	75+	57	*0*	*0*	*0*	*0*			42	*0*	*0*	*0*	*0*		
bearing type unknown	75+	14	*0*	*0*					19	*0*	*0*	*0*			
Unicondylar	**75+**	**8,307**	**0.91 (0.72-1.14)**	**2.29 (1.96-2.67)**	**3.14 (2.72-3.62)**	**5.72 (4.95-6.61)**	*7.15 (5.86-8.71)*	*8.10 (6.07-10.76)*	**7,371**	**1.07 (0.85-1.34)**	**2.98 (2.59-3.44)**	**4.59 (4.06-5.18)**	**7.92 (7.07-8.86)**	*9.86 (8.53-11.38)*	*11.10 (9.05-13.57)*
fixed	75+	2,796	0.47 (0.27-0.83)	1.41 (0.98-2.01)	2.33 (1.69-3.21)	*4.58 (3.17-6.60)*	*7.33 (3.97-13.34)*		2,414	0.75 (0.46-1.22)	2.45 (1.83-3.28)	3.54 (2.72-4.59)	5.83 (4.53-7.49)	*6.21 (4.76-8.09)*	
mobile	75+	5,459	1.12 (0.87-1.45)	2.69 (2.26-3.20)	3.53 (3.01-4.14)	6.03 (5.15-7.06)	*7.23 (5.88-8.87)*	*8.36 (6.08-11.45)*	4,898	1.22 (0.94-1.58)	3.19 (2.71-3.77)	4.95 (4.30-5.69)	8.35 (7.35-9.48)	*10.82 (9.15-12.76)*	*12.34 (9.84-15.43)*
bearing type unknown	75+	52	*0*	*2.08 (0.30-13.88)*	*2.08 (0.30-13.88)*	*15.76 (6.60-35.01)*			59	*1.75 (0.25-11.81)*	*5.54 (1.82-16.24)*	*9.61 (4.10-21.63)*	*26.49 (14.51-45.36)*		
Patellofemoral	**75+**	**461**	**0.47 (0.12-1.87)**	**3.22 (1.84-5.61)**	*4.38 (2.64-7.24)*	*6.76 (3.91-11.57)*			**1,108**	**0.56 (0.25-1.25)**	**2.91 (2.02-4.20)**	**5.94 (4.53-7.76)**	*9.35 (7.26-12.01)*	*9.35 (7.26-12.01)*	
Unclassified		**15**							**24**						

Note: Total sample on which results are based is 1,193,830 primary knee replacements. Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Unicompartmental knee replacements seem to fare worse compared to TKR with the chance of revision at each estimated time point being approximately double or more than that of a TKR (Table 3.25 and 3.26). The revision rate for unicondylar (medial or lateral UKR) knee replacements is 2.8 times higher than the observed rate for all types of knee replacement at 15 years and 3.8 times higher than the observed rate for all types of cemented TKR. The revision rate for patellofemoral replacement is over four times higher than all types of knee replacement at 13 and 15 years and 5.6 times higher than all types of cemented TKR, although less than 250 remain at risk at 15 years. First revision of an implant is slightly less likely in females than males overall for the most commonly used fixation method (cemented) but, broadly, a patient from a younger age group is more likely to be revised irrespective of gender, with the youngest group having the worst predicted outcome in terms of the risk of subsequent revision. Conversely, female patients are more likely to have a unicondylar implant revised in the longer term compared to their male, age equivalent counterpart, except for under the age of 55. For patellofemoral implants, males are generally more likely to undergo revision than their age-matched female counterparts.

3.4.3 Revisions after primary knee replacement surgery by main brands for TKR and UKR

As in previous reports, we have only included those brands that have been used in a primary knee replacement in 1,000 or more operations (Tables 3.27 and 3.28). In Table 3.29, brands are displayed where there are more than 2,500 operations for TKR and more than 1,000 operations for UKR. The figures in blue italics are at time points where fewer than 250 primary knee replacements remain at risk. No results are shown at all where the number had fallen below ten cases. No attempt has been made to adjust for other factors that may influence the chance of revision so the figures are unadjusted probabilities. Given that the sub-groups may differ in composition with respect to age and gender, the percentage of males and the median (IQR) of the ages are also shown in these tables.

Table 3.27 KM estimates of cumulative **revision** (95% CI) by **total knee** replacement **brands**.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

Brand[1]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
All total knee replacements	1,070,873	70 (63-76)	43	0.42 (0.41-0.43)	1.56 (1.53-1.58)	2.23 (2.20-2.26)	3.45 (3.40-3.50)	4.27 (4.20-4.35)	4.81 (4.69-4.95)
ACS porous coated	1,114	68 (61-73)	50	0.73 (0.36-1.45)	2.42 (1.64-3.56)	3.05 (2.14-4.35)			
Advance MP	8,842	70 (64-76)	47	0.52 (0.39-0.70)	2.08 (1.80-2.42)	2.96 (2.60-3.37)	4.33 (3.82-4.92)	5.04 (4.25-5.96)	*5.04 (4.25-5.96)*
Advance MP Stature	1,461	69 (62-75)	14	0.07 (0.01-0.50)	1.68 (1.11-2.54)	2.71 (1.93-3.81)	*2.99 (2.09-4.26)*		
Advance PS	1,303	72 (66-77)	45	0.64 (0.32-1.27)	2.54 (1.77-3.64)	3.19 (2.30-4.43)	6.40 (4.74-8.60)	*7.53 (5.41-10.45)*	*7.53 (5.41-10.45)*
AGC	29,196	71 (64-77)	42	0.30 (0.25-0.38)	1.57 (1.43-1.72)	2.18 (2.01-2.36)	3.62 (3.35-3.91)	4.96 (4.50-5.46)	*5.65 (4.83-6.59)*
AGC V2	39,287	71 (65-77)	43	0.31 (0.26-0.37)	1.52 (1.40-1.64)	2.18 (2.04-2.34)	3.57 (3.36-3.79)	4.96 (4.62-5.32)	6.12 (5.47-6.85)
AS Columbus Cemented	1,446	64 (59-70)	38	0.22 (0.07-0.69)	1.61 (0.98-2.64)	*2.03 (1.24-3.31)*			
Attune	23,724	69 (62-76)	43	0.39 (0.31-0.49)	1.55 (1.34-1.80)	2.67 (2.09-3.41)			

†denotes a brand that has been discontinued/withdrawn/not implanted in last three years.
[1]Brands shown have been used in at least 1,000 primary total knee replacement operations. Excludes 7,516 primary operations where the knee brand was not recorded.
Note: Blank cells indicate the number at risk is below ten and therefore estimates are omitted as they are unreliable.

Table 3.27 (continued)

Brand[1]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
Columbus Cemented	13,650	71 (65-77)	44	0.44 (0.34-0.58)	1.62 (1.40-1.88)	2.33 (2.04-2.66)	3.28 (2.80-3.85)	*3.81 (2.96-4.89)*	
E-Motion Bicondylar Knee	3,333	67 (61-74)	45	0.67 (0.44-1.02)	2.66 (2.15-3.29)	3.53 (2.92-4.26)	4.84 (4.01-5.83)	*5.63 (4.55-6.96)*	
EvolutionMP	1,152	69 (62-75)	44	0.78 (0.39-1.55)	2.42 (1.53-3.82)	*3.30 (2.01-5.40)*			
Genesis II	74,851	71 (65-77)	42	0.45 (0.40-0.50)	1.55 (1.45-1.65)	2.12 (2.00-2.25)	3.15 (2.96-3.35)	3.45 (3.17-3.75)	*3.45 (3.17-3.75)*
Genesis II Oxinium	10,154	59 (54-64)	40	0.55 (0.42-0.72)	2.36 (2.06-2.71)	3.50 (3.11-3.93)	5.95 (5.30-6.67)	7.36 (6.33-8.55)	*7.97 (6.50-9.76)*
Insall-Burstein II Microport	2,059	71 (65-77)	45	0.34 (0.16-0.72)	1.76 (1.27-2.44)	2.92 (2.26-3.77)	5.11 (4.18-6.23)	6.65 (5.49-8.06)	*7.13 (5.82-8.72)*
Journey II BCS Oxinium	2,620	65 (58-71)	41	0.70 (0.42-1.17)	3.50 (2.50-4.89)	*3.79 (2.68-5.35)*			
†Kinemax	11,090	71 (64-77)	43	0.25 (0.17-0.36)	1.76 (1.53-2.02)	2.71 (2.42-3.04)	4.76 (4.35-5.20)	5.98 (5.49-6.51)	6.53 (5.96-7.15)
†LCS	2,059	70 (63-76)	41	0.64 (0.37-1.09)	1.83 (1.33-2.52)	2.41 (1.82-3.18)	3.06 (2.38-3.94)	3.42 (2.68-4.36)	4.03 (3.17-5.11)
LCS Complete	27,842	70 (63-76)	44	0.45 (0.38-0.54)	1.69 (1.54-1.86)	2.55 (2.36-2.76)	3.74 (3.48-4.03)	4.55 (4.14-5.01)	
Legion	1,229	71 (65-77)	42	0.42 (0.18-1.02)	1.44 (0.87-2.38)	1.89 (1.18-3.02)			
Maxim	2,200	70 (63-77)	42	0.46 (0.25-0.85)	1.97 (1.46-2.66)	2.81 (2.19-3.62)	5.26 (4.30-6.43)	7.27 (5.86-9.01)	*8.46 (6.62-10.79)*
MRK	13,410	70 (64-77)	44	0.31 (0.23-0.43)	1.22 (1.03-1.45)	1.69 (1.45-1.97)	2.73 (2.35-3.18)	*3.18 (2.62-3.85)*	*4.14 (2.57-6.63)*
Natural Knee II	2,858	70 (64-76)	42	0.32 (0.17-0.61)	1.32 (0.96-1.82)	2.19 (1.70-2.81)	4.00 (3.27-4.90)	6.55 (5.23-8.17)	*7.44 (5.48-10.08)*
Nexgen	163,322	70 (63-76)	43	0.37 (0.34-0.41)	1.40 (1.34-1.47)	2.17 (2.09-2.25)	3.72 (3.58-3.86)	4.53 (4.32-4.75)	5.03 (4.64-5.45)
NRG	13,627	70 (64-76)	43	0.40 (0.31-0.52)	1.57 (1.37-1.80)	2.43 (2.17-2.72)	3.70 (3.31-4.13)		
Optetrak CR	1,675	70 (63-76)	43	0.90 (0.55-1.49)	3.55 (2.76-4.57)	4.92 (3.96-6.09)	7.82 (6.40-9.54)	*8.60 (6.97-10.59)*	
Persona CR	1,606	69 (63-75)	46	0.21 (0.07-0.65)	0.40 (0.13-1.21)				
PFC Sigma Bicondylar Knee	348,076	70 (64-76)	43	0.39 (0.37-0.41)	1.42 (1.38-1.46)	1.96 (1.91-2.01)	2.74 (2.67-2.81)	3.20 (3.10-3.30)	3.58 (3.41-3.75)
Profix	3,997	73 (67-78)	44	0.41 (0.25-0.66)	1.36 (1.04-1.78)	1.93 (1.54-2.42)	2.84 (2.34-3.45)	3.26 (2.64-4.02)	*4.30 (3.10-5.96)*
Profix Oxinium	1,008	61 (56-66)	43	0.80 (0.40-1.59)	2.91 (2.03-4.15)	3.31 (2.37-4.63)	4.75 (3.58-6.29)	*6.23 (4.72-8.22)*	*6.23 (4.72-8.22)*
Rotaglide	1,584	71 (63-77)	39	0.51 (0.26-1.02)	2.52 (1.83-3.46)	3.87 (2.96-5.04)	4.90 (3.79-6.32)	*7.42 (4.63-11.79)*	
†Rotaglide +	2,124	70 (63-76)	44	0.66 (0.39-1.12)	3.09 (2.43-3.94)	4.01 (3.24-4.95)	6.47 (5.44-7.70)	7.62 (6.43-9.03)	*8.67 (7.16-10.47)*
Saiph	1,091	69 (62-76)	35	0.55 (0.23-1.33)	1.34 (0.71-2.53)	*1.62 (0.87-3.02)*			
Scorpio	25,464	71 (64-77)	42	0.44 (0.36-0.53)	1.86 (1.70-2.04)	2.68 (2.48-2.89)	4.12 (3.86-4.38)	5.06 (4.74-5.41)	5.27 (4.88-5.70)

†denotes a brand that has been discontinued/withdrawn/not implanted in last three years.
[1]Brands shown have been used in at least 1,000 primary total knee replacement operations. Excludes 7,516 primary operations where the knee brand was not recorded.
Note: Blank cells indicate the number at risk is below ten and therefore estimates are omitted as they are unreliable.

Table 3.27 (continued)

Brand[1]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
Sphere	1,236	69 (62-75)	43	0.95 (0.52-1.70)	2.57 (1.68-3.90)	*3.52 (2.34-5.26)*			
TC Plus	15,932	70 (64-76)	45	0.70 (0.58-0.84)	1.83 (1.63-2.05)	2.43 (2.20-2.69)	3.59 (3.29-3.92)	4.21 (3.83-4.64)	*6.33 (4.15-9.59)*
Triathlon	113,137	70 (63-76)	43	0.49 (0.45-0.53)	1.54 (1.46-1.62)	2.15 (2.04-2.26)	3.40 (3.16-3.65)	*3.93 (3.47-4.45)*	
Unity Knee	1,185	70 (63-76)	45	0.29 (0.09-0.89)	0.99 (0.45-2.18)	*0.99 (0.45-2.18)*			
Vanguard	71,688	70 (63-76)	42	0.36 (0.32-0.41)	1.46 (1.37-1.57)	2.17 (2.04-2.31)	3.22 (2.92-3.55)		

†denotes a brand that has been discontinued/withdrawn/not implanted in last three years.
[1]Brands shown have been used in at least 1,000 primary total knee replacement operations. Excludes 7,516 primary operations where the knee brand was not recorded.
Note: Blank cells indicate the number at risk is below ten and therefore estimates are omitted as they are unreliable.

Tables 3.27 and 3.28 show the Kaplan-Meier estimates of the cumulative percentage probability of first revision, for any reason, of a primary TKR (Table 3.27) and primary UKR (Table 3.28) by implant brand.

Table 3.28 KM estimates of cumulative **revision** (95% CI) by **unicompartmental knee** replacement **brands**.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

Brand[1]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
All unicompartmental knee replacements	**122,910**	**63 (56-70)**	**50**	**1.08 (1.02-1.14)**	**4.17 (4.05-4.29)**	**6.44 (6.28-6.60)**	**12.11 (11.84-12.39)**	**16.28 (15.84-16.73)**	**19.13 (18.32-19.97)**
Unicondylar									
AMC/Uniglide	3,013	64 (57-71)	51	2.35 (1.87-2.96)	6.17 (5.35-7.11)	7.82 (6.89-8.88)	13.34 (11.95-14.89)	*19.01 (16.36-22.04)*	*19.01 (16.36-22.04)*
Journey Uni Oxinium	1,031	61 (55-68)	57	1.60 (0.95-2.70)	3.98 (2.70-5.84)	*6.79 (4.58-9.99)*			
†MG Uni	2,394	63 (56-70)	54	0.92 (0.61-1.40)	3.96 (3.25-4.82)	5.99 (5.10-7.03)	10.18 (8.99-11.52)	12.40 (10.92-14.07)	*14.90 (12.58-17.61)*
Oxford Partial Knee	68,098	64 (57-71)	53	1.14 (1.06-1.23)	3.90 (3.75-4.06)	5.96 (5.76-6.17)	11.32 (10.99-11.66)	15.36 (14.82-15.92)	18.36 (17.34-19.44)
*Physica ZUK	14,973	63 (56-70)	55	0.34 (0.26-0.46)	2.19 (1.93-2.48)	3.45 (3.08-3.86)	6.74 (5.87-7.75)	*8.84 (6.79-11.46)*	
†Preservation	1,524	62 (56-69)	55	2.57 (1.88-3.50)	8.09 (6.82-9.58)	11.61 (10.09-13.34)	17.78 (15.90-19.85)	23.29 (20.94-25.86)	*25.11 (22.32-28.18)*
Sigma HP (Uni)	10,445	63 (55-70)	57	0.75 (0.60-0.95)	3.21 (2.84-3.62)	4.62 (4.14-5.16)	*6.93 (6.03-7.97)*		
Triathlon Uni	1,235	62 (55-69)	54	1.44 (0.88-2.34)	5.12 (3.86-6.76)	8.23 (6.43-10.50)			

†denotes a brand that has been discontinued/withdrawn/not implanted in last three years.
*denotes that this brand is now marketed by Lima.
[1]Brands shown have been used in at least 1,000 primary total knee replacement operations. Excludes 154 primary operations where the knee brand was not recorded.
Note: Blank cells indicate the number at risk is below ten and therefore estimates are omitted as they are unreliable.

Table 3.28 (continued)

Brand[1]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
Patellofemoral									
Avon	6,067	58 (50-68)	22	0.74 (0.55-0.99)	4.29 (3.77-4.87)	7.46 (6.75-8.23)	15.22 (14.06-16.47)	19.41 (17.81-21.15)	*23.45 (20.21-27.11)*
FPV	1,646	59 (52-68)	23	0.92 (0.55-1.52)	6.99 (5.85-8.36)	10.13 (8.72-11.75)	*19.10 (16.65-21.87)*		
Journey PFJ Oxinium	1,930	58 (50-67)	23	2.05 (1.49-2.82)	7.82 (6.61-9.23)	13.33 (11.68-15.18)	*22.14 (19.71-24.82)*		
Sigma HP (PF)	1,323	58 (50-66)	23	2.81 (2.04-3.85)	9.16 (7.67-10.91)	13.76 (11.83-15.97)	*23.20 (19.72-27.18)*		
Zimmer PFJ	2,545	56 (50-65)	22	0.70 (0.43-1.14)	5.04 (4.13-6.15)	7.66 (6.42-9.14)	*15.67 (11.95-20.40)*		

†denotes a brand that has been discontinued/withdrawn/not implanted in last three years.
*denotes that this brand is now marketed by Lima.
[1]Brands shown have been used in at least 1,000 primary total knee replacement operations. Excludes 154 primary operations where the knee brand was not recorded.
Note: Blank cells indicate the number at risk is below ten and therefore estimates are omitted as they are unreliable.

Table 3.29 shows Kaplan-Meier estimates of the cumulative percentage probability of first revision of a primary TKR or primary UKR by implant brand and bearing/constraint type for those brands/bearing types which were implanted on at least 1,000 occasions for UKR and 2,500 occasions for TKR. Again, patient summaries of age and gender by brand are also given.

Table 3.29 KM estimates of cumulative **revision** (95% CI) by **fixation**, **constraint** and **brand**. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

Brand[1]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
Total knee replacements									
AGC									
Cemented, unconstrained, fixed	27,913	71 (64-77)	42	0.30 (0.24-0.37)	1.56 (1.41-1.72)	2.16 (1.99-2.35)	3.50 (3.23-3.79)	4.81 (4.34-5.32)	*5.56 (4.69-6.58)*
AGC V2									
Cemented, unconstrained, fixed	37,105	71 (65-77)	43	0.26 (0.21-0.31)	1.42 (1.30-1.55)	2.07 (1.93-2.23)	3.43 (3.22-3.65)	4.75 (4.41-5.12)	5.99 (5.30-6.76)
Advance MP									
Cemented, unconstrained, fixed	8,590	70 (64-76)	47	0.51 (0.38-0.69)	2.04 (1.75-2.37)	2.85 (2.49-3.26)	4.25 (3.72-4.84)	4.97 (4.17-5.92)	*4.97 (4.17-5.92)*
Attune									
Cemented, unconstrained, fixed	13,119	69 (62-75)	44	0.38 (0.28-0.51)	1.56 (1.28-1.90)	*1.91 (1.45-2.51)*			
Cemented, posterior-stabilised, fixed	7,268	70 (62-76)	41	0.50 (0.35-0.71)	1.74 (1.33-2.27)	*4.08 (2.43-6.83)*			
Columbus Cemented									
Cemented, unconstrained, fixed	11,544	71 (65-76)	45	0.45 (0.34-0.59)	1.58 (1.35-1.85)	2.25 (1.95-2.59)	3.22 (2.72-3.82)	*3.82 (2.89-5.05)*	

†denotes a brand that has been discontinued/withdrawn/not implanted in the last three years.
*denotes that this brand is now marketed by Lima.
[1]Brands shown have been used in at least 2,500 total primary knee replacement operations for that type of fixation and bearing type and at least 1,000 for unicondylar and patellofemoral knee replacement operations. Excludes 6,317 joint replacements with no record of main brand.
Note: Blank cells indicate the number at risk is below ten and therefore estimates are omitted as they are unreliable.

Table 3.29 (continued)

Brand[†]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
Genesis II									
Cemented, unconstrained, fixed	53,312	71 (65-77)	43	0.38 (0.33-0.44)	1.39 (1.29-1.50)	1.91 (1.77-2.05)	2.80 (2.59-3.02)	3.02 (2.76-3.30)	*3.02 (2.76-3.30)*
Cement, posterior-stabilised, fixed	18,866	71 (65-77)	39	0.62 (0.52-0.75)	1.88 (1.67-2.11)	2.61 (2.35-2.90)	3.97 (3.51-4.48)	*4.67 (3.41-6.38)*	
Genesis II Oxinium									
Cemented, unconstrained, fixed	6,428	59 (54-64)	40	0.49 (0.35-0.71)	2.02 (1.68-2.43)	2.93 (2.49-3.44)	4.73 (4.05-5.52)	6.08 (4.99-7.39)	*6.74 (5.19-8.74)*
Cemented, posterior-stabilised, fixed	3,121	58 (53-63)	41	0.70 (0.46-1.07)	3.16 (2.56-3.90)	4.82 (4.03-5.76)	9.17 (7.63-11.00)	*11.28 (8.41-15.05)*	
Journey II BCS Oxinium									
Cemented, posterior-stabilised, fixed	2,601	65 (58-71)	41	0.66 (0.39-1.11)	3.32 (2.33-4.71)	*3.62 (2.52-5.19)*			
†Kinemax									
Cemented, unconstrained, fixed	10,832	71 (64-77)	43	0.24 (0.17-0.36)	1.78 (1.54-2.05)	2.72 (2.43-3.06)	4.78 (4.37-5.23)	5.99 (5.49-6.53)	6.50 (5.94-7.12)
LCS Complete									
Cemented, unconstrained, mobile	11,803	70 (64-76)	42	0.43 (0.32-0.56)	1.59 (1.37-1.85)	2.60 (2.31-2.93)	4.17 (3.74-4.64)	*5.14 (4.44-5.95)*	
Uncemented hybrid, unconstrained, mobile	15,900	69 (62-75)	46	0.48 (0.38-0.60)	1.78 (1.58-2.01)	2.53 (2.28-2.81)	3.40 (3.07-3.76)	4.14 (3.64-4.72)	
MRK									
Cemented, unconstrained, fixed	13,163	70 (64-77)	44	0.32 (0.23-0.44)	1.23 (1.04-1.46)	1.71 (1.47-1.99)	2.77 (2.38-3.22)	*3.22 (2.66-3.89)*	*4.17 (2.60-6.66)*
NRG									
Cemented, unconstrained, fixed	8,586	70 (64-76)	43	0.36 (0.25-0.51)	1.45 (1.21-1.74)	2.38 (2.05-2.76)	3.69 (3.19-4.27)		
Cemented, posterior-stabilised, fixed	4,806	70 (63-77)	44	0.46 (0.30-0.70)	1.75 (1.42-2.17)	2.48 (2.06-2.97)	3.71 (3.11-4.42)		
Natural Knee II									
Cemented, unconstrained, fixed	2,710	70 (64-76)	41	0.33 (0.17-0.64)	1.39 (1.01-1.92)	2.18 (1.69-2.82)	3.93 (3.19-4.85)	6.09 (4.81-7.70)	*7.22 (5.02-10.35)*
Nexgen									
Cemented, unconstrained, fixed	77,455	70 (63-76)	43	0.29 (0.25-0.33)	1.08 (1.00-1.16)	1.58 (1.48-1.69)	2.65 (2.47-2.84)	3.12 (2.86-3.42)	*4.15 (2.66-6.43)*
Cemented, posterior-stabilised, fixed	74,836	70 (64-77)	41	0.44 (0.39-0.49)	1.62 (1.53-1.73)	2.65 (2.52-2.79)	4.62 (4.40-4.85)	5.61 (5.29-5.94)	6.02 (5.56-6.51)
Uncemented hybrid, unconstrained, fixed	5,386	65 (58-72)	55	0.57 (0.40-0.81)	2.28 (1.90-2.72)	2.95 (2.51-3.45)	3.86 (3.34-4.46)	4.47 (3.80-5.25)	*4.65 (3.91-5.53)*
PFC Sigma Bicondylar Knee									
Cemented, unconstrained, fixed	229,032	70 (64-76)	43	0.36 (0.34-0.39)	1.30 (1.25-1.35)	1.79 (1.73-1.85)	2.45 (2.37-2.54)	2.86 (2.74-2.98)	3.18 (2.99-3.38)
Cemented, unconstrained, mobile	8,340	64 (58-72)	47	0.59 (0.44-0.78)	1.96 (1.67-2.29)	2.74 (2.40-3.13)	3.93 (3.48-4.43)	4.59 (3.99-5.28)	*6.29 (3.67-10.69)*
Cemented, posterior-stabilised, fixed	84,972	71 (64-77)	41	0.42 (0.38-0.47)	1.59 (1.51-1.69)	2.18 (2.08-2.29)	3.12 (2.98-3.28)	3.70 (3.49-3.93)	4.24 (3.88-4.64)
Cemented, posterior-stabilised, mobile	7,073	65 (59-72)	46	0.69 (0.52-0.91)	2.22 (1.90-2.60)	3.06 (2.67-3.50)	4.42 (3.89-5.01)	4.87 (4.24-5.59)	*4.87 (4.24-5.59)*
Cemented, monobloc polyethylene tibia	12,590	74 (69-79)	42	0.34 (0.25-0.46)	1.41 (1.20-1.66)	1.92 (1.66-2.23)	2.28 (1.93-2.69)	*2.28 (1.93-2.69)*	
Scorpio									
Cemented, unconstrained, fixed	10,839	71 (64-77)	41	0.46 (0.35-0.61)	1.91 (1.67-2.19)	2.68 (2.39-3.01)	4.05 (3.67-4.46)	5.04 (4.54-5.59)	*5.23 (4.62-5.92)*

†denotes a brand that has been discontinued/withdrawn/not implanted in the last three years.
*denotes that this brand is now marketed by Lima.
[†]Brands shown have been used in at least 2,500 total primary knee replacement operations for that type of fixation and bearing type and at least 1,000 for unicondylar and patellofemoral knee replacement operations. Excludes 6,317 joint replacements with no record of main brand.
Note: Blank cells indicate the number at risk is below ten and therefore estimates are omitted as they are unreliable.

Table 3.29 (continued)

Brand[1]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
Cemented, posterior-stabilised, fixed	6,148	71 (65-77)	41	0.23 (0.14-0.39)	1.57 (1.29-1.92)	2.42 (2.06-2.85)	4.02 (3.53-4.58)	5.00 (4.40-5.68)	*5.41 (4.62-6.34)*
Uncemented hybrid, unconstrained, fixed	4,858	71 (64-77)	45	0.62 (0.44-0.89)	1.89 (1.54-2.31)	2.59 (2.17-3.08)	4.00 (3.44-4.64)	4.84 (4.15-5.65)	*4.84 (4.15-5.65)*
TC Plus									
Cemented, unconstrained, fixed	7,989	70 (64-76)	46	0.80 (0.63-1.03)	2.00 (1.72-2.34)	2.65 (2.32-3.03)	3.82 (3.40-4.29)	4.39 (3.84-5.01)	*4.92 (4.06-5.94)*
Cemented, unconstrained, mobile	5,106	70 (64-76)	44	0.55 (0.38-0.80)	1.61 (1.30-2.00)	2.16 (1.78-2.60)	3.35 (2.86-3.93)	3.82 (3.24-4.51)	
Triathlon									
Cemented, unconstrained, fixed	88,600	70 (63-76)	43	0.45 (0.41-0.50)	1.46 (1.37-1.56)	2.01 (1.89-2.13)	3.25 (2.98-3.54)	*3.65 (3.21-4.16)*	
Cemented, posterior-stabilised, fixed	19,949	70 (63-77)	41	0.61 (0.51-0.73)	1.79 (1.59-2.00)	2.64 (2.38-2.93)	3.93 (3.42-4.50)		
Uncemented hybrid, unconstrained fixed	2,815	68 (61-75)	51	0.64 (0.39-1.04)	2.06 (1.48-2.86)	2.75 (2.00-3.77)			
Vanguard									
Cement, unconstrained, fixed	58,339	70 (63-76)	42	0.33 (0.28-0.38)	1.38 (1.28-1.49)	2.08 (1.94-2.23)	2.98 (2.66-3.32)		
Cement, posterior-stabilised, fixed	8,937	70 (63-77)	41	0.57 (0.43-0.75)	2.14 (1.83-2.50)	3.02 (2.61-3.48)	*4.86 (3.78-6.24)*		
Cement, constrained condylar	2,586	70 (63-76)	36	0.43 (0.23-0.79)	1.22 (0.81-1.82)	1.42 (0.95-2.11)			
Unicondylar knee replacements									
AMC/Uniglide									
Unicondylar, fixed	1,472	66 (59-75)	48	0.35 (0.14-0.83)	2.99 (2.21-4.04)	4.36 (3.38-5.63)	8.68 (6.91-10.87)	*16.10 (11.78-21.79)*	
Unicondylar, mobile	1,525	61 (56-68)	53	4.30 (3.39-5.45)	9.19 (7.83-10.77)	11.11 (9.61-12.84)	17.23 (15.21-19.48)	*21.88 (18.62-25.62)*	
†MG Uni									
Unicondylar, fixed	2,354	63 (57-70)	55	0.89 (0.58-1.37)	3.98 (3.26-4.86)	6.01 (5.11-7.05)	10.17 (8.97-11.51)	12.43 (10.93-14.12)	*15.01 (12.63-17.79)*
Oxford Partial Knee									
Unicondylar, mobile	66,668	64 (58-71)	53	1.16 (1.08-1.24)	3.92 (3.77-4.09)	5.99 (5.79-6.20)	11.31 (10.97-11.65)	15.40 (14.85-15.97)	18.46 (17.42-19.55)
***Physica ZUK**									
Unicondylar, fixed	14,829	63 (56-70)	55	0.34 (0.26-0.46)	2.16 (1.90-2.46)	3.44 (3.07-3.85)	6.76 (5.85-7.80)	*8.65 (6.61-11.30)*	
†Preservation									
Unicondylar, fixed	1,227	63 (57-70)	54	1.96 (1.32-2.91)	7.10 (5.79-8.69)	10.40 (8.80-12.26)	15.78 (13.80-18.01)	*19.61 (17.21-22.30)*	*20.56 (17.89-23.57)*
Sigma HP (Uni)									
Unicondylar, fixed	10,430	63 (55-70)	57	0.75 (0.60-0.95)	3.19 (2.82-3.60)	4.60 (4.12-5.14)	*6.92 (6.01-7.96)*		
Triathlon Uni									
Unicondylar, fixed	1,229	62 (55-69)	54	1.45 (0.89-2.35)	5.01 (3.77-6.63)	8.01 (6.23-10.26)			
Patellofemoral knee replacements									
Avon									
Patellofemoral	6,067	58 (50-68)	22	0.74 (0.55-0.99)	4.29 (3.77-4.87)	7.46 (6.75-8.23)	15.22 (14.06-16.47)	19.41 (17.81-21.15)	*23.45 (20.21-27.11)*

†denotes a brand that has been discontinued/withdrawn/not implanted in the last three years.
*denotes that this brand is now marketed by Lima.
[1]Brands shown have been used in at least 2,500 total primary knee replacement operations for that type of fixation and bearing type and at least 1,000 for unicondylar and patellofemoral knee replacement operations. Excludes 6,317 joint replacements with no record of main brand.
Note: Blank cells indicate the number at risk is below ten and therefore estimates are omitted as they are unreliable.

Table 3.29 (continued)

Brand[†]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Time since primary					
				1 year	3 years	5 years	10 years	13 years	15 years
FPV									
Patellofemoral	1,646	59 (52-68)	23	0.92 (0.55-1.52)	6.99 (5.85-8.36)	10.13 (8.72-11.75)	*19.10 (16.65-21.87)*		
Journey PFJ Oxinium									
Patellofemoral	1,930	58 (50-67)	23	2.05 (1.49-2.82)	7.82 (6.61-9.23)	13.33 (11.68-15.18)	*22.14 (19.71-24.82)*		
Sigma HP (PF)									
Patellofemoral	1,323	58 (50-66)	23	2.81 (2.04-3.85)	9.16 (7.67-10.91)	13.76 (11.83-15.97)	*23.20 (19.72-27.18)*		
Zimmer PFJ									
Patellofemoral	2,545	56 (50-65)	22	0.70 (0.43-1.14)	5.04 (4.13-6.15)	7.66 (6.42-9.14)	*15.67 (11.95-20.40)*		

†denotes a brand that has been discontinued/withdrawn/not implanted in the last three years.
*denotes that this brand is now marketed by Lima.
[†]Brands shown have been used in at least 2,500 total primary knee replacement operations for that type of fixation and bearing type and at least 1,000 for unicondylar and patellofemoral knee replacement operations. Excludes 6,317 joint replacements with no record of main brand.
Note: Blank cells indicate the number at risk is below ten and therefore estimates are omitted as they are unreliable.

3.4.4 Revisions for different clinical indications after primary knee replacement

Table 3.30 shows the revision incidence rates for each indication recorded on data collection forms for knee revision surgery, for all cases and then sub-divided by fixation type and whether the primary procedure was a TKR or a UKR.

For all knee replacements, the highest PTIRs for the five most common reasons for revision in descending order, were for aseptic loosening / lysis, infection, pain, progressive arthritis and instability. For cemented TKR, the highest PTIRs in descending order were aseptic loosening / lysis, infection, instability, pain and 'other' indication. Revision incidences for pain and aseptic loosening / lysis were slightly higher for TKRs which were uncemented, compared to prosthesis implanted using a hybrid or cemented fixation, but revision for infection was lower for uncemented.

For patellofemoral replacements, the top three reasons for revision were for progressive arthritis, pain and 'other' indication. The first two reasons had the highest incidence rates across all reasons by fixation method breakdowns. Similarly, for unicondylar knee replacements (medial and lateral UKR), the highest three incidence rates for reasons for revising the implant were progressive arthritis, aseptic loosening / lysis and pain, respectively.

In Table 3.31 (on page 143), the PTIRs for each indication are shown separately for different time periods from the primary knee replacement, within the first year from primary operation, and between 1-3, 3-5, 5-7, 7-10, 10-13 and 13+ years after surgery (Note: the maximum follow-up for any implant is now 15.75 years). It is clear that most of the PTIRs for a particular indication do vary, especially for infection, aseptic loosening / lysis, pain and progressive arthritis for different time intervals after surgery. Infection is most likely to be the reason that a joint is revised in the first year but after seven years or more, is comparatively less likely than some of the other reasons. Conversely, revision between one and three years after surgery is more likely for aseptic loosening / lysis and pain, with incidence rates dropping off for pain later on but rising again for aseptic loosening / lysis. Aseptic loosening / lysis PTIRs continue to remain relatively higher than other indicated reasons for revision for implants surviving for longer periods after surgery.

Table 3.30 PTIR estimates of indications for revision (95% CI) by fixation, constraint and bearing type.

Fixation, constraint and bearing sub-groups	Pros-thesis-years at risk (x1,000)	Number of revisions per 1,000 prosthesis-years for: All causes	Pain	Dislocation / sub-luxation	Infection	Aseptic loosening / lysis	Peri-prosthetic fracture	Implant wear[1]	Instability	Malalign-ment	Other indication[2]	Stiffness[3] Prosthe-sis-years at risk (x1,000)	Revisions per 1,000 prosthe-sis-years	Progressive arthritis[4] Prosthe-sis-years at risk (x1,000)	Revisions per 1,000 prosthesis-years
All cases	6,821.9	4.88 (4.83-4.93)	0.80 (0.78-0.82)	0.18 (0.17-0.19)	0.92 (0.90-0.95)	1.32 (1.29-1.35)	0.16 (0.15-0.17)	0.29 (0.28-0.31)	0.68 (0.66-0.70)	0.36 (0.35-0.38)	0.56 (0.54-0.58)	6,581.1	0.32 (0.30-0.33)	4,626.6	0.74 (0.72-0.77)
Total knee replacement															
All cemented	5,722.8	3.89 (3.84-3.95)	0.56 (0.54-0.58)	0.11 (0.10-0.12)	0.99 (0.97-1.02)	1.07 (1.05-1.10)	0.15 (0.14-0.16)	0.18 (0.17-0.19)	0.64 (0.62-0.66)	0.32 (0.31-0.33)	0.40 (0.38-0.41)	5,529.5	0.32 (0.31-0.34)	3,939.6	0.35 (0.33-0.37)
unconstrained, fixed	3,773.2	3.54 (3.48-3.60)	0.55 (0.52-0.57)	0.10 (0.09-0.11)	0.90 (0.87-0.93)	0.89 (0.86-0.93)	0.12 (0.10-0.13)	0.16 (0.15-0.18)	0.59 (0.57-0.62)	0.31 (0.29-0.33)	0.37 (0.35-0.39)	3,646.6	0.31 (0.30-0.33)	2,634.8	0.36 (0.33-0.38)
unconstrained, mobile	280.8	4.61 (4.36-4.87)	0.77 (0.67-0.88)	0.21 (0.16-0.27)	0.97 (0.86-1.09)	1.48 (1.35-1.63)	0.17 (0.13-0.22)	0.30 (0.24-0.37)	0.90 (0.80-1.02)	0.44 (0.37-0.53)	0.37 (0.31-0.45)	271.7	0.47 (0.39-0.56)	157.0	0.24 (0.17-0.33)
posterior-stabilised, fixed	1,394.6	4.52 (4.41-4.64)	0.54 (0.50-0.58)	0.11 (0.09-0.12)	1.19 (1.14-1.25)	1.45 (1.39-1.52)	0.23 (0.20-0.25)	0.19 (0.17-0.21)	0.68 (0.64-0.73)	0.33 (0.30-0.36)	0.42 (0.39-0.45)	1,344.4	0.31 (0.28-0.34)	961.4	0.34 (0.31-0.38)
posterior-stabilised, mobile	89.6	4.96 (4.52-5.45)	0.78 (0.62-0.99)	0.17 (0.10-0.28)	0.96 (0.78-1.19)	1.22 (1.01-1.47)	0.25 (0.16-0.37)	0.27 (0.18-0.40)	0.91 (0.74-1.14)	0.20 (0.13-0.32)	0.81 (0.65-1.02)	87.5	0.61 (0.46-0.79)	54.5	0.37 (0.24-0.57)
constrained condylar	35.2	5.88 (5.13-6.74)	0.40 (0.24-0.67)	0.40 (0.24-0.67)	2.73 (2.23-3.33)	1.02 (0.74-1.42)	0.37 (0.21-0.64)	0.23 (0.11-0.45)	0.82 (0.57-1.18)	0.31 (0.17-0.56)	0.57 (0.37-0.88)	34.5	0.35 (0.20-0.61)	28.4	0.32 (0.16-0.61)
monobloc polyethylene tibia	76.8	3.45 (3.06-3.89)	0.55 (0.40-0.74)	0.12 (0.06-0.23)	0.83 (0.65-1.06)	0.83 (0.65-1.06)	0.23 (0.15-0.37)	0.08 (0.04-0.17)	0.57 (0.43-0.77)	0.34 (0.23-0.50)	0.36 (0.25-0.53)	76.2	0.34 (0.23-0.50)	65.6	0.15 (0.08-0.28)
bearing type unknown	72.5	5.63 (5.11-6.20)	0.84 (0.65-1.08)	0.21 (0.12-0.34)	1.10 (0.89-1.37)	1.59 (1.32-1.90)	0.19 (0.11-0.33)	0.44 (0.31-0.62)	0.79 (0.61-1.02)	0.43 (0.30-0.61)	0.81 (0.63-1.05)	68.5	0.26 (0.17-0.42)	37.8	0.69 (0.47-1.01)
All uncemented	327.5	4.69 (4.46-4.93)	0.92 (0.82-1.03)	0.17 (0.13-0.22)	0.65 (0.57-0.74)	1.67 (1.54-1.82)	0.16 (0.12-0.21)	0.31 (0.26-0.38)	0.78 (0.69-0.88)	0.41 (0.35-0.48)	0.63 (0.55-0.72)	310.5	0.39 (0.33-0.47)	180.8	0.44 (0.35-0.54)
unconstrained, fixed	125.7	4.78 (4.42-5.18)	0.82 (0.68-0.99)	0.10 (0.05-0.17)	0.63 (0.50-0.78)	1.91 (1.68-2.17)	0.16 (0.10-0.25)	0.28 (0.20-0.39)	0.77 (0.63-0.94)	0.43 (0.33-0.56)	0.62 (0.50-0.77)	118.9	0.36 (0.27-0.49)	71.1	0.46 (0.33-0.65)
unconstrained, mobile	173.6	4.40 (4.10-4.72)	0.92 (0.78-1.07)	0.20 (0.14-0.27)	0.64 (0.54-0.78)	1.45 (1.28-1.64)	0.13 (0.09-0.20)	0.31 (0.23-0.40)	0.71 (0.60-0.85)	0.35 (0.27-0.45)	0.56 (0.46-0.68)	165.3	0.37 (0.29-0.47)	95.1	0.46 (0.34-0.62)
posterior-stabilised, fixed	22.3	6.50 (5.53-7.65)	1.44 (1.02-2.03)	0.36 (0.18-0.72)	0.81 (0.51-1.28)	2.02 (1.51-2.70)	0.36 (0.18-0.72)	0.58 (0.34-1.00)	1.21 (0.83-1.77)	0.81 (0.51-1.28)	1.21 (0.83-1.77)	20.9	0.57 (0.33-1.01)	11.8	0.17 (0.04-0.68)
other constraint	1.6	4.30 (2.05-9.02)	3.07 (1.28-7.38)	0.61 (0.09-4.36)	1.23 (0.31-4.91)	0.61 (0.09-4.36)	0	0	0.61 (0.09-4.36)	0	0.61 (0.09-4.36)	1.6	1.25 (0.31-4.99)	1.4	0
bearing type unknown	4.3	4.42 (2.82-6.92)	0.70 (0.22-2.16)	0	0.23 (0.03-1.65)	2.56 (1.42-4.62)	0.23 (0.03-1.65)	0.46 (0.12-1.86)	1.63 (0.78-3.41)	0.46 (0.12-1.86)	0.46 (0.12-1.86)	3.7	0.81 (0.26-2.52)	1.3	0

[1]The reason implant failure, as reported on in annual reports up to 2013, has been renamed implant wear as this reflects the wearing down of the implant but distinguishes from the implant itself breaking.
[2]Other indication now includes other indications not listed, implant fracture and incorrect sizing.
[3]Stiffness was asked in versions MDSv2, v3, v6 and v7 of the clinical assessment forms for joint replacement/revision surgery and hence, for these reasons, there are fewer prosthesis-years at risk.
[4]Progressive arthritis remains was asked in versions MDSv3, v6 and v7 of the clinical assessment forms for joint replacement/revision surgery and hence, for these reasons, there are fewer prosthesis-years at risk

Table 3.30 (continued)

Fixation, constraint and bearing sub-groups	Pros-thesis-years at risk (x1,000)	Number of revisions per 1,000 prosthesis-years for:										Stiffness[3]		Progressive arthritis[4]	
		All causes	Pain	Disloca-tion / sub-luxation	Infection	Aseptic loosening / lysis	Peri-prosthetic fracture	Implant wear[1]	Instability	Malalign-ment	Other indication[2]	Prosthe-sis-years at risk (x1,000)	Revisions per 1,000 prosthe-sis-years	Prosthe-sis-years at risk (x1,000)	Revisions per 1,000 prosthesis-years
Hybrid	76.8	3.83 (3.41-4.29)	0.66 (0.50-0.87)	0.14 (0.08-0.26)	0.87 (0.69-1.11)	1.17 (0.95-1.44)	0.10 (0.05-0.21)	0.34 (0.23-0.50)	0.64 (0.48-0.84)	0.34 (0.23-0.50)	0.33 (0.22-0.48)	69.6	0.22 (0.13-0.36)	33.7	0.39 (0.22-0.66)
unconstrained, fixed	56.8	3.33 (2.89-3.84)	0.56 (0.40-0.80)	0.14 (0.07-0.28)	0.83 (0.62-1.10)	0.99 (0.76-1.28)	0.07 (0.03-0.19)	0.35 (0.23-0.55)	0.51 (0.35-0.73)	0.32 (0.20-0.50)	0.28 (0.17-0.46)	50.8	0.20 (0.11-0.37)	22.9	0.22 (0.09-0.53)
unconstrained, mobile	11.5	4.28 (3.23-5.66)	0.61 (0.29-1.28)	0.17 (0.04-0.70)	0.70 (0.35-1.40)	1.66 (1.06-2.60)	0.09 (0.01-0.62)	0.44 (0.18-1.05)	0.87 (0.47-1.62)	0.61 (0.29-1.28)	0.44 (0.18-1.05)	10.7	0.19 (0.05-0.75)	7.4	0.40 (0.13-1.25)
posterior-stabilised, fixed	4.3	6.54 (4.52-9.48)	0.93 (0.35-2.49)	0	1.87 (0.93-3.74)	2.10 (1.09-4.04)	0.47 (0.12-1.87)	0	1.17 (0.49-2.81)	0	0	4.0	0.25 (0.04-1.77)	2.0	0.49 (0.07-3.47)
other constraint	3.3	4.81 (2.95-7.85)	1.50 (0.63-3.61)	0.30 (0.04-2.13)	0.60 (0.15-2.40)	0.30 (0.04-2.13)	0.30 (0.04-2.13)	0.30 (0.04-2.13)	1.20 (0.45-3.20)	0	0.30 (0.04-2.13)	3.3	0.60 (0.15-2.41)	0.9	2.24 (0.56-8.95)
bearing type unknown	1.0	12.23 (6.95-21.54)	3.06 (0.99-9.48)	0	2.04 (0.51-8.15)	5.10 (2.12-12.25)	0	0	1.02 (0.14-7.24)	1.02 (0.14-7.24)	3.06 (0.99-9.48)	0.8	0	0.5	4.12 (1.03-16.47)
Unicompartmental knee replacement															
Unicondylar	608.9	12.20 (11.93-12.48)	2.43 (2.31-2.56)	0.76 (0.69-0.83)	0.53 (0.47-0.59)	3.32 (3.18-3.47)	0.27 (0.23-0.31)	1.13 (1.05-1.22)	0.99 (0.91-1.07)	0.64 (0.58-0.70)	1.71 (1.61-1.82)	588.3	0.21 (0.17-0.25)	413.1	3.43 (3.26-3.62)
fixed	183.1	10.68 (10.22-11.16)	2.48 (2.26-2.72)	0.13 (0.08-0.19)	0.59 (0.49-0.71)	3.09 (2.85-3.36)	0.23 (0.17-0.31)	1.00 (0.86-1.16)	0.73 (0.61-0.86)	0.56 (0.46-0.68)	1.20 (1.05-1.37)	179.3	0.25 (0.18-0.33)	138.4	3.22 (2.94-3.54)
mobile	418.5	12.86 (12.52-13.21)	2.40 (2.25-2.55)	1.04 (0.95-1.14)	0.50 (0.44-0.58)	3.43 (3.26-3.61)	0.28 (0.24-0.34)	1.19 (1.09-1.30)	1.10 (1.00-1.20)	0.67 (0.60-0.75)	1.92 (1.80-2.06)	402.0	0.19 (0.15-0.24)	270.4	3.51 (3.30-3.74)
bearing type unknown	7.3	12.71 (10.37-15.58)	3.14 (2.09-4.73)	0.27 (0.07-1.09)	0.41 (0.13-1.27)	2.87 (1.87-4.40)	0.14 (0.02-0.97)	0.82 (0.37-1.83)	1.50 (0.83-2.71)	0.55 (0.21-1.46)	2.05 (1.24-3.40)	7.0	0	4.3	5.33 (3.54-8.02)
All patellofemoral	85.3	20.45 (19.51-21.43)	4.85 (4.41-5.34)	0.76 (0.60-0.97)	0.46 (0.33-0.63)	2.43 (2.12-2.78)	0.18 (0.11-0.29)	1.74 (1.48-2.04)	1.01 (0.82-1.25)	1.30 (1.08-1.57)	3.32 (2.95-3.73)	82.7	0.48 (0.35-0.66)	59.4	9.33 (8.59-10.14)
Unclassified															
	0.5	3.81 (0.95-15.23)	0	0	0	3.81 (0.95-15.23)	0	3.81 (0.95-15.23)	0	0	0	0.5	0	0	0

[1]The reason implant failure, as reported on in annual reports up to 2013, has been renamed implant wear as this reflects the wearing down of the implant but distinguishes from the implant itself breaking.
[2]Other indication now includes other indications not listed, implant fracture and incorrect sizing.
[3]Stiffness was asked in versions MDSv2, v3, v6 and v7 of the clinical assessment forms for joint replacement/revision surgery and hence, for these reasons, there are fewer prosthesis-years at risk.
[4]Progressive arthritis remains was asked in versions MDSv3, v6 and v7 of the clinical assessment forms for joint replacement/revision surgery and hence, for these reasons, there are fewer prosthesis-years at risk

Table 3.31 PTIR estimates of **indications** for **revision** (95% CI) by **years** following primary knee replacement.

Time since primary	Prosthesis-years at risk (x1,000)	Number of revisions per 1,000 prosthesis-years for: All causes	Pain	Dislocation / subluxation	Infection	Aseptic loosening / lysis	Periprosthetic fracture	Implant wear[1]	Instability	Malalignment	Other indication[2]	Stiffness[3] Prosthesis-years at risk (x1,000)	Stiffness[3] Revisions per 1,000 prosthesis-years	Progressive arthritis[4] Prosthesis-years at risk (x1,000)	Progressive arthritis[4] Revisions per 1,000 prosthesis-years
All cases	6,821.9	4.88 (4.83-4.93)	0.80 (0.78-0.82)	0.18 (0.17-0.19)	0.92 (0.90-0.95)	1.32 (1.29-1.35)	0.16 (0.15-0.17)	0.29 (0.28-0.31)	0.68 (0.66-0.70)	0.36 (0.35-0.38)	0.56 (0.54-0.58)	6,581.1	0.32 (0.30-0.33)	4,626.6	0.74 (0.72-0.77)
<1 year	1,135.7	4.89 (4.76-5.02)	0.54 (0.50-0.58)	0.38 (0.35-0.42)	1.81 (1.73-1.89)	0.65 (0.61-0.70)	0.27 (0.24-0.31)	0.19 (0.16-0.21)	0.55 (0.50-0.59)	0.33 (0.30-0.36)	0.57 (0.53-0.62)	1,115.2	0.31 (0.28-0.34)	926.0	0.26 (0.23-0.30)
1-3 years	1,911.8	6.79 (6.67-6.91)	1.45 (1.40-1.50)	0.20 (0.18-0.22)	1.24 (1.19-1.29)	1.66 (1.60-1.71)	0.12 (0.11-0.14)	0.21 (0.19-0.23)	0.99 (0.94-1.03)	0.59 (0.55-0.62)	0.84 (0.80-0.88)	1,872.1	0.56 (0.53-0.60)	1,505.9	0.91 (0.87-0.96)
3-5 years	1,441.4	4.31 (4.20-4.42)	0.82 (0.77-0.87)	0.10 (0.09-0.12)	0.64 (0.60-0.68)	1.36 (1.30-1.42)	0.12 (0.10-0.14)	0.22 (0.19-0.24)	0.63 (0.59-0.67)	0.34 (0.31-0.37)	0.48 (0.45-0.52)	1,404.0	0.28 (0.25-0.31)	1,057.2	0.76 (0.71-0.81)
5-7 years	1,034.8	3.55 (3.43-3.66)	0.49 (0.44-0.53)	0.09 (0.08-0.11)	0.49 (0.45-0.53)	1.22 (1.16-1.29)	0.12 (0.10-0.14)	0.29 (0.26-0.33)	0.50 (0.46-0.55)	0.25 (0.22-0.28)	0.40 (0.37-0.44)	1,000.1	0.16 (0.14-0.19)	676.1	0.81 (0.75-0.88)
7-10 years	912.9	3.55 (3.43-3.67)	0.34 (0.30-0.38)	0.11 (0.09-0.14)	0.35 (0.32-0.39)	1.33 (1.26-1.41)	0.19 (0.16-0.22)	0.46 (0.42-0.50)	0.53 (0.48-0.58)	0.19 (0.17-0.22)	0.36 (0.32-0.40)	866.5	0.12 (0.10-0.14)	433.6	1.00 (0.91-1.10)
10-13 years	335.6	4.28 (4.06-4.50)	0.23 (0.18-0.29)	0.13 (0.09-0.17)	0.37 (0.31-0.44)	1.68 (1.55-1.82)	0.26 (0.21-0.32)	0.88 (0.79-0.99)	0.66 (0.58-0.76)	0.19 (0.15-0.24)	0.33 (0.27-0.40)	296.8	0.10 (0.07-0.14)	27.3	0.99 (0.68-1.44)
13+ years	49.6	4.31 (3.77-4.93)	0.18 (0.09-0.35)	0.10 (0.04-0.24)	0.28 (0.17-0.48)	1.95 (1.60-2.39)	0.20 (0.11-0.37)	1.15 (0.89-1.49)	0.42 (0.28-0.65)	0.20 (0.11-0.37)	0.22 (0.12-0.40)	26.5	0.23 (0.10-0.50)	0.4	2.36 (0.33-16.77)

[1]The reason implant failure, as reported on in annual reports up to 2013, has been renamed implant wear as this reflects the wearing down of the implant but distinguishes from the implant itself breaking.
[2]Other indication now includes other indications not listed, implant fracture and incorrect sizing.
[3]Stiffness was asked in versions MDSv2, v3, v6 and v7 of the clinical assessment forms for joint replacement/revision surgery and hence, for these reasons, there are fewer prosthesis-years at risk.
[4]Progressive arthritis remains was asked in versions MDSv3, v6 and v7 of the clinical assessment forms for joint replacement/revision surgery and hence, for these reasons, there are fewer prosthesis-years at risk.

3.4.5 Mortality after primary knee surgery

This section describes the mortality of the cohort up to 15 years from primary operation, according to gender and age group. Deaths were updated on 16 February 2018 using data from the NHS Personal Demographic Service. For simplicity, we do not take into account whether the patient had a first (or further) joint revision after the primary operation when calculating the cumulative probability of death (see Survival analysis methods note in section 3.2). Of the 1,193,830 records of a primary knee replacement, there were 12,321 bilateral operations in which the patient had both knees replaced on the same day; here the second of the two has been excluded, leaving 1,181,509 procedures of whom 172,708 had died before the end of 2018.

Table 3.32 (a) KM estimates of cumulative **mortality** (95% CI) by **age** and **gender**, in primary TKR.
Blue italics signify that fewer than 250 cases remained at risk at these time points

Age group (years)	Number of patients	Time since primary					
		30 days	90 days	1 year	5 years	10 years	15 years
All cases	**1,062,408**	**0.17 (0.16-0.18)**	**0.31 (0.30-0.33)**	**1.05 (1.03-1.07)**	**8.81 (8.75-8.87)**	**26.19 (26.06-26.33)**	**48.01 (47.64-48.38)**
Males							
<55	26,202	0.05 (0.03-0.08)	0.08 (0.05-0.12)	0.29 (0.23-0.36)	2.11 (1.92-2.32)	5.97 (5.53-6.43)	*11.55 (10.05-13.26)*
55-59	37,288	0.05 (0.03-0.08)	0.10 (0.07-0.14)	0.37 (0.31-0.44)	2.95 (2.75-3.16)	8.63 (8.20-9.09)	16.46 (15.19-17.82)
60-64	68,813	0.07 (0.05-0.09)	0.13 (0.10-0.16)	0.48 (0.43-0.54)	4.09 (3.92-4.27)	11.69 (11.34-12.06)	25.12 (23.88-26.40)
65-69	89,705	0.10 (0.08-0.12)	0.19 (0.16-0.22)	0.68 (0.62-0.73)	5.85 (5.67-6.03)	17.73 (17.34-18.13)	37.97 (36.67-39.30)
70-74	93,809	0.15 (0.13-0.18)	0.29 (0.26-0.33)	1.10 (1.03-1.17)	9.40 (9.18-9.62)	28.33 (27.87-28.79)	56.07 (54.79-57.35)
75-79	76,654	0.30 (0.26-0.34)	0.53 (0.48-0.58)	1.85 (1.76-1.95)	15.26 (14.96-15.56)	44.71 (44.15-45.27)	*76.26 (74.96-77.55)*
80-84	42,659	0.61 (0.54-0.69)	1.03 (0.94-1.13)	3.10 (2.94-3.28)	24.25 (23.77-24.73)	64.02 (63.27-64.78)	*93.19 (91.67-94.52)*
85+	16,277	1.17 (1.02-1.35)	2.04 (1.83-2.27)	5.81 (5.45-6.19)	39.14 (38.24-40.05)	83.07 (82.00-84.10)	
Females							
<55	37,223	0.03 (0.01-0.05)	0.05 (0.03-0.07)	0.19 (0.15-0.24)	1.55 (1.41-1.70)	4.45 (4.12-4.80)	8.91 (7.87-10.07)
55-59	50,240	0.03 (0.02-0.05)	0.06 (0.04-0.08)	0.26 (0.21-0.31)	2.09 (1.94-2.24)	6.38 (6.06-6.72)	13.54 (12.45-14.71)
60-64	82,842	0.04 (0.03-0.06)	0.09 (0.07-0.11)	0.33 (0.30-0.38)	2.81 (2.68-2.94)	8.68 (8.39-8.98)	18.49 (17.49-19.55)
65-69	111,579	0.07 (0.06-0.09)	0.12 (0.10-0.15)	0.43 (0.40-0.47)	3.92 (3.79-4.06)	12.80 (12.49-13.12)	29.02 (27.95-30.13)
70-74	123,124	0.10 (0.08-0.12)	0.19 (0.16-0.21)	0.65 (0.61-0.70)	6.09 (5.93-6.25)	20.66 (20.30-21.02)	45.26 (44.13-46.40)
75-79	110,391	0.16 (0.14-0.19)	0.32 (0.28-0.35)	1.17 (1.10-1.23)	10.31 (10.11-10.52)	34.13 (33.70-34.57)	66.31 (65.14-67.48)
80-84	67,632	0.29 (0.25-0.33)	0.57 (0.52-0.63)	1.89 (1.79-2.00)	16.62 (16.30-16.95)	52.02 (51.42-52.63)	*84.65 (83.48-85.78)*
85+	27,970	0.64 (0.55-0.74)	1.26 (1.13-1.40)	3.59 (3.38-3.82)	29.07 (28.44-29.71)	73.49 (72.63-74.36)	*94.08 (92.65-95.32)*

Note: Excludes 8,465 bilateral operations performed on the same day. Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Table 3.32 (b) KM estimates of cumulative **mortality** (95% CI) by **age** and **gender**, in primary unicondylar replacements. *Blue italics signify that fewer than 250 cases remained at risk at these time points*

Age group (years)	Number of patients	Time since primary					
		30 days	90 days	1 year	5 years	10 years	15 years
All cases	105,356	0.04 (0.03-0.05)	0.08 (0.06-0.10)	0.40 (0.37-0.44)	4.14 (3.99-4.28)	13.15 (12.83-13.48)	26.55 (25.57-27.55)
Males							
<55	9,005	0.01 (0.00-0.08)	0.02 (0.01-0.09)	0.19 (0.11-0.31)	1.12 (0.89-1.40)	3.35 (2.79-4.02)	*7.24 (5.07-10.29)*
55-59	8,702	0.03 (0.01-0.11)	0.05 (0.02-0.12)	0.23 (0.15-0.36)	1.82 (1.51-2.19)	6.08 (5.33-6.92)	*12.01 (9.98-14.41)*
60-64	11,165	0.05 (0.02-0.12)	0.09 (0.05-0.17)	0.38 (0.28-0.51)	2.83 (2.50-3.22)	8.76 (8.01-9.58)	*20.42 (17.53-23.71)*
65-69	10,813	0.01 (0.00-0.07)	0.06 (0.03-0.13)	0.35 (0.25-0.49)	4.24 (3.80-4.72)	14.08 (13.05-15.19)	*25.20 (22.63-27.99)*
70-74	8,223	0.02 (0.01-0.10)	0.07 (0.03-0.17)	0.61 (0.46-0.81)	7.77 (7.08-8.52)	22.82 (21.37-24.36)	*46.45 (41.86-51.28)*
75-79	5,074	0.06 (0.02-0.18)	0.18 (0.09-0.35)	0.99 (0.75-1.32)	10.96 (9.95-12.06)	37.74 (35.54-40.03)	*66.30 (61.12-71.42)*
80-84	2,275	0.09 (0.02-0.35)	0.22 (0.09-0.53)	1.77 (1.28-2.43)	20.75 (18.77-22.91)	*51.96 (48.64-55.37)*	
85+	732	0.55 (0.21-1.45)	0.69 (0.29-1.65)	4.04 (2.79-5.85)	*34.39 (30.21-38.97)*	*78.01 (71.67-83.77)*	
Females							
<55	10,205	0.02 (0.00-0.08)	0.03 (0.01-0.09)	0.06 (0.03-0.13)	0.84 (0.65-1.08)	2.88 (2.39-3.47)	*4.46 (3.39-5.86)*
55-59	8,078	0.01 (0.00-0.09)	0.01 (0.00-0.09)	0.08 (0.03-0.17)	1.12 (0.87-1.43)	4.03 (3.42-4.74)	*8.21 (6.36-10.56)*
60-64	8,721	0.01 (0.00-0.08)	0.01 (0.00-0.08)	0.15 (0.08-0.26)	1.79 (1.49-2.15)	5.68 (4.99-6.46)	*11.95 (10.10-14.12)*
65-69	8,320	0.04 (0.01-0.11)	0.10 (0.05-0.19)	0.29 (0.19-0.43)	2.38 (2.02-2.79)	8.07 (7.19-9.06)	*18.87 (15.53-22.83)*
70-74	6,840	0.06 (0.02-0.16)	0.09 (0.04-0.20)	0.33 (0.21-0.50)	3.84 (3.31-4.44)	13.87 (12.60-15.26)	*32.08 (28.78-35.65)*
75-79	4,375	0	0.05 (0.01-0.19)	0.41 (0.26-0.66)	6.34 (5.52-7.26)	24.01 (22.12-26.02)	*56.86 (50.68-63.22)*
80-84	2,100	0.14 (0.05-0.44)	0.39 (0.19-0.77)	1.20 (0.81-1.79)	12.66 (11.06-14.48)	43.31 (40.05-46.71)	
85+	728	0.28 (0.07-1.10)	0.97 (0.47-2.03)	3.53 (2.38-5.22)	21.44 (18.00-25.42)	*64.76 (58.22-71.24)*	

Note: Excludes 3,120 bilateral operations performed on the same day. Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Table 3.32 (a) shows Kaplan-Meier estimates of cumulative percentage mortality at 30 days, 90 days and at 1, 5, 10 and 15 years from the primary knee replacement, for all cases and by age and gender. Fewer men than women have had a primary knee replacement and, proportionally, more women than men undergo surgery above the age of 75. Males, particularly in the older age groups, had a higher cumulative percentage probability of dying in the short or longer term after their primary knee replacement operation than females in the equivalent age group. The mortality rates are lower in males and females following UKR than TKR, but these figures do not adjust for selection and hence do not account for residual confounding[6].

Note: These cases were not censored when further revision surgery was undertaken. Whilst such surgery may have contributed to the overall mortality, the impact of this is not investigated in this report.

[6] Hunt LP, Whitehouse MR, Howard PW, Ben-Shlomo Y, Blom AW. Using long term mortality to determine which perioperative risk factors of mortality following hip and knee replacement may be causal. Sci Rep. 2018 Oct 9;8(1):15026.

3.4.6 Overview of knee revisions

This section looks at all recorded knee revision procedures performed since the registry began on 1 April 2003 up to the end of December 2018, for all patients with valid patient identifiers (i.e. whose data could therefore be linked).

In total there were 75,881 revisions recorded on 63,268 individual patient-sides[7] (60,294 actual patients). In addition to the 33,292 revised primaries described previously in this section, there were 29,976 additional revisions for a patient-side for which we have no associated primary operation recorded in the NJR.

Revisions are classified as single-stage, stage one of two-stage or stage two of two-stage revisions. Information on stage one and stage two of two-stage revisions are entered into the database separately, whereas stage one and stage two revisions in practice are typically linked. Although not all patients who undergo a stage one of two revision will undergo a stage two of two revision. In some cases, stage one revisions have been entered without stage two, and vice versa, making identification of entire patient revision episodes difficult. An attempt has been made to do this later in this section.

Table 3.33 Number and percentage of failures by procedure type and year.

Year of revision surgery	Type of revision procedure			Total revision joint operations
	Single stage N(%)	Stage one of two-stage N(%)	Stage two of two-stage N(%)	
2003*	634 (99.8)	- - - -	- - - -	635
2004	987 (80.0)	80 (6.5)	166 (13.5)	1,233
2005	1,482 (73.7)	211 (10.5)	318 (15.8)	2,011
2006	1,964 (75.2)	286 (11.0)	360 (13.8)	2,610
2007	2,643 (75.1)	386 (11.0)	492 (14.0)	3,521
2008	3,342 (75.7)	479 (10.8)	596 (13.5)	4,417
2009	3,719 (76.2)	528 (10.8)	636 (13.0)	4,883
2010	4,194 (77.1)	575 (10.6)	674 (12.4)	5,443
2011	4,343 (77.4)	619 (11.0)	651 (11.6)	5,613
2012	5,025 (78.5)	633 (9.9)	741 (11.6)	6,399
2013	4,709 (78.4)	631 (10.5)	668 (11.1)	6,008
2014	5,074 (77.9)	742 (11.4)	700 (10.7)	6,516
2015	5,337 (79.0)	744 (11.0)	677 (10.0)	6,758
2016	5,460 (80.6)	679 (10.0)	636 (9.4)	6,775
2017	5,402 (80.6)	648 (9.7)	652 (9.7)	6,702
2018	5,227 (82.2)	564 (8.9)	566 (8.9)	6,357
All years	59,542	7,806	8,533	75,881

*Incomplete year.
Note: MDSv1, in use in 2003, only defined operations as primary or revision. All revisions using MDSv1 have been listed as single stage revisions in this and subsequent tables.

Table 3.33 gives an overview of all knee revision procedures carried out each year since April 2003. There were a maximum number of 13 documented revision procedures associated with any individual patient side (making up 12 revision episodes as one episode consisted of a stage one of a two-stage procedure and a stage two of a two-stage procedure). The increase in the number of operations over time reflects the increasing number of at-risk implants prevailing in the database.

[7] For 67 patient sides, multiple procedures had been entered on the same operation date. Details of the components that had been entered for these cases were reviewed. As a result of this, 130 of the 134 duplicated patient side records with the same operation date have been dropped and the remainder have been reclassified.

Table 3.34 (a) Number and percentage of knee revision by indication and procedure type.

Reason for revision	Type of revision procedure		
	Single stage N(%) (n=59,538)	Stage one of two-stage N(%) (n=7,806)	Stage two of two-stage N(%) (n=8,528)
Aseptic loosening / lysis	23,592 (39.6)	1,419 (18.2)	1,278 (15.0)
Instability	10,421 (17.5)	328 (4.2)	326 (3.8)
Pain	9,568 (16.1)	355 (4.5)	317 (3.7)
Implant wear	8,463 (14.2)	260 (3.3)	167 (2.0)
Other indication	6,943 (11.7)	302 (3.9)	458 (5.4)
Malalignment	4,542 (7.6)	111 (1.4)	125 (1.5)
Infection	3,971 (6.7)	6,600 (84.6)	6,765 (79.3)
Dislocation/subluxation	2,446 (4.1)	127 (1.6)	91 (1.1)
Periprosthetic fracture	2,437 (4.1)	115 (1.5)	128 (1.5)
Stiffness*	3,417 (5.8) n=58,627	190 (2.4) n=7,806	153 (1.8) n=8,528
Progressive arthritis remains*	7,038 (13.7) n=51,357	53 (0.8) n=6,766	68 (1.0) n=7,095

*These reasons were not recorded in the earliest phase of the registry; only in MDSv2 onwards for stiffness and MDSv3 onwards for remaining progressive arthritis.
Note: The number of joints on which these two percentages are based is stated below the percentage figure.

Table 3.34 (b) Number and percentage of knee revision by indication and procedure type in the last five years.

Reason for revision	Type of revision procedure		
	Single stage N(%) (n=26,506)	Stage one of two-stage N(%) (n=3,378)	Stage two of two-stage N(%) (n=3,232)
Aseptic loosening / lysis	9,284 (35.0)	494 (14.6)	394 (12.2)
Progressive arthritis remains	4,964 (18.7)	38 (1.1)	45 (1.4)
Instability	4,663 (17.6)	128 (3.8)	109 (3.4)
Implant wear	3,436 (13.0)	82 (2.4)	48 (1.5)
Pain	3,046 (11.5)	82 (2.4)	72 (2.2)
Other indication	2,768 (10.4)	122 (3.6)	168 (5.2)
Infection	2,238 (8.4)	2,927 (86.6)	2,632 (81.4)
Malalignment	1,816 (6.9)	40 (1.2)	40 (1.2)
Stiffness	1,500 (5.7)	76 (2.2)	57 (1.8)
Periprosthetic fracture	1,295 (4.9)	64 (1.9)	73 (2.3)
Dislocation/subluxation	943 (3.6)	63 (1.9)	31 (1.0)

Table 3.34 (a) shows the stated reasons for the revision knee surgery. Please note that, as several reasons can be selected, the reasons are not mutually exclusive and therefore column percentages do not add up to 100%. Aseptic loosening / lysis is the most common reason for revision, accounting for approximately one third of single stage revision operations, while other indications, instability and pain account for almost a fifth each. Of the two-stage revision operations, infection is the main reason recorded for revision surgery in approximately four-fifths of either stage one or stage two procedures. Table 3.34 (b) presents these results restricted to the last five years (1,826 days).

3.4.7 Rates of knee re-revision

In most instances (85.7%), the first revision procedure was a single stage revision, however in the remaining 14.3% it was part of a two-stage procedure. For a given patient-side, we have looked at the survival following the first documented revision procedure in the NJR (n=63,268). We have looked at the time from the first documented revision procedure (of any type) to the time at which a second revision procedure was undertaken. For this purpose, we regarded an initial stage one followed by either a stage one or a stage two of a two-stage procedure as being the same revision episode and these were disregarded, looking instead for the start of a second revision episode. (We counted the maximum number of distinct revision episodes for any patient-side to be twelve.)

Kaplan-Meier estimates of the cumulative percentage probability of having a subsequent revision (re-revision) were calculated. There were 6,112 re-revisions and, for 10,677 cases, the patient died without having been re-revised. The censoring date for the remainder was the end of 2018.

Figure 3.22 (a) KM estimates of cumulative **re-revision**, in linked revised primary knee replacements (shaded area indicate point-wise 95% CI).

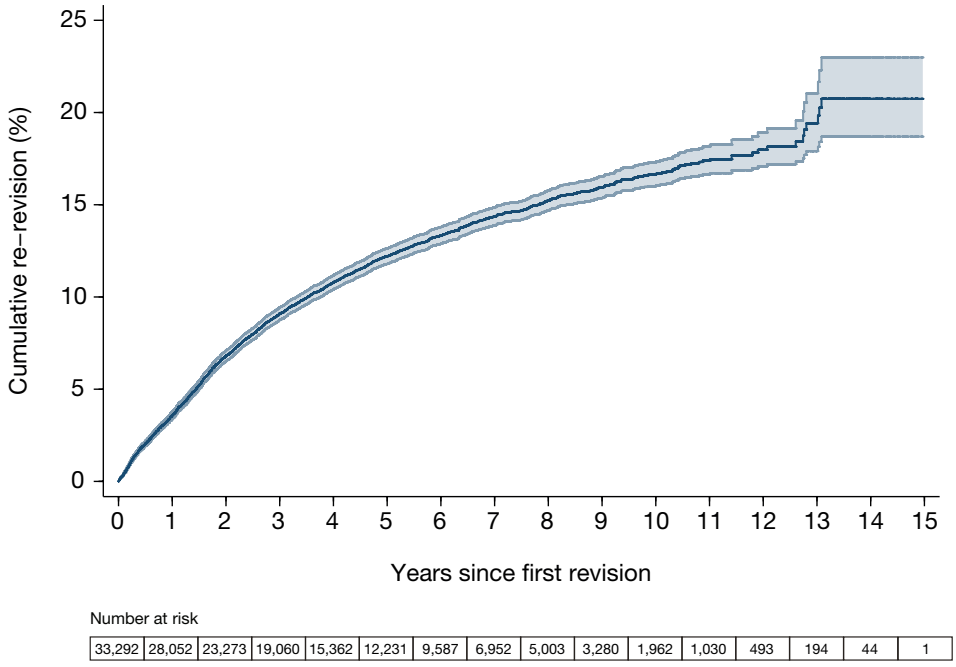
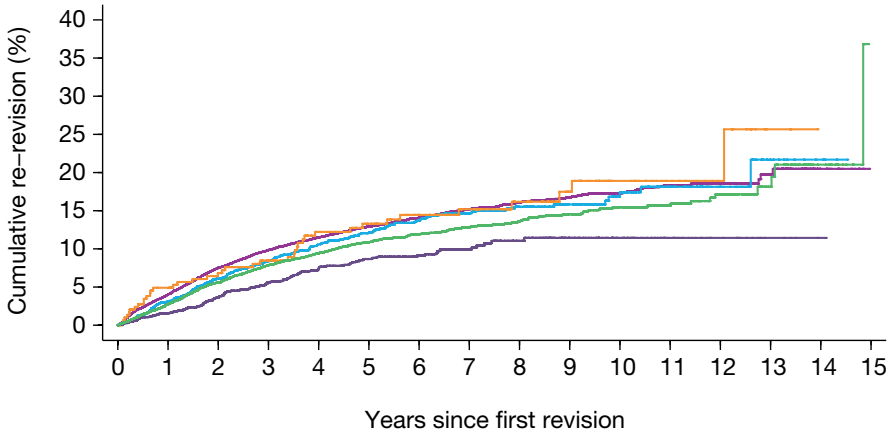


Figure 3.22 (a) plots Kaplan-Meier estimates of the cumulative probability of a subsequent revision in linked revised primary knee replacements between 1 and 15 years since the primary operation.

Figure 3.22 (b) KM estimates of cumulative **re-revision** by **primary fixation**, in linked primary knee replacements.

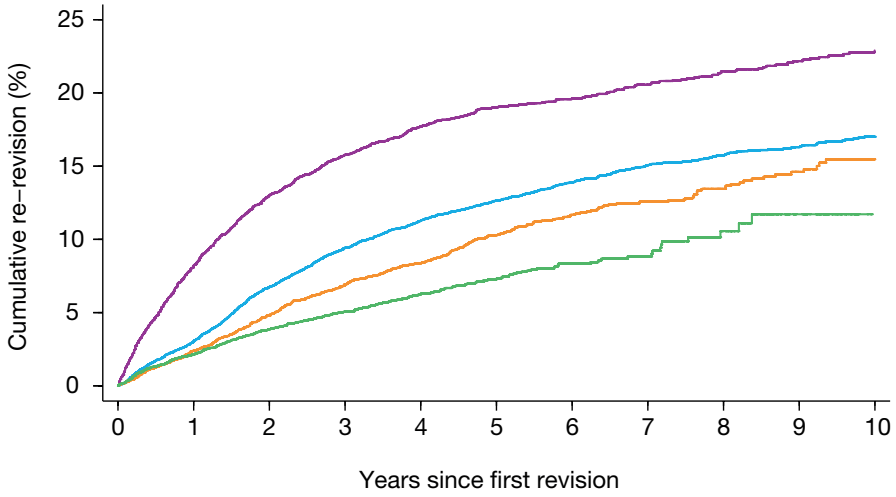


Number at risk

Cemented	22,287	18,502	15,163	12,246	9,740	7,626	5,861	4,202	2,987	1,952	1,154	581	261	110	21	1
Uncemented	1,536	1,375	1,193	1,034	891	757	625	467	342	234	145	78	38	11	4	0
Hybrid	294	260	238	210	177	157	136	109	83	59	33	21	12	3	0	0
Patellofemoral	1,744	1,521	1,288	1,052	824	657	509	346	238	128	70	30	14	5	1	0
Unicondylar	7,429	6,393	5,390	4,517	3,729	3,033	2,455	1,827	1,352	907	560	320	168	65	18	0

Figure 3.22 (b) shows estimates of re-revision by type of primary knee replacement. Patellofemoral knee replacements have the lowest risk of re-revision until seven years, followed by unicondylar knee replacements, after which the rates converge except from the hybrid TKRs and patellofemoral knee replacement re-revisions, but the numbers at risk are low and should therefore be interpreted with caution.

Figure 3.22 (c) KM estimates of cumulative **re-revision** by **years to first revision**, in linked primary knee replacements.

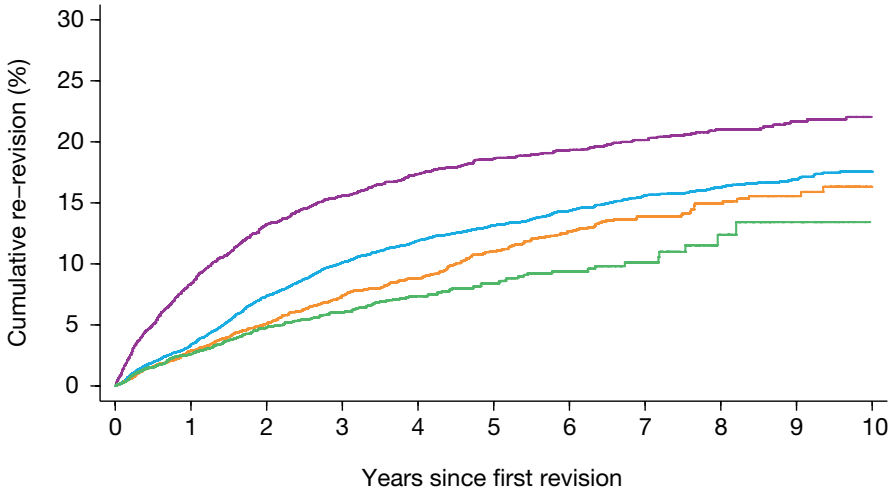


Number at risk

First rev. <1y	5,548	4,601	3,894	3,303	2,752	2,319	1,921	1,530	1,220	879	596
First rev. 1–3y	12,979	11,492	9,909	8,396	7,070	5,886	4,812	3,656	2,764	1,865	1,138
First rev. 3–5y	6,208	5,320	4,494	3,754	3,086	2,451	1,894	1,281	814	465	217
First rev. 5+y	8,557	6,639	4,976	3,607	2,454	1,575	960	485	205	71	11

Figure 3.22 (c) shows the relationship between time to first revision and risk of subsequent revision. The earlier the primary knee replacement fails, the higher the risk of second revision. For example, if a primary knee replacement is revised within the first year of the primary replacement being performed, there is an 8% re-revision rate at one year following the first revision, rising to 19% by five years; if a primary knee replacement is not revised until five years or more after the primary procedure, the re-revision rate is approximately 2% at one year following the first revision, rising to 7% by five years.

Figure 3.23 (a) KM estimates of cumulative **re-revision** in primary **cemented TKRs** by **years to first revision**.

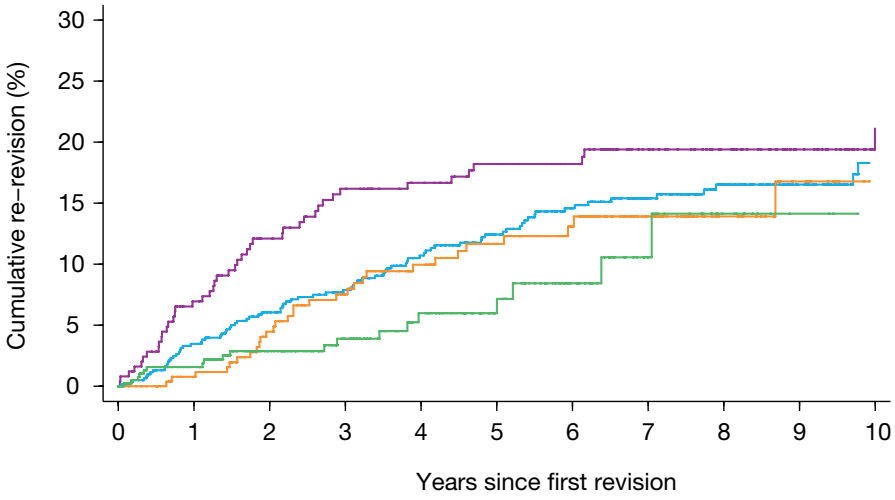


Number at risk

First rev. <1y	4,000	3,267	2,726	2,274	1,855	1,518	1,221	947	732	515	343
First rev. 1–3y	9,199	8,001	6,761	5,652	4,672	3,805	3,033	2,266	1,700	1,138	681
First rev. 3–5y	4,159	3,461	2,881	2,338	1,888	1,466	1,109	743	456	263	125
First rev. 5+y	4,929	3,773	2,795	1,982	1,325	837	498	246	99	36	5

For those with documented primary knee replacements within the NJR, Figures 3.23 (a) to (e) show cumulative re-revision rates following the first revision, according to the main type of primary knee replacement. Each sub-group has been further sub-divided according to the time interval from the primary to the first revision, i.e. less than 1 year, 1 to 3, 3 to 5 and more than 5 years. For cemented, uncemented, unicondylar and patellofemoral knee replacements, those who had their first revision within one year of the initial primary knee replacement, experienced the worst re-revision rates. However, for hybrid TKRs, the worst re-revision rates were experienced by those who had their first revision within 3 to 5 years of the initial primary knee replacement; however, the numbers were small and therefore the results should be interpreted with caution.

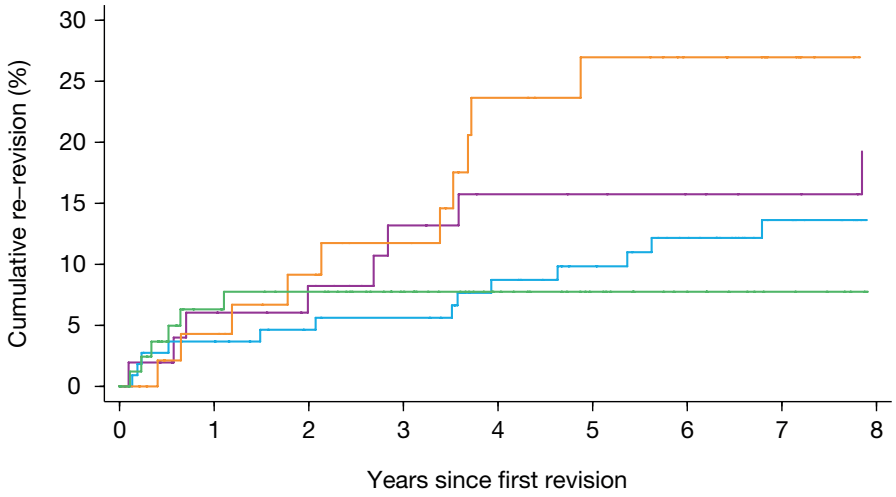
Figure 3.23 (b) KM estimates of cumulative **re-revision** in primary **uncemented TKRs** by **years to first revision**.



Number at risk

First rev. <1y	249	222	198	182	170	156	139	116	97	71	46
First rev. 1–3y	616	575	529	475	426	382	330	261	193	133	83
First rev. 3–5y	270	252	225	199	169	139	105	65	40	26	15
First rev. 5+y	401	326	241	178	126	80	51	25	12	4	1

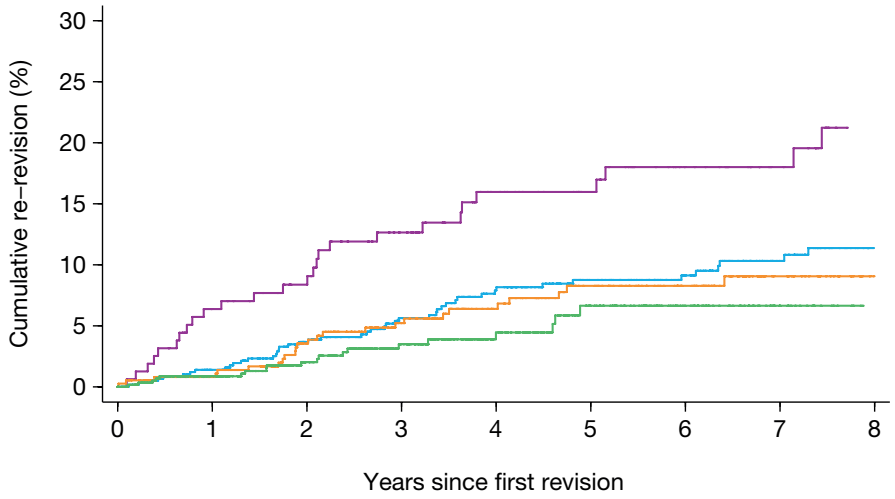
Figure 3.23 (c) KM estimates of cumulative re-revision in primary hybrid TKRs by years to first revision.



Number at risk

First rev. <1y	52	46	42	35	31	30	28	26	23
First rev. 1–3y	109	103	97	95	86	79	72	58	47
First rev. 3–5y	50	43	37	32	25	22	18	13	7
First rev. 5+y	83	68	62	48	35	26	18	12	6

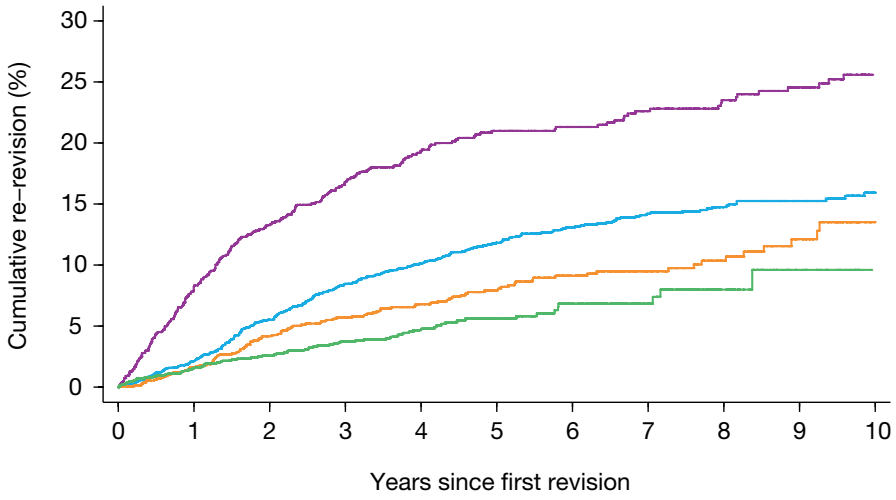
Figure 3.23 (d) KM estimates of cumulative **re-revision** in primary **patellofemoral** knee replacements by **years to first revision**.



Number at risk

First rev. <1y	158	144	131	114	96	83	67	54	42
First rev. 1–3y	597	540	488	411	345	292	241	179	132
First rev. 3–5y	374	345	302	256	213	171	137	85	53
First rev. 5+y	615	492	367	271	170	111	64	28	11

Figure 3.23 (e) KM estimates of cumulative re-revision in primary unicondylar knee replacements by years to first revision.



Number at risk

First rev. <1y	1,089	922	797	698	600	532	466	387	326	247	180
First rev. 1–3y	2,458	2,273	2,034	1,763	1,541	1,328	1,136	892	692	483	307
First rev. 3–5y	1,355	1,219	1,049	929	791	653	525	375	258	147	69
First rev. 5+y	2,527	1,979	1,510	1,127	797	520	328	173	76	30	4

Table 3.35 (a) KM estimates of cumulative **re-revision** (95% CI).
Blue italics signify that fewer than 250 cases remained at risk at these time points.

	Number of first revised joints at risk of re-revision	Time since first revision					
		1 year	3 years	5 years	7 years	10 years	15 years
Primary recorded in the NJR	33,292	3.59 (3.39-3.81)	9.11 (8.77-9.45)	12.21 (11.80-12.63)	16.68 (16.04-17.33)	*19.42 (17.91-21.04)*	*30.65 (16.33-52.84)*

Note: Estimates in blue italics are based on the number at risk falling below 250 patient-sides (see methodological notes in earlier sections). The number at risk for the 15-year estimate is only two.

Table 3.35 (a) shows the re-revision rate of the 33,292 primary knee replacements (33,290 with known knee type) registered in the NJR that were revised. Of these, 6,112 were re-revised.

Table 3.35 (b) KM estimates of cumulative **re-revision** (95% CI) by **years since first revision**.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

Primary in the NJR where the first revision took place:	Number of first revised joints at risk of re-revision	Time since first revision				
		1 year	3 years	5 years	7 years	10 years
<1 year after primary	5,548	8.20 (7.49-8.97)	15.77 (14.78-16.83)	19.02 (17.90-20.20)	20.55 (19.35-21.82)	22.90 (21.48-24.40)
1-3 years after primary	12,979	3.06 (2.77-3.38)	9.43 (8.90-9.99)	12.64 (12.00-13.30)	15.08 (14.34-15.85)	17.00 (16.12-17.94)
3-5 years after primary	6,208	2.40 (2.04-2.83)	6.93 (6.26-7.66)	10.29 (9.42-11.24)	12.58 (11.53-13.71)	*15.47 (13.91-17.18)*
5+ years after primary*	8,557	2.16 (1.86-2.51)	5.07 (4.55-5.66)	7.28 (6.53-8.10)	8.83 (7.83-9.95)	*11.72 (9.61-14.24)*

Note: Maximum interval was 15.5years.

Table 3.35 (b) shows that primary knee replacements that fail within the first year after surgery have approximately two to four times the chance of needing re-revision at each time point compared with primaries that last more than five years.

Table 3.35 (c) shows cumulative re-revision rates at 1, 3, 5, 7 and 10 years following the first revision for those with documented primary knee replacements within the NJR, broken down by type of knee replacement, constraint and mobility. Overall, the worst re-revision rates were demonstrated in those where the initial primary had been a cemented TKR although the confidence intervals broadly overlap after five years.

Table 3.35 (c) KM estimates of cumulative **re-revision** (95% CI) by **fixation** and **constraint**.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

Knee type	Constraint	N	Time since first revision				
			1 year	3 years	5 years	7 years	10 years
All types		33,292	3.59 (3.39-3.80)	9.10 (8.77-9.45)	12.21 (11.79-12.63)	14.37 (13.89-14.87)	16.67 (16.04-17.33)
Cemented		22,287	4.04 (3.78-4.32)	9.86 (9.43-10.30)	12.93 (12.41-13.47)	15.22 (14.60-15.86)	17.32 (16.53-18.14)
	unconstrained fixed	13,358	3.96 (3.63-4.31)	9.74 (9.19-10.31)	12.99 (12.32-13.70)	15.03 (14.24-15.85)	16.91 (15.91-17.96)
	unconstrained mobile	1,294	3.32 (2.45-4.48)	10.30 (8.65-12.23)	12.78 (10.88-14.98)	16.73 (14.35-19.45)	*19.65 (16.74-22.99)*
	posterior-stabilised fixed	6,310	4.25 (3.77-4.80)	9.85 (9.05-10.71)	12.83 (11.86-13.87)	15.19 (14.02-16.45)	17.47 (15.93-19.14)
Uncemented		1,536	3.12 (2.34-4.14)	8.40 (7.04-10.02)	12.07 (10.36-14.04)	14.68 (12.70-16.94)	*17.40 (14.72-20.51)*
Unicondylar		7,429	2.77 (2.41-3.19)	7.88 (7.23-8.59)	10.88 (10.08-11.75)	12.84 (11.91-13.85)	15.47 (14.22-16.82)
	fixed	1,955	2.32 (1.72-3.13)	8.43 (7.15-9.93)	11.71 (10.11-13.56)	14.01 (12.12-16.17)	*15.28 (13.06-17.82)*
	mobile	5,381	2.90 (2.48-3.40)	7.73 (6.98-8.55)	10.59 (9.67-11.60)	12.43 (11.37-13.59)	15.50 (14.02-17.12)
Patellofemoral		1,744	1.57 (1.07-2.30)	5.61 (4.52-6.95)	8.67 (7.19-10.45)	9.91 (8.22-11.93)	*11.44 (9.38-13.92)*

Note: Maximum interval was 14.8 years.

3.4.8 Reason for knee re-revision

Table 3.36 (a) Number of failures by indication for all revisions.

Reason for revision	All recorded revisions, N(%)
Aseptic loosening / lysis	26,289 (34.6)
Infection	17,336 (22.8)
Instability	11,075 (14.6)
Pain	10,240 (13.5)
Implant wear	8,890 (11.7)
Malalignment	4,778 (6.3)
Periprosthetic fracture	2,680 (3.5)
Dislocation/subluxation	2,664 (3.5)
Other indication	7,703 (10.2)
Stiffness*	3,760 (5.0)
Progressive arthritis remains**	7,159 (11.0)

*Stiffness as a reason for revision was not recorded in MSDv1 and as such was only a potential reason for revision among a total of 74,961 revisions as opposed to 75,872 revisions for the other reasons.
**Progressive arthritis remains as a reason for revision was not recorded in MSDv1 or MSDv2 and as such was only a potential reason for revision among a total of 65,218 revisions as opposed to 75,872 revisions for the other reasons.

Table 3.36 (b) Number of failures by indication for first linked revision and second linked re-revision.

	First linked revision		Second linked revision
Reason for revision	N	Subsequently re-revised, N(%)	N
Aseptic loosening / lysis	23,466	1,959 (8.3)	1,765
Infection	10,314	1,589 (15.4)	2,138
Instability	9,676	930 (9.6)	1,048
Pain	9,328	1,008 (10.8)	656
Implant wear	8,418	619 (7.4)	330
Malalignment	4,358	374 (8.6)	329
Periprosthetic fracture	2,347	171 (7.3)	187
Dislocation/subluxation	2,286	285 (12.5)	274
Other indication	6,805	600 (8.8)	514
Stiffness*	3,240	337 (10.4)	367
Progressive arthritis remains**	6,932	305 (4.4)	163

*Stiffness as a reason for revision was not recorded in MSDv1 and as such was only a potential reason for revision among a total of 74,961 revisions as opposed to 75,872 revisions for the other reasons.
**Progressive arthritis remains as a reason for revision was not recorded in MSDv1 or MSDv2 and as such was only a potential reason for revision among a total of 65,218 revisions as opposed to 75,872 revisions for the other reasons.

Tables 3.36 (a) and (b) show a breakdown of the stated indications for the first revision and for any second revision (note the indications are not mutually exclusive). Table 3.36 (a) shows the indications for all knee revisions recorded in the NJR and Table 3.36 (b) reports the indications for the first linked revision and the number and percentage of first recorded revisions that were subsequently revised. The final column reports the indications for all the second linked revisions. It is interesting to note that infection, dislocation/subluxation, instability and stiffness are more common indications for second revision than first revision. This reflects the complexity and soft tissue elements that contribute to the outcome of revision knee replacement.

Table 3.37 (a) Number of re-revisions by year.

Year of first revision in the NJR*	Number of first revisions	Number of first revisions (%) with the associated primary recorded in the NJR
2003	627	12 (1.9)
2004	1,175	84 (7.1)
2005	1,853	281 (15.2)
2006	2,360	514 (21.8)
2007	3,143	878 (27.9)
2008	3,833	1,401 (36.6)
2009	4,202	1,833 (43.6)
2010	4,628	2,215 (47.9)
2011	4,691	2,357 (50.2)
2012	5,317	2,987 (56.2)
2013	4,911	2,831 (57.6)
2014	5,248	3,215 (61.3)
2015	5,405	3,499 (64.7)
2016	5,407	3,682 (68.1)
2017	5,359	3,761 (70.2)
2018	5,109	3,742 (73.2)
Total	63,268	33,292 (52.6)

*First documented revision in the NJR.

Table 3.37 (b) Number of re-revisions by year, stage, and whether or not primary is in the NJR.

Year of (first) revision	Single stage		First documented stage of two-stage	
	Primary not in the NJR total per year	Primary in the NJR total per year	Primary not in the NJR total per year	Primary in the NJR total per year
2003	614	12	1	0
2004	907	63	184	21
2005	1,242	202	330	79
2006	1,502	391	344	123
2007	1,864	665	401	213
2008	2,047	1,097	385	304
2009	1,989	1,503	380	330
2010	2,066	1,815	347	400
2011	2,044	1,929	290	428
2012	2,069	2,520	261	467
2013	1,838	2,399	242	432
2014	1,818	2,713	215	502
2015	1,722	3,017	184	482
2016	1,563	3,255	162	427
2017	1,455	3,320	143	441
2018	1,275	3,319	92	423
All years	26,015	28,220	3,961	5,072

Tables 3.37 (a) and (b) show that the numbers of revisions and the relative proportion of revisions with an associated primary in the NJR increased with time. Approximately 70% of revisions performed in 2018 had a linked primary in the NJR. This is likely to reflect improved data capture over time, improved linkability of records and the longevity of knee replacements with a proportion of primaries being revised being performed before NJR data capture began or outside the coverage of the NJR.

3.4.9 90-day mortality after knee revision

The overall cumulative percentage probability of mortality at 90 days after knee revision was lower in the cases with their primaries documented in the NJR compared with the remainder (Kaplan-Meier estimates 0.60 (95% CI 0.52-0.69) versus 0.91 (0.81-1.02)), which may reflect the fact that this patient group was younger at the time of their first revision, median age of 68 (IQR 60-75) years, compared to the group without primaries documented in the NJR who had a median age of 72 (IQR 65-79) years. The percentage of males was similar in both groups (45.3% versus 47.2% respectively).

3.4.10 Conclusions

There are now over 1.19 million primary knee replacements with a maximum follow-up of 15.75 years recorded in the NJR making this the largest dataset of its kind in the world. Of these, 96.2% of the procedures are performed for osteoarthritis as the only indication. Approximately 90% of the procedures are TKRs, 9% medial or lateral unicondylar knee replacements and 1% patellofemoral replacements. These proportions have remained relatively constant over time but the proportion of unicondylar knee replacements has risen slightly, hitting 10% for the first time in 2017, rising to 11.1% in 2018. Cemented, unconstrained (cruciate retaining), fixed bearing

TKR remains by far the most common type of knee replacement followed by cemented, posterior stabilised, fixed bearing TKR. Patients who received unicondylar or patellofemoral knee replacement were typically younger than those receiving a TKR. TKR and patellofemoral replacement are more likely to be performed in females whereas unicondylar knee replacement is more likely to be performed in males.

TKRs with a monobloc polyethylene tibia consistently show some of the lowest crude revision rates although the numbers at risk in later years is small so the results must be interpreted with caution. Cemented TKRs that are unconstrained with a fixed bearing, as well as being the most common type of TKR, consistently show low revision rates in comparison to alternatives; crude revision rates are approximately one percentage point lower in comparison to cemented unconstrained TKRs with a mobile bearing and cemented TKRs that are posterior stabilised with either a fixed or mobile bearing at ten years.

Age and gender influence the risk of revision surgery with younger patients and males being more likely to undergo revision, it has previously been felt that this may explain the higher revision rates observed in UKR. We have continued presentation of results divided by gender and age band from the 15th Annual Report and these show the risk of revision of a unicondylar knee replacement is at least 1.9 times higher in males and 2.3 times higher in females at ten years than a cemented TKR. The risk of revision of a patellofemoral replacement is at least 2.8 times higher in males and females than a cemented TKR across all age groups. The difference in revision rates rises from age less than 55 up to the 65-74 age group and declines again in the over-75s.

The most common causes of revision across all primary knee replacements were aseptic loosening / lysis, infection, pain, progressive arthritis and instability. For uncemented TKRs, the incidence of revision for pain and aseptic loosening / lysis were higher but the risk of revision for infection lower than for cemented TKR. For unicondylar knee replacements, the highest risk of revision was for progressive arthritis, aseptic loosening / lysis and pain. Progression of osteoarthritis elsewhere in the knee is also the fourth most common indication selected by surgeons for TKR. The risk of revision for progressive arthritis, aseptic loosening / lysis and pain were all higher for UKRs than TKRs but the risk of revision for infection is lower.

Infection accounts for the majority of the two-stage revision procedures performed. Only approximately 7% of revisions for infection that have been carried out in the NJR to date have been single stage procedures indicating low usage and take-up of this technique. The soft tissue envelope makes single stage revision surgery potentially more challenging than in the hip which may explain the differences in utilisation of a single stage approach.

The risk of re-revision following a revision procedure is higher than for the risk of revision of a primary TKR across all types of knee replacement. The risk of re-revision of a revised patellofemoral replacement is slightly lower than the other types of knee with the rest being broadly similar. This suggests that caution should be used when suggesting that UKR may be considered an interim procedure or a lesser intervention than a TKR as the crude re-revision rates are worse than the revision rates for primary TKR and are broadly similar regardless of the type of the knee replacement implanted at the primary procedure. This area requires further research to explore the risk of revision in light of the different demographics in these groups. The risk of re-revision is higher for those revised after a shorter period of time following the primary and is associated with the indication for revision. This suggests that not all of the processes that lead to revision are the same and some are more aggressive than others with consequences beyond the initial revision.

Knee replacement remains a safe procedure with low rates of perioperative mortality. The rates of mortality are, unsurprisingly, higher for males than for females. The average age of a patient undergoing TKR is approximately 70 years, just over 56% of males and 45% of females in the 70-74 age bracket will have died 15 years after their knee replacement. This means that for the average patient undergoing a knee replacement, their knee replacement should last them for the rest of their life without the need for revision surgery.

Part 3

3.5 Outcomes after ankle replacement

3.5.1 Overview of primary ankle surgery

This section looks at revision and mortality for all primary ankle operations submitted to the NJR up to 31 December 2018. There were 5,587 primary ankle operations in total (see Tables 3.1 and 3.2), including eight bilateral operations (both sides operated on the same date). Although ankle replacements were routinely entered into the NJR from 2010, 14 primary operations have been entered that had been carried out before 2010.

The median age at primary surgery was 68 years (IQR 61-74 years), with an overall range of 17 to 97 years. More procedures were performed in men (59.6%) than women. Of the 5,587 primary procedures, 5,334 (95.5%) were uncemented, 135 (2.4%) used cemented fixation, and 118 (2.1%) used a hybrid fixation method. In 2018, 91%, 4% and 5% of primary ankle operations used uncemented, hybrid, and cemented fixations respectively. The percentage of operations with cemented and hybrid fixation have remained approximately constant in the last three years. The inclusion of hybrid fixation in this report is due to the fixation of both talar and tibial components now being recorded, whereas previously we relied on the documented fixation method of the tibial component.

Table 3.38 Descriptive statistics of ankle procedures performed by consultant and unit by year of surgery.

Number of primary replacements during each year	Year of primary								
	≤2010[1]	2011	2012	2013	2014	2015	2016	2017	2018
Operations (n)	417	523	583	557	551	618	725	770	843
Units (n)	111	128	145	133	137	143	140	144	143
Mean number of primary replacements per unit	3.8	4.1	4.0	4.2	4.0	4.3	5.2	5.3	5.9
Median (IQR) number of any primary replacements per unit	2 (1-4)	2 (1-5)	2 (1-4)	2 (1-5)	2 (1-4)	2 (1-5)	2 (1-7)	3 (1-7)	3 (1-7)
Units who entered ≥ 10 operations (n)	10	7	10	10	10	10	16	16	20
Units who entered ≥ 20 operations (n)	3	3	3	3	4	5	5	6	6
Consultants providing operation (n)	114	126	143	132	126	141	133	141	145
Mean number of operations per consultant	3.7	4.2	4.1	4.2	4.4	4.4	5.5	5.5	5.8
Median (IQR) number of operations per consultant	2 (1-4)	3 (2-5)	2 (1-5)	3 (1-6)	3 (2-5)	2 (1-6)	3 (2-8)	3 (1-8)	3 (2-8)
Consultant who entered ≥ 10 operations (n)	9	10	10	11	8	13	17	21	27
Consultant who entered ≥ 20 operations (n)	2	2	2	2	2	4	5	5	4

*Includes 14 operation dates prior to 2010.

Table 3.38 shows an increasing number of cases reported annually over the nine-year period. This could represent improved compliance or the reporting of a true increase in caseload.

A total of 262 consultants carried out the 5,587 reported primary procedures; with 85 (32.4%) of them entering twenty or more procedures over the nine-year period. The maximum number of procedures for any consultant was 291.

Of the 259 units which submitted data to the NJR, 72 (27.8%) of them carried out twenty or more procedures over the nine-year period. However, the percentage of units submitting twenty or more ankle primary operations each year does not exceed 4%. The maximum number of procedures submitted for any unit was 397.

Table 3.39 Numbers (%) of primary ankle replacements by ankle brand.

Brand	Number (%)	Number (%) of each brand, for each year of operation								
		≤2010*	2011	2012	2013	2014	2015	2016	2017	2018
Infinity**	1,198 (21.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	28 (5.1)	96 (15.5)	213 (29.4)	381 (49.5)	480 (56.9)
Mobility	1,133 (20.3)	259 (62.1)	297 (56.8)	286 (49.1)	203 (36.4)	88 (16.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Zenith	998 (17.9)	78 (18.7)	109 (20.8)	126 (21.6)	133 (23.9)	153 (27.8)	159 (25.7)	108 (14.9)	61 (7.9)	71 (8.4)
Box	690 (12.4)	23 (5.5)	29 (5.5)	45 (7.7)	51 (9.2)	84 (15.2)	134 (21.7)	124 (17.1)	109 (14.2)	91 (10.8)
Star	528 (9.5)	16 (3.8)	29 (5.5)	31 (5.3)	35 (6.3)	60 (10.9)	82 (13.3)	84 (11.6)	99 (12.9)	92 (10.9)
Salto	315 (5.6)	23 (5.5)	29 (5.5)	40 (6.9)	45 (8.1)	56 (10.2)	55 (8.9)	48 (6.6)	9 (1.2)	10 (1.2)
Hintegra	300 (5.4)	15 (3.6)	18 (3.4)	35 (6.0)	69 (12.4)	49 (8.9)	58 (9.4)	33 (4.6)	9 (1.2)	14 (1.7)
Inbone**	222 (4.0)	0 (0.0)	0 (0.0)	2 (0.3)	4 (0.7)	22 (4.0)	20 (3.2)	58 (8.0)	53 (6.9)	63 (7.5)
Rebalance	61 (1.1)	0 (0.0)	4 (0.8)	13 (2.2)	13 (2.3)	6 (1.1)	4 (0.6)	13 (1.8)	7 (0.9)	1 (0.1)
AKILE	34 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.6)	8 (1.1)	12 (1.6)	10 (1.2)
Cadence Talar	21 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.4)	7 (0.9)	11 (1.3)
TARIC	1 (0.0)	0 (0.0)	0 (0.0)	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Not known	86 (1.5)	3 (0.7)	8 (1.5)	4 (0.7)	4 (0.7)	5 (0.9)	6 (1.0)	33 (4.6)	23 (3.0)	0 (0.0)
Total	**5,587 (100.0)**	**417 (100.0)**	**523 (100.0)**	**583 (100.0)**	**557 (100.0)**	**551 (100.0)**	**618 (100.0)**	**725 (100.0)**	**770 (100.0)**	**843 (100.0)**

*Includes 14 operation dates prior to 2010.
**In 2016 and earlier years, 49 Inbone and 330 Infinity implants were classified as cemented by the manufacturer and NJR. In 2017, this was changed to uncemented.

Table 3.39 shows the number of operations by the brand of implant, and by the brand and year of primary operation. Please note that 14 procedures had dates of operation before 2010 (one in 2006, four in 2008 and nine in 2009) and these have been combined with those performed in 2010 for the purposes of reporting. The most common brand overall was the fixed bearing, Infinity (Wright Medical), which was used in just over a fifth of the procedures overall. The Mobility (DePuy) was the most commonly used brand until 2014, when it was voluntarily withdrawn from the market. In 2018, the most common brand used was the Infinity (56.9%), followed by the Star (10.9%) and the Box (10.8%).

3.5.2 Revisions after primary ankle surgery

From June 2018 the NJR's minimum dataset (version 7) for ankle revisions includes Debridement and Implant Retention (DAIR), with or without modular exchange. Therefore, from now on, any subsequent procedure in which an implant (including the polyethylene liner in a mobile bearing implant) is added, removed or exchanged is considered a revision procedure and should be recorded on an NJR A2 MDS form. A DAIR with or without a modular exchange should also be recorded as a revision on an NJR A2 MDS form. Only 265 (4.7%) of the 5,587 primary procedures had a linkable NJR A2 MDS form completed to indicate revision before the end of 2018. The first revisions shown here include 37 conversions to arthrodesis, but no amputations have been recorded. These small numbers likely reflect a failure to record removal of the prosthesis during a conversion to fusion or an amputation procedure as a revision in line with the accepted definition and mandated by the Department of Health. No DAIR procedure was recorded by the NJR in 2018.

Table 3.40 KM estimates of **revision** (95% CI) after primary ankle replacement, by **gender** and **age**.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

Age at primary (years)	n	Time since primary			
		1 year	3 year	5 years	7 years
All cases	5,587	0.71 (0.52-0.99)	3.80 (3.25-4.43)	6.86 (6.03-7.81)	8.51 (7.46-9.71)
Male					
<65 years	1,072	1.05 (0.56-1.94)	5.23 (3.88-7.04)	8.62 (6.65-11.15)	*10.65 (8.24-13.70)*
65-74 years	1,406	0.62 (0.31-1.24)	3.40 (2.45-4.69)	6.83 (5.24-8.88)	*8.48 (6.52-11.00)*
75+ years	849	0.53 (0.20-1.40)	1.77 (0.97-3.21)	3.12 (1.87-5.16)	*3.12 (1.87-5.16)*
Female					
<65 years	859	0.89 (0.42-1.85)	5.54 (4.03-7.58)	10.30 (7.96-13.29)	*12.30 (9.49-15.87)*
65-74 years	880	0.76 (0.34-1.68)	4.16 (2.86-6.04)	7.40 (5.45-10.02)	*10.10 (7.33-13.83)*
75+ years	521	0.20 (0.03-1.38)	1.36 (0.56-3.30)	*1.72 (0.76-3.85)*	*1.72 (0.76-3.85)*

Table 3.40 shows that the overall estimated cumulative percentage probability of (first) revision was: 0.71 (95% CI 0.52-0.99) at 1 year; 3.80 (95% CI 3.25-4.43) at 3 years; 6.86 (95% CI 6.03-7.81) at 5 years; and 8.51 (95% CI 7.46-9.71) at 7 years. Results are also stratified by gender and age.

Table 3.41 Indications for the 265 (first) revisions following primary ankle replacement. Note: these are not mutually exclusive.

Indication		Number
Infection	High suspicion (e.g. pus or confirmed micro)	13
	Low suspicion (awaiting micro/histology)	50
Aseptic loosening[1]	Tibial component	88
	Talar component	99
Lysis[2]	Tibia	32
	Talus	43
Malalignment		45
Implant fracture[3]	Tibial component[4]	2
	Talar component	4
Implant fracture	Meniscal component	6
Wear of polyethylene component		25
Meniscal insert dislocation		5
Component migration/dissociation		21
Pain[5]		59
Stiffness		29
Soft tissue impingement		22
Other indication for revision		38

[1]59 patients had aseptic loosening of both tibial and talar component.
[2]23 patients had lysis of both tibial and talar component.
[3]2 patients had implant fracture of both tibial and talar component.
[4]1 more operation was recorded as implant fracture-tibial component in the 2017 Annual Report.
[5]In MDSv4 pain was referred to as "Pain (undiagnosed)" and in MDSv6 onwards pain was referred to as "Unexplained pain".

Table 3.41 shows the reasons for revision of ankle replacements, with loosening and pain as the most commonly cited reasons.

We believe that there may be under-reporting revisions of an ankle replacement to an ankle fusion or amputation and this notion is supported by the British Orthopaedic Foot and Ankle Society (BOFAS) who, along with the NJR, encourage surgeons to complete A2 MDS forms where relevant and wishes to remind surgeons and hospitals that this is a mandated requirement by the Department of Health, and that all revisions, conversion of an ankle replacement to an arthrodesis, and amputations require the completion of an NJR A2 MDS form.

3.5.3 Mortality after primary ankle replacement

Our analysis excluded four procedures where the NHS number was untraceable (and hence the age could not be validated) and also excludes the second of each of the eight bilateral procedures. Among the remaining 5,575, a total of 308 patients had died before the end of 2018.

Table 3.42 KM estimates of **mortality** (95% CI) after primary ankle replacement, by **gender** and **age**.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

Age at primary (years)	n	Time since primary					
		30 days	90 days	1 year	3 years	5 years	7 years
All cases	5,575	0.09 (0.04-0.22)	0.16 (0.09-0.31)	0.74 (0.54-1.02)	3.09 (2.59-3.67)	6.24 (5.43-7.16)	11.24 (9.90-12.74)
Male							
<65 years	1,070	0	0	0	1.46 (0.81-2.64)	2.89 (1.80-4.63)	*4.70 (2.91-7.54)*
65-74 years	1,402	0.22 (0.07-0.67)	0.29 (0.11-0.77)	0.69 (0.36-1.33)	2.46 (1.67-3.61)	6.03 (4.52-8.04)	*9.75 (7.47-12.67)*
75+ years	846	0.12 (0.02-0.84)	0.36 (0.12-1.12)	1.81 (1.08-3.05)	7.13 (5.33-9.51)	13.35 (10.56-16.80)	*29.55 (24.21-35.76)*
Female							
<65 years	856	0	0.12 (0.02-0.85)	0.37 (0.12-1.16)	1.23 (0.61-2.47)	2.02 (1.09-3.74)	*4.23 (2.45-7.24)*
65-74 years	880	0.11 (0.02-0.80)	0.11 (0.02-0.80)	0.75 (0.34-1.67)	2.55 (1.59-4.10)	4.83 (3.26-7.14)	*7.14 (4.94-10.26)*
75+ years	521	0	0	1.30 (0.59-2.88)	5.65 (3.70-8.58)	*11.52 (8.30-15.88)*	*18.77 (13.87-25.12)*

Note: Some patients had operations on the left and right side on the same day. The second of bilateral operations performed on the same day were excluded.

Table 3.42 shows the estimated cumulative percentage probability of death at different times after surgery by gender and age at primary. Unsurprisingly, earlier death was associated with male gender and older age. Overall the cumulative percentage probability of death was 0.09 (0.04-0.22) at 30 days; 0.16 (95% CI 0.09-0.31) at 90 days; 0.74 (95% CI 0.54-1.02) at 1 year; 3.09 (95% CI 2.59-3.67) at 3 years; 6.24 (95% CI 5.43-7.16) at 5 years and 11.24 (9.90-12.74) at 7 years.

3.5.4 Conclusions

The collection of data relating to ankle primary operations only began in 2010 and hence the total number of primaries recorded remains low and numbers of linked first revisions even lower, although we believe that there is under-reporting of revision procedures, making outcome analysis difficult.

A total of 67.6% of consultant surgeons and 72.2% of units have submitted less than twenty primary procedures in the nine years the NJR has been capturing data. BOFAS discourages surgeons working in isolation carrying out small numbers of ankle replacement and encourages surgeons to pool their resources or operate jointly, where practicable.

Since the withdrawal of the Mobility implant in 2014 the fixed bearing Infinity implant has rapidly gained popularity to become the market leader. The cumulative percentage probability of 90-day mortality following primary ankle surgery is very low and the cumulative percentage of revision at seven years following a primary ankle replacement is 8.51 (95% CI 7.46-9.71).

Part 3

3.6 Outcomes after elbow replacement

3.6.1 Overview of primary elbow replacement surgery

This section contains an overview of the primary elbow replacements with data linked revision and mortality data entered into the registry since recording began (1 April 2012) up to the end of 31 December 2018, and documents the first revision and mortality for these primaries. Primary elbow replacement in this section refers to total prosthetic replacement, distal humeral hemiarthroplasty, lateral resurfacing and radial head replacement.

A total of 3,573 primary replacements were available for analysis for a total of 3,441 patients. Of these patients, 132 had documented replacements on both left and right sides, and in three patients these were both performed on the same day (bilateral), see Table 3.2 in section 3.2.

The majority of replacements were performed on women (70.6%) and the median age at the primary operation was 68 years (IQR 57-76), with an overall range of 14 to 98 years.

Table 3.43 Number of primary elbow replacements by year and percentages of each type of procedure.

Procedure type	All years	Year of primary						
		2012* N(%)	2013 N(%)	2014 N(%)	2015 N(%)	2016 N(%)	2017 N(%)	2018 N(%)
Total	3,573	262 (100)	451 (100)	452 (100)	546 (100)	565 (100)	649 (100)	648 (100)
Total prosthetic replacement	2,640	210 (80.2)	383 (84.9)	382 (84.5)	426 (78.0)	405 (71.7)	450 (69.3)	384 (59.3)
Radial head replacement**	701	24 (9.2)	36 (8.0)	57 (12.6)	97 (17.8)	130 (23.0)	165 (25.4)	192 (29.6)
Lateral resurfacing	20	9 (3.4)	5 (1.1)	2 (0.4)	0 (0.0)	1 (0.2)	2 (0.3)	1 (0.2)
Distal humeral hemiarthroplasty	167	9 (3.4)	13 (2.9)	9 (2.0)	14 (2.6)	23 (4.1)	29 (4.5)	70 (10.8)
Uncertain	45	10 (3.8)	14 (3.1)	2 (0.4)	9 (1.7)	6 (1.1)	3 (0.5)	1 (0.2)

*Includes one primary operation with date entered as 2010.
**Radial head replacement in isolation i.e. no other components entered.

Table 3.43 shows that the annual number of primary elbow replacements entered into the NJR has increased since 2012. This is likely to reflect an increase in data capture as well as an increase in the volume of procedures.

This table also gives a breakdown by the stated type of replacement. Six were reclassified on the basis of obvious component anomalies (i.e. radial head replacements with humeral components entered (n=2) and lateral resurfacings with either an ulnar component or a linked humeral component entered (n=4). A further five entered as total replacements had components indicative of radial head replacement.

Distal humeral hemiarthroplasty was not included in the earlier minimum datasets (MDS) on the primary elbow (E1) form and this resulted in implants being entered with an incorrect procedure type. A number of primary operations entered as total replacements only had humeral components entered (n=130). Given a large proportion of these (n=116) were branded Latitude Humeral, which can also be used in distal humeral hemiarthroplasty, we have classified them to distal humeral hemiarthroplasty if we found that the associated components included an anatomical spool (n=108). Distal humeral hemiarthroplasty has been included in the new MDSv7, from June 2018.

Six implants entered as total elbow replacements had ulnar parts entered as well as anatomical spools and were classified as Uncertain. There may be further anomalies and a full independent review is being planned.

Finally, 54 of the total elbow replacements had only accessories entered. These were considered as Uncertain unless the accessories/accessory brands suggested a definite category (thirteen were retained as total prosthetic replacement; three were changed to distal humeral hemiarthroplasty and the remainder left as Uncertain).

Table 3.44 details the type of primary operation in each year. A total of 1,254 (35.1%) elbow replacements were carried out for acute trauma. These have been separated from the remaining 2,319 elective cases in the rest of this section. An increasing volume of elbow trauma is being treated with distal humeral hemiarthroplasty.

Table 3.44 Types of primary elbow procedures used in **acute trauma** and **elective** cases by **year**.

	Year of primary	Type of primary procedure					
		Total prosthetic replacement	Radial head replacement	Lateral resurfacing	Distal humeral hemiarthro-plasty	Uncertain	Total
Acute trauma	All years	538	554	0	147	15	1,254
	2012	39	16	0	8	3	66
	2013	76	29	0	10	4	119
	2014	63	51	0	7	1	122
	2015	109	78	0	12	4	203
	2016	87	99	0	20	1	207
	2017	88	123	0	28	2	241
	2018	76	158	0	62	0	296
Elective	All years	2,102	147	20	20	30	2,319
	2012	171	8	9	1	7	196
	2013	307	7	5	3	10	332
	2014	319	6	2	2	1	330
	2015	317	19	0	2	5	343
	2016	318	31	1	3	5	358
	2017	362	42	2	1	1	408
	2018	308	34	1	8	1	352

Table 3.45 Reasons for main types of primary elbow replacements, by **year of primary**.

(a) Total prosthetic replacement

Year of primary	Number of primaries	Acute trauma	Elective						
		Number of cases	Number of cases	Number (%)* for each reason (amongst elective cases only):					
				Osteoarthritis N(%)	Other inflammatory arthritis N(%)	Trauma sequelae N(%)	Essex Lopresti N(%)	Avascular necrosis N(%)	Other cause(s) N(%)
All years	2,640	538	2,102	719 (34.2)	1,064 (50.6)	316 (15.0)	5 (0.2)	4 (0.2)	106 (5.0)
2012	210	39	171	61 (35.7)	81 (47.4)	27 (15.8)	1 (0.6)	0 (0.0)	10 (5.9)
2013	383	76	307	107 (34.9)	156 (50.8)	37 (12.1)	1 (0.3)	1 (0.3)	19 (6.2)
2014	382	63	319	117 (36.7)	161 (50.5)	40 (12.5)	0 (0.0)	0 (0.0)	15 (4.7)
2015	426	109	317	110 (34.7)	161 (50.8)	44 (13.9)	1 (0.3)	2 (0.6)	18 (5.7)
2016	405	87	318	103 (32.4)	166 (52.2)	53 (16.7)	0 (0.0)	0 (0.0)	14 (4.4)
2017	450	88	362	120 (33.2)	178 (49.2)	63 (17.4)	1 (0.3)	1 (0.3)	18 (5.0)
2018	384	76	308	101 (32.8)	161 (52.3)	52 (16.9)	1 (0.3)	0 (0.0)	12 (3.9)

*Percentages based on the total numbers of elective cases; note the listed reasons are not mutually exclusive, more than one reason could have been stated.

(b) Lateral resurfacings and distal humeral hemiarthroplasty

Year of primary	Number of primaries	Acute trauma	Elective					
		Number of cases	Number of cases	Number* for each reason (amongst elective cases only):				
				Osteoarthritis	Other inflammatory arthritis	Trauma sequelae	Essex Lopresti	Avascular necrosis	Other cause(s)
All years	187	147	40	25	3	12	0	0	1
2012	18	8	10	9	1	0	0	0	0
2013	18	10	8	6	1	2	0	0	0
2014	11	7	4	4	0	0	0	0	0
2015	14	12	2	0	0	2	0	0	0
2016	24	20	4	2	0	1	0	0	1
2017	31	28	3	1	0	2	0	0	0
2018	71	62	9	3	1	5	0	0	0

*Numbers are too few for meaningful percentages here.

(c) Radial head replacement

Year of primary	Number of primaries	Acute trauma	Elective						
		Number of cases	Number of cases	Number* for each reason (amongst elective cases only):					
				Osteoarthritis	Other inflammatory arthritis	Trauma sequelae	Essex Lopresti	Avascular necrosis	Other cause(s)
All years	701	554	147	30	2	97	12	3	10
2012	24	16	8	2	0	4	0	0	2
2013	36	29	7	3	1	4	0	0	0
2014	57	51	6	0	1	4	1	0	0
2015	97	78	19	5	0	12	1	1	0
2016	130	99	31	6	0	24	1	2	1
2017	165	123	42	6	0	27	5	0	6
2018	192	158	34	8	0	22	4	0	1

*Numbers are too few for meaningful percentages here.

Tables 3.45 (a) to (c) detail the indications for the primary operation shown separately for total elbow replacement, lateral resurfacing/distal humeral hemiarthroplasty and radial head replacement.

Please note that the reasons are not mutually exclusive as more than one reason could have been stated. In 32 of the 1,254 acute trauma cases a second reason for surgery was given. In 119 of 2,319 elective cases (5.1%) more than one indication was given.

Table 3.46 Number of units and consultant surgeons providing primary elbow replacements during each year from 2016-2018, by region.

(a) All primary elbow replacements

Region	Year of primary								
	2016			2017			2018		
	Number of primaries	Number of units (Mean number of primaries per unit)	Number of consultants (Mean number of primaries per consultant)	Number of primaries	Number of units (Mean number of primaries per unit)	Number of consultants (Mean number of primaries per consultant)	Number of primaries	Number of units (Mean number of primaries per unit)	Number of consultants (Mean number of primaries per consultant)
Total	565	168 (3.4)	221 (2.6)	649	169 (3.8)	228 (2.8)	648	166 (3.9)	216 (3.0)
North East	44	13 (3.4)	14 (3.1)	76	14 (5.4)	20 (3.8)	73	12 (6.1)	16 (4.6)
Yorkshire and the Humber	35	11 (3.2)	18 (1.9)	63	17 (3.7)	18 (3.5)	68	14 (4.9)	20 (3.4)
North West	93	25 (3.7)	35 (2.7)	95	25 (3.8)	33 (2.9)	112	27 (4.1)	38 (2.9)
West Midlands	50	16 (3.1)	20 (2.5)	47	17 (2.8)	23 (2.0)	45	13 (3.5)	19 (2.4)
East Midlands	53	10 (5.3)	20 (2.7)	75	11 (6.8)	26 (2.9)	70	14 (5.0)	27 (2.6)
East of England	59	18 (3.3)	22 (2.7)	62	14 (4.4)	20 (3.1)	69	13 (5.3)	17 (4.1)
London	53	21 (2.5)	28 (1.9)	48	20 (2.4)	26 (1.8)	51	19 (2.7)	25 (2.0)
South West	63	18 (3.5)	21 (3.0)	66	14 (4.7)	21 (3.1)	46	15 (3.1)	20 (2.3)
South Central	33	9 (3.7)	13 (2.5)	29	8 (3.6)	11 (2.6)	26	5 (5.2)	11 (2.4)
South East Coast	61	19 (3.2)	23 (2.7)	63	20 (3.2)	22 (2.9)	53	25 (2.1)	18 (2.9)
Wales (combining North, Mid and West, South East)	21	8 (2.6)	8 (2.6)	25	9 (2.8)	8 (3.1)	35	9 (3.9)	6 (5.8)

Table 3.46 Number of units and consultant surgeons providing primary elbow replacements during each year from 2016-2018, by region.

(b) All primary total prosthetic elbow replacements

Region	Year of primary								
	2016			2017			2018		
	Number of primary total prosthetic replacements	Number of units (Mean number of primaries per unit)	Number of consultants (Mean number of primaries per consultant)	Number of primary total prosthetic replacements	Number of units (Mean number of primaries per unit)	Number of consultants (Mean number of primaries per consultant)	Number of primary total prosthetic replacements	Number of units (Mean number of primaries per unit)	Number of consultants (Mean number of primaries per consultant)
Total	405	145 (2.8)	172 (2.4)	450	146 (3.1)	179 (2.5)	384	126 (3.0)	148 (2.6)
North East	26	11 (2.4)	12 (2.2)	47	13 (3.6)	16 (2.9)	29	12 (2.4)	13 (2.2)
Yorkshire and the Humber	25	8 (3.1)	11 (2.3)	45	15 (3.0)	15 (3.0)	48	12 (4.0)	14 (3.4)
North West	59	21 (2.8)	29 (2.0)	65	20 (3.3)	26 (2.5)	58	18 (3.2)	20 (2.9)
West Midlands	43	14 (3.1)	18 (2.4)	38	16 (2.4)	20 (1.9)	36	11 (3.3)	16 (2.3)
East Midlands	37	10 (3.7)	13 (2.8)	45	11 (4.1)	16 (2.8)	40	10 (4.0)	15 (2.7)
East of England	39	16 (2.4)	16 (2.4)	52	14 (3.7)	19 (2.7)	43	10 (4.3)	14 (3.1)
London	37	17 (2.2)	23 (1.6)	36	15 (2.4)	20 (1.8)	29	10 (2.9)	16 (1.8)
South West	58	17 (3.4)	18 (3.2)	47	13 (3.6)	17 (2.8)	32	14 (2.3)	16 (2.0)
South Central	22	7 (3.1)	10 (2.2)	18	5 (3.6)	7 (2.6)	17	4 (4.3)	7 (2.4)
South East Coast	42	17 (2.5)	16 (2.6)	44	16 (2.8)	17 (2.6)	30	17 (1.8)	12 (2.5)
Wales (combining North, Mid and West, South East)	17	7 (2.4)	7 (2.4)	13	8 (1.6)	6 (2.2)	22	8 (2.8)	6 (3.7)

Over the last three years (from 2016 to 2018) 1,862 primary elbow replacements were entered into the registry of which 1,239 were total elbow replacements.

Table 3.46 (a) (page 173) shows the number of all types of elbow replacement by year and region over this time period, together with the number of units and consultants. Table 3.46 (b) shows the number of units and consultants doing total elbow replacement by region and the average annual caseload per unit and consultant. A list of units in each region is provided in the downloads section of **www.njrreports.org.uk** and further information can be found on **www.njrsurgeonhospitalprofile.org.uk**.

The number of units and consultants performing total elbow arthroplasty decreased in 2018 but, due to a fall in the total number of elbow replacements performed overall, the average number per unit and consultant has changed very little and remains around three per annum with little variation by region. These figures may be subject to change, as some units may not have submitted all data for this period by the time of data analysis.

Table 3.47 lists the brands used in total elbow replacement, with sub-division by acute trauma and elective cases.

Table 3.47 Brands used in total elbow replacement.

Brand	Total number	Acute trauma	Elective
Unlinked brands:			
Latitude	126	4	122
K Elbow	4	0	4
IBP	11	1	10
NES	2	0	2
Linked brands:			
Latitude (+ ulnar cap)	218	31	187
Discovery	739	142	597
Coonrad Morrey	1,344	326	1,018
GSB III	44	4	40
Mutars	2	0	2
Nexel	144	29	115
Comprehensive Segmented Revision System	3	1	2
Uncertain	**3**	**0**	**3**
Total	**2,640**	**538**	**2,102**

Four implants (Coonrad-Morrey, Discovery, Latitude and Nexel) account for 97% of total elbow replacements performed. There is no separation of Latitude Legacy and Latitude EV at this point.

Table 3.48 Radial head brands used in radial head replacements.

Brand	Total number	Acute trauma	Elective
Bipolar brands:			
Latitude	2	1	1
RHS	24	10	14
rHead (Recon)	6	3	3
Mono brands:			
Corin Radial Head	26	21	5
Evolve Proline	132	107	25
ExploR	57	48	9
Anatomic Radial Head	370	302	68
MoPyC	9	7	2
Ascension	53	38	15
Liverpool	4	3	1
Uni Radial (Standard)	6	4	2
Uncertain:	**12**	**10**	**2**
Total	**701**	**554**	**147**

Table 3.48 lists the radial head brands used for radial head replacement, with sub-division by acute trauma and elective procedures.

3.6.2 Revisions after primary elbow replacement surgery

A total of 123 elbow primaries in the registry (19 acute trauma cases and 104 elective) had been revised up to the end of 2018, including four excision arthroplasties and one DAIR.

Note that the NJR also includes revision procedures for which a primary has not been recorded; in all, 1,022 revision procedures[8] had been entered by 205 consultant surgeons working across 143 units. Over the last year, 187 revision procedures were entered into the NJR by 80 consultants working across 60 units.

[8] Two-stage procedures counted twice; stage one and stage two were entered separately.

Table 3.49 KM estimates of cumulative **revision** (95% CI) by primary elbow procedures for **acute trauma** and **elective** cases. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

		Number of cases (number revised)	Time since primary				
			1 year	2 years	3 years	4 years	5 years
All cases		3,573 (123)	1.1 (0.8-1.5)	2.3 (1.8-2.9)	4.1 (3.3-5.0)	5.4 (4.4-6.5)	6.1 (5.0-7.4)
Acute trauma	All acute trauma cases	1,254 (19)	0.6 (0.3-1.3)	1.4 (0.8-2.3)	1.8 (1.1-3.0)	2.3 (1.4-3.8)	*3.0 (1.7-5.2)*
	Total prosthetic replacements	538 (14)	0.8 (0.3-2.1)	2.1 (1.1-3.9)	*3.0 (1.7-5.3)*	*3.5 (2.0-6.0)*	*4.5 (2.4-8.3)*
	Radial head replacements	554 (4)	0.4 (0.1-1.7)	0.7 (0.2-2.2)	*0.7 (0.2-2.2)*	*1.4 (0.5-4.3)*	*1.4 (0.5-4.3)*
	Distal humeral hemiarthroplasty	147 (1)	*0.8 (0.1-5.7)*	*0.8 (0.1-5.7)*	*0.8 (0.1-5.7)*	*0.8 (0.1-5.7)*	*0.8 (0.1-5.7)*
Elective	All elective cases	2,319 (104)	1.3 (0.9-1.9)	2.7 (2.1-3.5)	5.1 (4.1-6.3)	6.7 (5.4-8.1)	7.4 (6.1-9.1)
	Total prosthetic replacements	2,102 (96)	1.1 (0.7-1.7)	2.6 (1.9-3.5)	5.1 (4.1-6.4)	6.8 (5.5-8.4)	7.7 (6.2-9.4)
	Radial head replacements	147 (4)	*3.2 (1.2-8.3)*	*3.2 (1.2-8.3)*	*3.2 (1.2-8.3)*	*3.2 (1.2-8.3)*	*3.2 (1.2-8.3)*
	Lateral resurfacing	20 (2)	*				
	Distal humeral hemiarthroplasty	20 (2)	*				

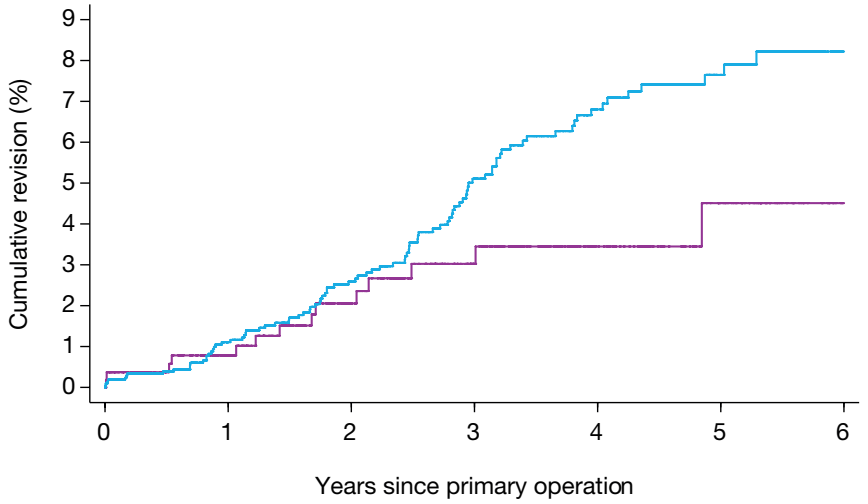
*Insufficient data.

Table 3.49 shows Kaplan-Meier estimates of the cumulative percentage probability of revision up to five years after the primary operation, together with 95% Confidence Intervals for all cases and for acute trauma and elective cases separately.

At four years after implantation there is a higher cumulative revision rate for elbow arthroplasty for elective indications compared to trauma. This, however, may reflect a difference in the distribution of type of elbow replacement between these two groups; more total elbow arthroplasty in the elective group and more radial head arthroplasty in the trauma group.

There is no difference in the survival of total elbow replacement for trauma or elective indications up to two years, after which the data is not reliable due to the low numbers in the registry. There is insufficient data to compare radial head replacement, lateral resurfacing and distal humeral hemiarthroplasty between elective and trauma indications. The number of revisions reported for radial head replacement remains low, which may reflect poor reporting levels for revision to excision arthroplasty. At the current time there are too few cases for further sub-division into age/gender sub-groups. As the numbers increase more useful comparisons can be drawn.

Figure 3.24 KM estimates of cumulative **revision** after primary **total prosthetic elbow replacement** by **acute trauma** and **elective** cases.



Number at risk

Acute trauma	538	432	328	229	137	83	23
Elective	2,102	1,737	1,332	977	658	368	125

Figure 3.24 shows Kaplan-Meier estimates of the cumulative percentage probability of revision after primary total prosthetic elbow replacement divided into acute trauma and elective cases.

Table 3.50 Indications for first data linked **revision** after any primary elbow replacement. Acute trauma and elective cases are shown separately, for total elbow replacement, lateral resurfacing and distal humeral hemiarthroplasty, and radial head replacement.

	Total prosthetic replacement		Lateral resurfacing* or distal humerus hemiarthroplasty		Radial head replacement	
	Acute trauma	Elective	Acute trauma	Elective	Acute trauma	Elective
All cases	**538**	**2,102**	**147**	**40**	**554**	**147**
Total revised	14	96	1	4	4	4
Infection	5	34	0	0	0	1
Periprosthetic fracture	3	16	0	0	0	0
Instability	1	5	1	3	1	2
Aseptic loosening	6	44	0	0	1	1
Other indications	2	6	0	1	2	0

*Only for elective cases.

Table 3.50 gives a breakdown of the indications for the first data linked revision procedure, the most common reasons remain aseptic loosening and infection. Please note, the indications for revision were not mutually exclusive; in 12 of the 123 revisions more than one reason was stated. A few cases (n=13) had gone on to have further revision procedures (other than planned two-stage revisions for infection). The numbers are too small for any further analysis or to draw any conclusions.

3.6.3 Mortality after primary elbow replacement surgery

For this analysis, the second procedure of the pair of bilateral operations performed on the same day (see Table 3.2) was excluded. Among the remaining 3,570 implants, 327 of the recipients had died by the end of December 2018. Estimates of the cumulative percentage probability of mortality in this cohort were 0.20 (95% CI 0.09-0.41) at 30 days, 0.51 (95% CI 0.32-0.82) at 90 days and 2.5 (95% CI 2.0-3.1), 8.5 (95% CI 7.4-9.7) and 16.5 (95% CI 14.7-18.6) respectively at 1, 3 and 5 years after the primary operation.

Table 3.51 KM estimates of cumulative **mortality** (95% CI) by time from primary elbow replacement, for **acute trauma** and **elective** cases. *Blue italics signify that fewer than 250 cases remained at risk at these time points, hence the 95% CIs are not reliable.*

		Number of cases	Time since primary				
			30 days	90 days	1 year	3 year	5 years
Acute trauma	All cases	1,253	0.40 (0.17-0.97)	0.49 (0.22-1.08)	3.4 (2.4-4.6)	10.5 (8.5-12.9)	*19.8 (16.1-24.2)*
	Total prosthetic replacements	537	0.56 (0.18-1.73)	0.76 (0.28-2.00)	5.8 (4.1-8.3)	*16.8 (13.4-20.8)*	*28.8 (23.5-35.1)*
	Radial head replacements	554	0.18 (0.03-1.29)	0.18 (0.03-1.29)	0.7 (0.2-2.1)	*1.5 (0.6-3.8)*	*2.1 (0.9-5.1)*
	Distal humeral hemiarthroplasty	147	*0.72 (0.10-5.00)*	*0.72 (0.10-5.00)*	*3.6 (1.3-9.4)*	*12.5 (6.3-23.9)*	*28.2 (14.5-50.3)*
Elective	All cases	2,317	0.09 (0.02-0.34)	0.53 (0.30-0.93)	2.0 (1.5-2.7)	7.5 (6.3-8.9)	15.2 (13.1-17.5)
	Total prosthetic replacements	2,101	0.10 (0.02-0.38)	0.58 (0.33-1.02)	2.1 (1.6-2.9)	8.0 (6.8-9.5)	16.1 (13.9-18.6)
	Radial head replacements	146	*0*	*0*	*0.9 (0.1-6.0)*	*0.9 (0.1-6.0)*	*0.9 (0.1-6.0)*
	Lateral resurfacing	20	*				
	Distal humeral hemiarthroplasty	20	*				

*Insufficient data.
Note: 30 day and 90 day mortality is reported to two decimal places due to the low mortality rate.

Table 3.51 shows the overall cumulative percentage probability of mortality shown separately for acute trauma and the elective cases.

Rates for the acute trauma cases generally were higher than for the elective indications (logrank P=0.011) with the difference more marked amongst the total prosthetic replacements (P<0.001). However, this is all-cause mortality and in extended follow-up beyond the immediate post-operative period, we would expect higher rates in older age groups; and also in men. As the size of the dataset increases, we will be able to present mortality for elective cases in age/gender sub-groups.

3.6.4 Conclusions

The annual number of primary elbow replacement procedures entered into the registry has increased since 2012 and is one of the largest datasets of elbow arthroplasty globally. It is not yet known how accurate or complete the dataset is, as an independent audit of elbow replacement data has to be undertaken.

An attempt has been made to separate out different procedure types based on the description of the procedure entered and the types of prosthesis used. This has identified a number of anomalies and further work is required to address these.

Distal humeral hemiarthroplasty was not included in the MDS until June 2018. Despite this, an increasing number of hemiarthroplasty implants were registered between 2015 and 2018 but total numbers remain low. This rise may accelerate with the inclusion in the MDS and may overtake total elbow replacement numbers in acute trauma, which may reflect a change in practice nationally. In the future it should be possible to compare the revision rates for this newer procedure compared to total elbow replacement. Most distal humeral hemiarthroplasty and radial head replacement procedures are performed for acute trauma and trauma sequelae as expected.

The distribution of indications for total elbow replacement have been consistent over the five years of data entry with inflammatory replacement accounting for half of cases. In 2018 there were 384 primary total elbow replacements performed in 126 units by 148 consultants. This is a substantial reduction in the annual number of total elbow replacements (down from 451 in 2017) but may reflect a delay in data entry for this period from some units.

It is the intention of the NHSI GIRFT programme to centralise total elbow replacement into fewer specialist centres. As yet, while the number of centres has reduced slightly, the average number of cases per unit, and per surgeon has changed little, due to the overall reduction in number of cases recorded. This may be due, in part, to the increase in the use of distal humeral hemiarthroplasty for the management of trauma and trauma sequelae.

The Kaplan-Meier estimate of cumulative revision of elbow replacement at four years was 2.3 (95% CI 1.4-3.8) for trauma patients and 6.7 (95% CI 5.4-8.1) for elective cases, but radial head replacement makes up over 40% of the cases in the trauma group compared to less than 10% for elective replacement. The main indications for revision were infection and aseptic loosening.

Five year mortality for all elbow replacement is 16.5% with overall differences seen between trauma and elective surgery. The one-year mortality rate following total elbow replacement remains higher in the trauma population than in those having elective surgery, however this may represent a difference in the demographics of these two groups.

Part 3

3.7 Outcomes after shoulder replacement

3.7.1 Overview of primary shoulder replacement surgery

The NJR has recorded shoulder replacements since 1 April 2012. This section contains an overview of the (data linked) primary shoulder replacements performed up to 31 December 2018 and documents the first revision and mortality when these events had occurred following a primary shoulder replacement.

In 2018 a rigorous independent review of the shoulder data was undertaken due to the rapid expansion of shoulder implant types available. As a consequence, new classifications and component attributes are now used to define the primary groupings throughout the whole of this section. Despite this, 3,545 (9.3%) procedures remain unclassifiable; although this is expected to improve in future reports with the introduction of the new minimum data set (MDSv7) which is now in use and reflects the industry expansion in shoulder implant types. For humeral components, we define a stemmed component as a humeral component in which any part enters the humeral diaphysis, while a stemless humeral component is defined as being completely confined to the metaphysis with no part entering the diaphysis.

A total of 37,916 linked primary shoulder replacements were available for analysis in a total of 35,265 patients. Of these patients, 2,651 had documented replacements on both left and right sides, 26 of which were bilateral simultaneous operations (left and right on the same day), see Table 3.2 in section 3.2, summary of data sources, linkages and methodology.

Table 3.52 Numbers of primary shoulder replacements (elective and acute trauma), by **year** with **percentages** of each type.

		Year of primary						
	All years	2012 N(%)	2013 N(%)	2014 N(%)	2015 N(%)	2016 N(%)	2017 N(%)	2018 N(%)
All cases	37,916 (100)	2,568 (100)	4,388 (100)	5,283 (100)	5,684 (100)	6,474 (100)	6,905 (100)	6,614 (100)
Proximal humeral hemiarthroplasty	6,786 (17.9)	853 (33.2)	1,255 (28.6)	1,251 (23.7)	1,034 (18.2)	997 (15.4)	831 (12.0)	565 (8.5)
Resurfacing	2,675 (7.1%)	468 (18.2)	577 (13.2)	534 (10.1)	373 (6.6)	368 (5.7)	220 (3.2)	135 (2.0)
Stemless	775 (2.0)	43 (1.7)	103 (2.4)	134 (2.5)	116 (2.0)	149 (2.3)	167 (2.4)	63 (1.0)
Stemmed	3,336 (8.8)	342 (13.3)	575 (13.1)	583 (11.0)	545 (9.6)	480 (7.4)	444 (6.4)	367 (5.6)
Total shoulder replacement	10,741 (28.3)	644 (25.1)	1,193 (27.2)	1,532 (29.0)	1,765 (31.1)	1,894 (29.3)	1,976 (28.6)	1,737 (26.3)
Resurfacing	437 (1.2)	45 (1.8)	96 (2.2)	75 (1.4)	83 (1.5)	73 (1.1)	45 (0.7)	20 (0.3)
Stemless	3,411 (9.0)	136 (5.3)	256 (5.8)	388 (7.3)	502 (8.8)	627 (9.7)	729 (10.6)	773 (11.7)
Stemmed	6,893 (18.2)	463 (18.0)	841 (19.2)	1,069 (20.2)	1,180 (20.8)	1,194 (18.4)	1,202 (17.4)	944 (14.3)
Reverse polarity total shoulder replacement	16,824 (44.4)	716 (27.9)	1,360 (31.0)	1,959 (37.1)	2,341 (41.2)	3,044 (47.0)	3,654 (52.9)	3,750 (56.7)
Stemless	148 (0.4)	6 (0.2)	15 (0.3)	15 (0.3)	28 (0.5)	25 (0.4)	20 (0.3)	39 (0.6)
Stemmed	16,676 (44.0)	710 (27.7)	1,345 (30.7)	1,944 (36.8)	2,313 (40.7)	3,019 (46.6)	3,634 (52.6)	3,711 (56.1)
Pyrocarbon Ball	20 (0.1)	0 (0)	2 (0.1)	2 (<0.1)	3 (0.1)	5 (0.1)	5 (0.1)	3 (0.1)
Unclassifiable	3,545 (9.4)	355 (13.8)	578 (13.2)	539 (10.2)	541 (9.5)	534 (8.3)	439 (6.4)	559 (8.5)

Table 3.52 (opposite) demonstrates that in 2018, for the first time since 2012, the number of primary shoulder replacements did not increase. The majority of the replacements continue to be performed on women (women 70.5%; men 29.6%). The median age at the primary operation was 73 years (IQR 67-79 years) overall, with a range of 17-99 years.

In summary, the number of reverse polarity total shoulder replacements continues to increase annually, now accounting for 57% of all primary shoulder replacements in 2018. The use of proximal humeral hemiarthroplasty has decreased further, while the use of conventional total shoulder replacement remains stable. Stemless humeral components used in conventional replacements are increasing slowly, while stemless components for reverse polarity replacements have not gained popularity.

Table 3.53 Numbers of units and consultant surgeons providing primary shoulder replacements over the last five years, 2014-2018.

Year of primary	Number of primary replacements	Number of units providing primary replacements in each year	Median (IQR) number of primary replacements per unit	Number of consultants providing the primary replacements	Median (IQR) number of primary replacements per consultant
2014	5,283	339	9 (4-21)	454	8 (3-17)
2015	5,684	346	11 (4-23)	486	8 (3-17)
2016	6,474	346	13.5 (5-26)	489	10 (4-19)
2017	6,905	360	14 (5-27)	487	10 (5-21)
2018	6,614	358	12.5 (5-26)	495	10 (4-19)

Over the last five years, primary shoulder replacements were undertaken by 722 consultant surgeons working across 395 units. A breakdown of the numbers of units and consultants for each year, together with their number of primaries, is shown in Table 3.53.

Table 3.54 (overleaf) details the indications for the primary operation, for the cases overall and with further sub-division by type of procedure.

Shoulder replacements for acute trauma accounted for 3,457 cases, these have been separated from the remaining 34,459 elective cases. Please note that 117 of the 3,457 acute trauma cases had another reason(s) stated in addition to acute trauma.

The reasons given for the elective cases are documented in Table 3.54. Again, the reasons entered were not all mutually exclusive, in some cases more than one indication was recorded in the MDS. Amongst these 34,459 cases, 2,065 (6%) had two or more reasons stated, the most common combinations included osteoarthritis together with cuff tear arthropathy, suggesting some uncertainty in defining and classifying these particular indications. We will monitor if the introduction of the more detailed MDSv7 has any impact on this.

Proximal humeral hemiarthroplasty is used across all indications including trauma, while total shoulder replacement is used mainly for osteoarthritis. Reverse polarity shoulder replacement is now in common use across all indications, not just cuff tear arthropathy and acute fracture. This observation suggests a widespread growing confidence in the use of this implant type for indications other than those for which it was originally intended.

Table 3.54 Reasons for main types of primary shoulder replacements.

	Acute trauma	Elective							
			Number (%)* for each reason (amongst elective cases only):						
	Number of cases	Number of cases	Osteoarthritis N(%)	Cuff tear arthroplasty N(%)	Cuff tear without arthroplasty N(%)**	Trauma sequelae N(%)	Other inflammatory arthropathy N(%)	Avascular necrosis N(%)	Other cause N(%)***
All cases	3,457	34,459	21,040 (61.1)	9,703 (28.2)	164/3,834 (4.3)	2,375 (6.9)	1,461 (4.2)	1,127 (3.3)	765 (2.2)
Proximal humeral hemiarthroplasty	1,335	5,451	4,090 (75.0)	354 (6.5)	1/210 (0.5)	455 (8.4)	349 (6.4)	418 (7.7)	132 (2.4)
Resurfacing	5	2,670	2,266 (84.9)	163 (6.1)	0/85 (0.0)	65 (2.4)	148 (5.5)	92 (3.5)	45 (1.7)
Stemless	9	766	615 (80.3)	16 (2.1)	0/7 (0.0)	53 (6.9)	46 (6.0)	78 (10.2)	18 (2.4)
Stemmed	1,321	2,015	1,209 (60.0)	175 (8.7)	1/118 (0.9)	337 (16.7)	155 (7.7)	248 (12.3)	69 (3.4)
Total shoulder replacement	13	10,728	9,939 (92.7)	34 (0.3)	1/1,057 (0.1)	222 (2.1)	403 (3.8)	271 (2.5)	132 (1.2)
Resurfacing	0	437	416 (95.2)	0 (0.0)	0/13 (0.0)	4 (0.9)	21 (4.8)	2 (0.5)	3 (0.7)
Stemless	3	3,408	3,130 (91.8)	11 (0.3)	0/475 (0.0)	80 (2.4)	132 (3.9)	82 (2.4)	55 (1.6)
Stemmed	10	6,883	6,393 (92.9)	23 (0.3)	1/569 (0.2)	138 (2.0)	250 (3.6)	187 (2.7)	74 (1.1)
Reverse polarity total shoulder replacement	1,903	14,921	4,981 (33.4)	8,486 (56.9)	153/2,196 (7.0)	1,437 (9.6)	554 (3.7)	326 (2.2)	329 (2.2)
Stemless	0	148	49 (33.1)	91 (61.5)	3/22 (13.6)	4 (2.7)	2 (1.4)	6 (4.1)	0 (0.0)
Stemmed	1,903	14,773	4,932 (33.4)	8,395 (56.8)	150/2,174 (6.9)	1,433 (9.7)	552 (3.7)	320 (2.2)	329 (2.2)
Pyrocarbon Ball	0	20	17 (85.0)	0 (0.0)	0/1 (0.0)	1 (5.0)	0 (0.0)	2 (10.0)	0 (0.0)
Unclassifiable	206	3,339	2,013 (60.3)	829 (24.8)	9/370 (2.4)	260 (7.8)	155 (4.6)	110 (3.3)	172 (5.2)

*Percentages based on the total numbers of elective cases; note the listed reasons are not mutually exclusive as more than one reason could have been stated although this was only 6% for elective cases.
**Only documented since the introduction of MDSv7 in June 2018, hence denominators are shown.
***Includes 51 metastatic cancer/malignancies documented from MDSv6, together with 42 dislocation arthropathy cases documented from MDSv7 (i.e. out of 25,181 and 3,834 electives respectively).

Table 3.55 Gender and age at primary for the main types of primary shoulder replacements. These are shown separately for acute trauma and elective cases.

	Shoulder type	Number of cases	Number (%) male	Age in years at primary Median (IQR*), Range**
Acute trauma	All cases	3,457	803 (23.2)	74 (67-80) 35-99
	Proximal humeral hemiarthroplasty	1,335	391 (29.3)	69 (61-77) 27-96
	Total shoulder replacement	13	8 (61.5)	68 (53-74) 43-79
	Reverse polarity total shoulder replacement	1,903	364 (19.1)	76 (71-81) 48-99
	Pyrocarbon Ball	0		
	Unclassifiable	206	40 (19.4)	74 (68-80) 35-91
Elective	All cases	34,459	10,403 (30.2)	73 (67-79) 17-99
	Proximal humeral hemiarthroplasty	5,451	1,746 (32.0)	71 (62-78) 17-95
	Resurfacing	2,670	809 (30.3)	71 (64-78) 20-95
	Stemless	766	322 (42.0)	67 (57-75) 17-93
	Stemmed	2,015	615 (30.5)	71 (61-78) 19-95
	Total shoulder replacement	10,728	3,275 (30.5)	70 (64-76) 18-96
	Resurfacing	437	125 (28.6)	71 (64-77) 29-95
	Stemless	3,408	1,203 (35.3)	69 (62-75) 18-93
	Stemmed	6,883	1,947 (28.3)	71 (65-76) 24-96
	Reverse polarity total shoulder replacement	14,921	4,246 (28.5)	76 (71-80) 18-99
	Stemless	148	63 (42.6)	72 (68-76) 49-89
	Stemmed	14,773	4,183 (28.3)	76 (71-80) 18-99
	Pyrocarbon Ball	20	12 (60.0)	62 (55-70) 34-75
	Unclassifiable	3,339	1,124 (33.7)	72 (64-78) 18-96

*IQR=Inter-quartile range, i.e. 25th to 75th centile.
**Range is lowest – highest.

Table 3.55 summarises the age and gender distributions of the acute trauma and elective cases according to their main primary procedure. Where numbers permit (elective cases only), the groups have been further sub-divided by specific type. There are far more females undergoing elective shoulder surgery than males, although the distribution of implant type used is the same in both males and females.

Figure 3.25 (a) Gender and age distribution of elective shoulder primaries for proximal humeral hemiarthroplasty.

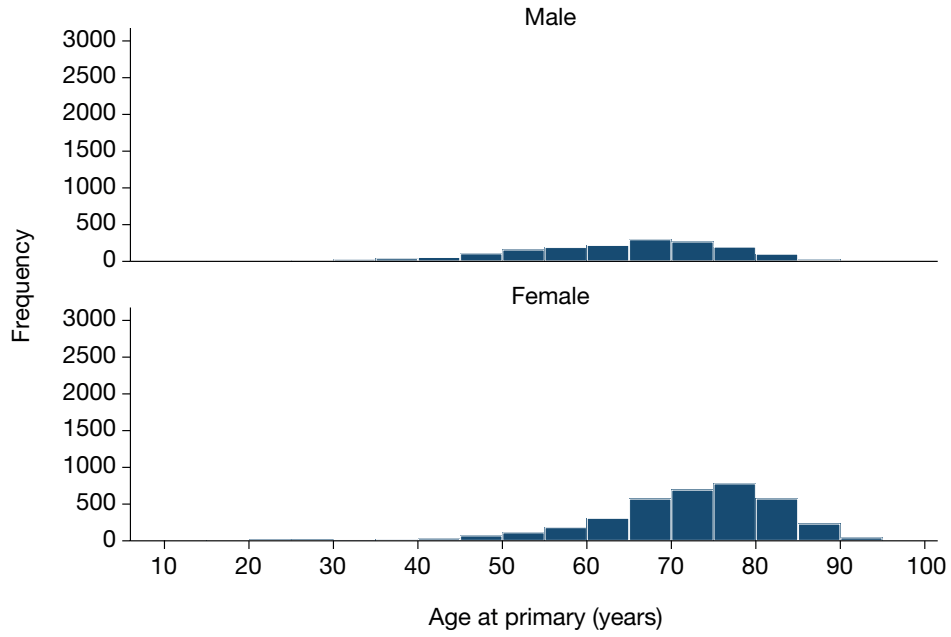


Figure 3.25 (b) Gender and age distribution of elective shoulder primaries for total conventional shoulder replacement.

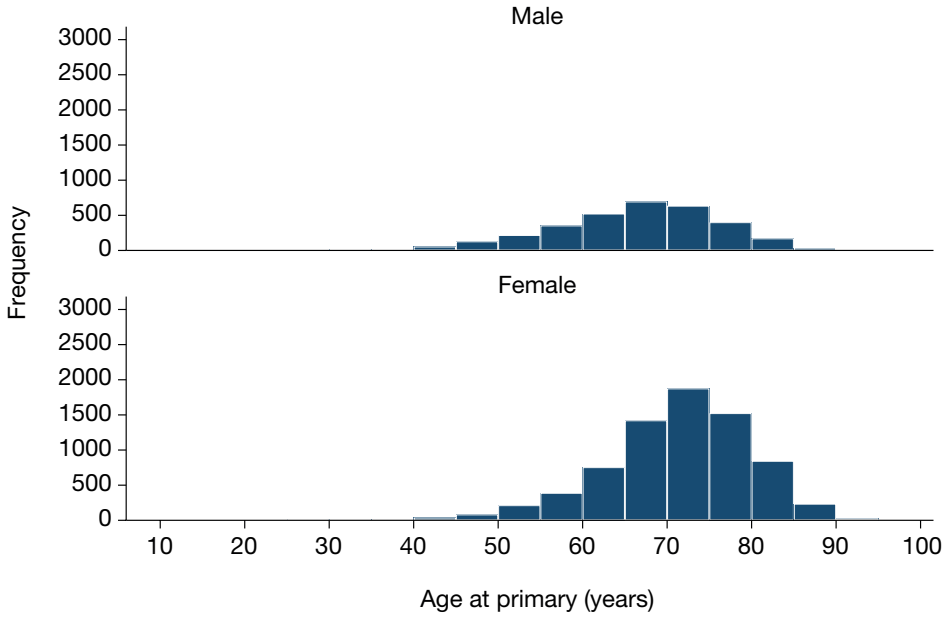
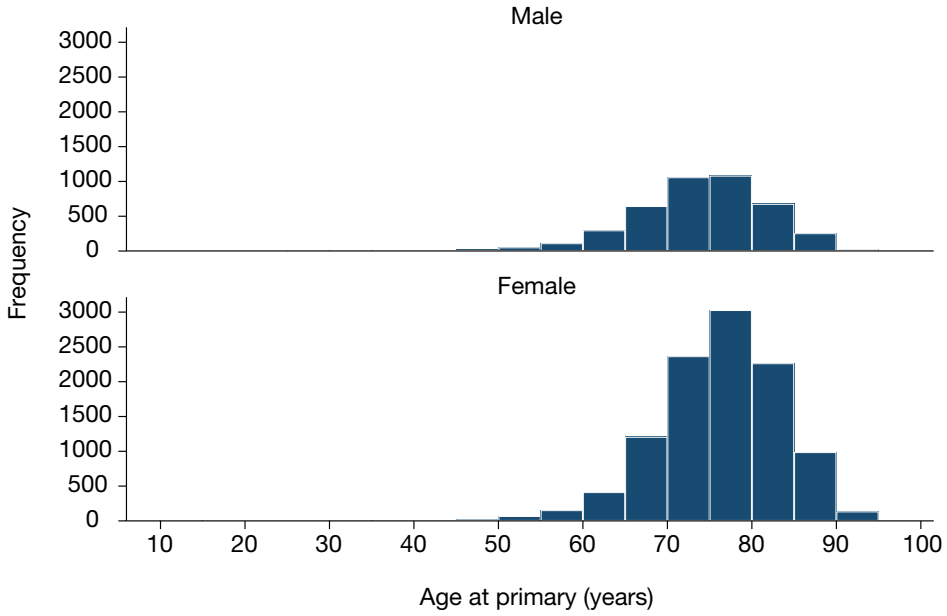


Figure 3.25 (c) Gender and age distribution of elective shoulder primaries for reverse polarity total shoulder replacement.



Figures 3.25 (a) to (c) illustrate the distributions by gender and age groups of the elective patients, according to the primary patient procedure. Over the last three years, the percentage of elective patients under 55 years old having shoulder replacements was 6.4%, 5.5% and 5.5% respectively. As some younger patients of both genders are undergoing these types of procedures, we now provide information later in this section that includes younger age related revision rates.

Table 3.56 (overleaf) lists the main stemmed brands used in primary shoulder procedures. The table shows the total numbers recorded in the registry since April 2012 as well as the numbers within the last twelve months. The latter are further sub-divided into acute trauma and elective cases, and the numbers of elective cases are further divided into the types of implant. Finally, Tables 3.57 (a) and (b) (overleaf) show similar tables for stemless brands and the resurfacing brands used in primary shoulder replacements.

Table 3.56 Stemmed brands used for primary shoulder procedures.

Stemmed brands	Total number of primaries	Number of primaries in 2018					
		Total number 2018	Acute trauma	Elective			
			Total number of primaries	Total number of primaries	Proximal humeral hemi-arthroplasty	Total conventional shoulder replacement	Reverse polarity shoulder replacement
Aequelis	442	22	1	21	9	12	0
Aequalis Reversed Fracture	351	81	57	24	0	0	24
Aequalis Fracture	184	25	17	8	8	0	0
Aequalis-Press-Fit	16	0					
Aequalis-Reversed-II	1,186	186	5	181	0	0	181
Affinis	1,083	225	64	161	11	14	136
Affiniti	14	0					
Anatomical	1,270	208	4	204	2	31	171
Anatomical Fracture	138	9	7	2	0	0	2
Arrow	334	36	11	25	0	15	10
Ascend	34	0					
Ascend Flex	2,564	898	10	888	64	249	575
Bigliani/Flatow	113	1	0	1	0	0	1
Bio-Modular	15	0					
Comprehensive	2,545	587	9	578	28	153	397
Comprehensive Fracture	490	82	59	23	5	0	18
Comprehensive Segmental revision	18	4	0	4	0	0	4
Delta Xtend	4,657	791	117	674	3	1	670
Epoca	651	6	0	6	1	5	0
Equinoxe	3,219	706	77	629	7	173	449
Global AP	1,395	100	0	100	6	94	0
Global Advantage	972	71	2	69	7	62	0
Global FX	206	15	12	3	3	0	0
Global Unite	760	129	47	82	10	66	6
Humelock	9	0					
METS	6	3	0	3	2	0	1
MUTARS	5	1	0	1	0	0	1
Medacta	2	2	0	2	0	1	1
Mosaic	1	0					
Nottingham	45	0					
Oxford	77	0					
Polarus	4	0					
RSP	312	89	10	79	1	0	78
SMR	2,313	452	80	372	17	47	308
TESS	40	4	0	4	0	0	4
TM	103	13	0	13	7	6	0
TM Reverse	531	111	7	104	2	0	102
Unic	6	0					
Univers Fracture	1	0					
Univers II	2	0					
Univers Reverse	150	87	3	84	0	0	84
Vaios	206	20	3	17	3	14	0
Verso	404	58	1	57	0	0	57
Zimmer Biomet Custom	1	0					
Uncertain	*40*	*0*					
Total	26,905	5,022	603	4,419	196	943	3,280

Table 3.57 Stemless brands and resurfacing brands used in primary shoulder replacements, shown separately.

(a) Stemless brands

Stemless brands	Total number of primaries	Number of primaries in 2018					
		Total number 2018	Acute trauma	Elective			
			Total number of primaries	Total number of primaries	Proximal humeral hemi-arthroplasty	Total shoulder replacement	Reverse polarity shoulder replacement
Affinis	1,886	341	1	340	37	303	0
Eclipse	573	98	0	98	1	97	0
Global ICON	76	68	0	68	2	66	0
Nano	465	94	1	93	1	92	0
SMR	238	83	0	83	2	42	39
Sidus	326	78	1	77	11	66	0
Simpliciti	644	111	1	110	6	104	0
TESS	126	2	0	2	2	0	0
Total	**4,334**	**875**	**4**	**871**	**62**	**770**	**39**

(b) Resurfacing brands

Resurfacing brands	Total number of primaries	Number of primaries in 2018				
		Total number 2018	Acute trauma	Elective		
			Total number of primaries	Total number of primaries	Resurfacing humeral hemi-arthroplasty	Resurfacing conventional total shoulder replacement
Aequalis Resurfacing	277	6	0	6	4	2
Arrow	49	4	0	4	1	3
Arthrosurface	1	0	0	0		
Copeland	1,514	71	0	71	71	0
Epoca	461	9	0	9	0	9
Equinoxe	45	14	0	14	8	6
Global CAP	562	35	0	35	35	0
SMR	133	4	0	4	4	0
Vaios	70	12	0	12	12	0
Total	**3,112**	**155**	**0**	**155**	**135**	**20**

Glenoid components used in total conventional shoulder replacement

The NJR is currently only able to report brand information for glenoids. Many manufacturers continue to have more than one glenoid type as an option for a conventional total shoulder replacement, some with optional methods of fixation and also some that include augmented glenoid implants. The current NJR database requires an update to accommodate these variable issues before any reliable differentiation and analysis is possible. Work is also still needed between the implant manufacturers and the NJR to ensure any sub-brands are fully and separately captured; allowing the performance of these different components and their fixation methods to be analysed.

Table 3.58 highlights the current glenoid brands recorded in the NJR and those used in the last year.

Table 3.58 Glenoid brands used in total conventional shoulder replacement.

Glenoid brands	Total number of primaries	Number of primaries in 2018					
		Total number 2018	Acute trauma	Elective			
			Total number of primaries	Total number of primaries	Resurfacing total shoulder replacement	Stemless total shoulder replacement	Stemmed total shoulder replacement
Aequalis	459	12	0	12	0	0	12
Aequalis Performa+	1,366	356	1	355	2	104	249
Affinis	1,541	315	0	315	0	301	14
Affiniti	19	0					
Anatomical	153	17	0	17	0	13	4
Arrow	170	18	0	18	3	0	15
Bayley	6	0					
Bigliani/Flatow	205	19	0	19	0	6	13
Bio-Modular	9	0					
Comprehensive	1,110	280	1	279	0	124	155
Copeland	4	0					
Epoca	1,001	17	0	17	9	3	5
Equinoxe	892	181	1	180	6	1	173
Global	565	60	0	60	0	8	52
Global Anchor Peg	1,777	226	0	226	0	58	168
MUTARS	1	0					
Medacta	1	1	0	1	0	0	1
Mosaic	1	0					
SMR	599	91	0	91	0	44	47
TESS	72	0					
TM	332	34	1	33	0	15	18
Unic	1	0					
Univers II	296	81	0	81	0	78	3
Universal	30	15	0	15	0	15	0
Vaios	129	14	0	14	0	0	14
Verso	1	0					
Zimmer Biomet Custom	1	0					
Total	10,741	1,737	4	1,733	20	770	943

3.7.2 Revisions after primary shoulder replacement surgery

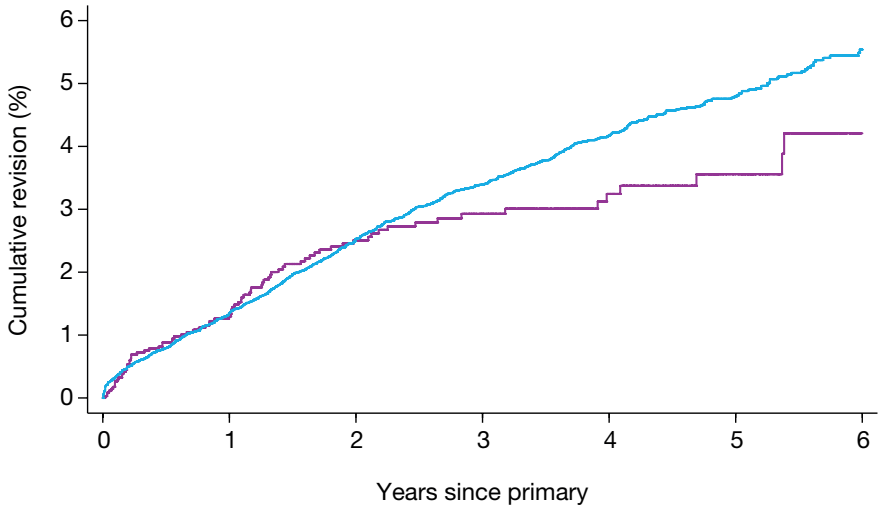
A total of 1,158 linked shoulders were subsequently revised, 105 of these have also had a further re-revision.

Kaplan-Meier estimates of the cumulative percentage revision at 1, 2, 3, 4, 5 and 6 years after the primary operation, together with 95% Confidence Intervals (CI), for all cases are shown in Table 3.59, together with a separation into acute trauma and elective cases.

Table 3.59 KM estimates of cumulative **revision** (95% CI) for primary shoulder replacement for **acute trauma** and **elective** cases. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

	Total number of primaries	Total number revised	Time since primary					
			1 year	2 years	3 years	4 years	5 years	6 years
All cases	37,916	1,158	1.3 (1.2-1.5)	2.5 (2.4-2.7)	3.4 (3.2-3.6)	4.1 (3.9-4.4)	4.7 (4.4-5.0)	5.4 (5.1-5.9)
Acute trauma	3,457	84	1.3 (1.0-1.8)	2.5 (2.0-3.2)	2.9 (2.3-3.7)	3.2 (2.6-4.1)	3.6 (2.8-4.5)	*4.2 (3.1-5.7)*
Elective	34,459	1,074	1.4 (1.2-1.5)	2.5 (2.4-2.7)	3.4 (3.2-3.6)	4.2 (3.9-4.5)	4.8 (4.5-5.1)	5.5 (5.1-6.0)

Figure 3.26 KM estimates of cumulative **revision** for primary shoulder replacement by **acute trauma** and **elective** cases.



Number at risk

Acute trauma	3,457	2,637	1,881	1,282	787	399	106
Elective	34,459	27,745	21,026	14,901	9,774	5,310	1,884

Figure 3.26 further compares the acute trauma and elective cases for all time points up to six years, after which time point there were too few cases for a meaningful summary to be presented.

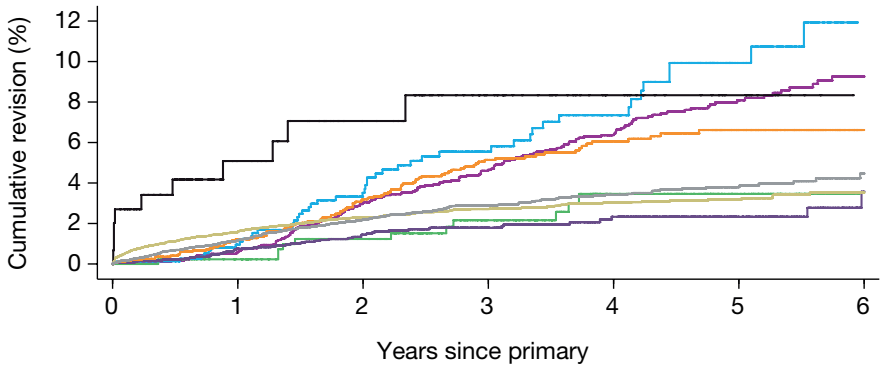
Table 3.60 KM estimates of cumulative **revision** (95% CI) for **elective** shoulder primaries by **gender** and **age**. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

Age at primary (years)*	Males							Females						
	n	Time since primary						n	Time since primary					
		1 year	2 years	3 years	4 years	5 years	6 years		1 year	2 years	3 years	4 years	5 years	6 years
<55	1,146	3.0 (2.1-4.2)	5.8 (4.5-7.5)	7.6 (6.0-9.6)	10.2 (8.2-12.7)	*12.0 (9.6-15.0)*	*14.3 (11.0-18.4)*	942	2.7 (1.8-4.0)	5.5 (4.1-7.3)	7.9 (6.1-10.2)	9.7 (7.6-12.4)	*11.1 (8.6-14.2)*	*12.3 (9.1-16.4)*
56-64	1,949	2.0 (1.4-2.7)	3.7 (2.9-4.8)	5.3 (4.2-6.7)	6.4 (5.1-7.9)	6.9 (5.6-8.6)	*8.8 (6.7-11.6)*	2,458	1.3 (0.9-1.8)	3.1 (2.4-3.9)	4.8 (3.9-6.0)	6.3 (5.2-7.7)	7.4 (6.1-9.0)	*9.0 (7.3-11.1)*
65-74	4,013	2.1 (1.7-2.6)	3.1 (2.5-3.7)	3.8 (3.2-4.6)	5.0 (4.2-5.9)	5.9 (4.9-7.1)	*6.8 (5.6-8.2)*	8,932	1.1 (0.9-1.3)	2.3 (2.0-2.6)	3.1 (2.7-3.5)	3.6 (3.2-4.1)	4.3 (3.7-4.9)	5.0 (4.3-5.8)
75+	3,293	2.1 (1.7-2.7)	3.4 (2.8-4.2)	4.2 (3.5-5.1)	4.7 (3.9-5.7)	4.9 (4.0-6.0)	*4.9 (4.0-6.0)*	11,720	0.7 (0.6-0.9)	1.4 (1.2-1.7)	1.8 (1.6-2.1)	2.2 (1.9-2.5)	2.5 (2.1-2.9)	2.6 (2.2-3.1)

*Excludes six elective cases for whom the NHS number was not traced and therefore age could not be validated.

A further breakdown by gender and age of the cumulative percentage of revisions in the elective cases is shown in Table 3.60 (on the opposite page). For some age groups, it demonstrates a worse outcome for men, where it is more equal in other age groups. There remains a clear trend to a worse outcome in younger patients of either gender which is around 10% by four years. The acute trauma group remains too small for a similar analysis to be conducted.

Figure 3.27 KM estimates of cumulative **revision** for primary shoulder replacement, by **type of procedure** in **elective** cases only.



Number at risk

Resurfacing HA	2,670	2,505	2,197	1,757	1,352	841	361
Resurfacing TA	437	413	358	278	196	128	38
Stemless HA	766	689	509	349	243	117	31
Stemless RTA	148	101	79	55	31	16	5
Stemless TA	3,408	2,600	1,853	1,229	718	349	119
Stemmed HA	2,015	1,762	1,454	1,118	779	475	185
Stemmed RTA	14,773	11,082	7,749	5,062	3,091	1,503	475
Stemmed TA	6,883	5,825	4,531	3,307	2,157	1,154	398

Note: HA=Hemiarthroplasty, TA=Total arthroplasty, RTA=Reverse total arthroplasty.

Table 3.61 KM estimates of cumulative **revision** (95% CI) for **elective** shoulder primaries by main **type of procedure**. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

Elective	Number of primaries	Time since primary					
		1 year	2 years	3 years	4 years	5 years	6 years
Proximal humeral hemiarthroplasty	**5,451**	**0.9 (0.7-1.2)**	**3.2 (2.7-3.7)**	**5.0 (4.4-5.6)**	**6.4 (5.7-7.2)**	**7.8 (7.0-8.8)**	**8.7 (7.7-9.8)**
Resurfacing	2,670	0.6 (0.4-1.0)	3.1 (2.4-3.8)	4.7 (3.9-5.6)	6.4 (5.4-7.5)	8.1 (6.9-9.5)	9.3 (7.9-10.9)
Stemless	766	1.0 (0.5-2.0)	3.5 (2.3-5.3)	5.6 (4.0-7.8)	*7.4 (5.4-10.1)*	*9.9 (7.3-13.5)*	*11.9 (8.4-16.7)*
Stemmed	2,015	1.1 (0.8-1.8)	3.2 (2.5-4.2)	5.1 (4.1-6.4)	6.1 (4.9-7.4)	6.6 (5.4-8.1)	*6.6 (5.4-8.1)*
Total shoulder replacement	**10,728**	**1.0 (0.8-1.2)**	**1.9 (1.7-2.2)**	**2.5 (2.2-2.9)**	**3.1 (2.7-3.6)**	**3.4 (3.0-3.9)**	**4.1 (3.5-5.0)**
Resurfacing	437	0.2 (0.03-1.6)	1.2 (0.5-2.9)	2.2 (1.1-4.3)	*3.5 (1.9-6.3)*	*3.5 (1.9-6.3)*	*3.5 (1.9-6.3)*

Table 3.61 (continued)

Elective	Number of primaries	Time since primary					
		1 year	2 years	3 years	4 years	5 years	6 years
Stemless	3,408	0.8 (0.5-1.2)	1.4 (1.0-2.0)	1.8 (1.3-2.4)	2.3 (1.7-3.2)	2.3 (1.7-3.2)	*3.6 (2.1-6.1)*
Stemmed	6,883	1.2 (0.1-1.5)	2.2 (1.9-2.6)	2.9 (2.5-3.4)	3.4 (2.9-4.0)	3.8 (3.3-4.4)	4.5 (3.7-5.4)
Reverse polarity total shoulder replacement	**14,921**	**1.6 (1.4-1.9)**	**2.4 (2.1-2.6)**	**2.8 (2.5-3.1)**	**3.1 (2.8-3.5)**	**3.2 (2.9-3.7)**	**3.6 (3.1-4.1)**
Stemless	148	*5.1 (2.4-10.4)*	*7.1 (3.7-13.3)*	*8.3 (4.5-15.2)*	*8.3 (4.5-15.2)*	*8.3 (4.5-15.2)*	-
Stemmed	14,773	1.6 (1.4-1.8)	2.3 (2.1-2.6)	2.7 (2.4-3.0)	3.0 (2.7-3.4)	3.2 (2.8-3.6)	3.5 (3.1-4.1)

In Figure 3.27 and Table 3.61, the elective cases have been sub-divided by the type of procedure.

With data now out to six years, some clear patterns are emerging. Despite an initial worse cumulative revision rate observed and reported in earlier annual reports for the stemmed reverse polarity shoulder replacements during the first two years, Figure 3.27 (on the previous page) now demonstrates a lower revision rate similar to conventional total shoulder replacement at six years. Figure 3.27 also demonstrates that conventional total shoulder replacements (stemmed, stemless, resurfacing) and stemmed reverse shoulder replacements have the lowest revision rates at five and six years.

Proximal humeral hemiarthroplasty operations have higher revision rates by three years and this continues out to six years but appears higher for resurfacing and stemless implants as opposed to stemmed proximal humeral hemiarthroplasty. One explanation for this is that resurfacing and stemless proximal hemiarthoplasties are easier to revise and that the reasons to revise relates to the primary decision not to replace the glenoid or subsequent rotator cuff failure (see Table 3.62 (a)). It is worth noting that when these stemless and resurfacing humeral implants are used in a total shoulder replacement, they have low revision rates. While these observations may persuade some to perform only total shoulder replacement or reverse shoulder replacement, it is important to consider that these latter two do not provide easy revision options if there are outcome problems and so low revision rates alone can be misleading for shoulder replacements. It demonstrates the importance for the NJR to collect shoulder PROMs in order to more thoroughly assess the outcomes of these implants when used in different constructs and to provide insight into those having and not having revision surgery. This year we present more PROMs data in section 3.7.3, which can be interpreted alongside these revision rates.

While stemless humeral implants as part of total shoulder replacements appear to be performing well and display the lowest revision rates at years 3, 4, 5 and 6, stemless reverse shoulder replacements have higher revision rates. There are very different mechanical forces involved here which may explain this, but the numbers are small which make statistical conclusions less robust, but it is encouraging that this type of procedure has not become mainstream and seems to have diminished in numbers. This is possibly due to such early revision problems being observed by surgeons and implant manufacturers.

Finally, this report currently does not yet look at revision rates by combined age group and implant types, although the intention is for this type of sub-analysis in future reports as the numbers in the NJR increase.

Table 3.62 Numbers of first revisions for each type of primary shoulder replacement and indications for revision where those revisions were reported using MDSv7. Acute trauma and elective cases are shown separately.

(a) Acute trauma cases only

Acute trauma	Total number of primaries	Total number revised	Total number revised [reported using MDSv7]	Indications for revision: number (N) reported out of those using MDSv7																
				Infection	Instability	Cuff insufficiency	Aseptic loosening humerus	Aseptic loosening glenoid	Periprosthetic fracture	Stiffness	Impingement	Component dissociation	Glenoid implant wear	Native glenoid surface erosion	Implant fracture	Lysis humerus	Lysis glenoid	Dislocation / subluxation	Unexplained pain	Other indications
All cases	3,457	84	14	2	2	5	1	0	1	2	0	0	0	3	0	1	0	3	0	1
Proximal humeral hemiarthroplasty	1,335	59	9	2	2	4	0	0	0	2	0	0	0	3	0	0	0	1	0	0
Total shoulder replacement	13	0	0																	
Reverse polarity total shoulder replacement	1,903	23	4	0	0	0	1	0	1	0	0	0	0	0	0	1	0	2	0	1
Pyrocarbon Ball	0																			
Unclassifiable	206	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.62 Numbers of first revisions for each type of primary shoulder replacement and indications for revision where those revisions were reported using MDSv7. Acute trauma and elective cases are shown separately.

(b) Elective cases only

Elective	Total number of primaries	Total number revised	Total number revised [reported using MDSv7]	Indications for revision: number (N(%)) reported out of those using MDSv7															
				Infection	Instability	Cuff insufficiency	Aseptic loosening humerus	Aseptic loosening glenoid	Periprosthetic fracture	Stiffness	Impingement	Component dissociation	Glenoid implant wear	Native glenoid surface erosion	Implant fracture	Lysis humerus	Lysis glenoid	Dislocation / subluxation	Unexplained pain	Other indications
All cases	**34,459**	**1,074**	**176**	**20 (11)**	**28 (16)**	**52 (30)**	**7 (4)**	**15 (9)**	**5 (3)**	**8 (5)**	**4 (2)**	**6 (3)**	**11 (6)**	**24 (14)**	**2 (1)**	**3 (2)**	**6 (3)**	**14 (8)**	**12 (7)**	**21 (12)**
Proximal humeral hemiarthroplasty	**5,451**	**312**	**58**	**4 (7)**	**4 (7)**	**22 (38)**	**0 (0)**	**0 (0)**	**0 (0)**	**4 (7)**	**1 (2)**	**0 (0)**	**3 (5)**	**22 (38)**	**1 (2)**	**0 (0)**	**2 (3)**	**1 (2)**	**8 (14)**	**6 (10)**
Resurfacing	2,670	170	28	0 (0)	2 (7)	9 (32)	0 (0)	0 (0)	0 (0)	2 (7)	1 (4)	0 (0)	2 (7)	12 (43)	1 (4)	0 (0)	1 (4)	0 (0)	4 (14)	4 (14)
Stemless	766	47	12	1 (8)	0 (0)	6 (50)	0 (0)	0 (0)	0 (0)	1 (8)	0 (0)	0 (0)	0 (0)	2 (17)	0 (0)	0 (0)	1 (8)	0 (0)	2 (17)	1 (8)
Stemmed	2,015	95	18	3 (17)	2 (11)	7 (39)	0 (0)	0 (0)	0 (0)	1 (6)	0 (0)	0 (0)	1 (6)	8 (44)	0 (0)	0 (0)	0 (0)	1 (6)	2 (11)	1 (6)
Total shoulder replacement	**10,728**	**247**	**45**	**1 (2)**	**8 (18)**	**25 (56)**	**3 (7)**	**7 (16)**	**2 (4)**	**2 (4)**	**1 (2)**	**1 (2)**	**6 (13)**	**0 (0)**	**0 (0)**	**1 (2)**	**2 (4)**	**7 (16)**	**2 (4)**	**4 (9)**
Resurfacing	437	11	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Stemless	3,408	50	16	1 (6)	2 (13)	9 (56)	1 (6)	1 (6)	2 (13)	0 (0)	0 (0)	0 (0)	2 (13)	0 (0)	0 (0)	0 (0)	0 (0)	2 (13)	0 (0)	1 (6)
Stemmed	6,883	186	27	0 (0)	6 (22)	15 (56)	2 (7)	6 (22)	0 (0)	2 (7)	1 (4)	1 (4)	4 (15)	0 (0)	0 (0)	1 (4)	2 (7)	5 (19)	2 (7)	2 (7)
Reverse polarity total shoulder replacement	**14,921**	**346**	**47**	**13 (28)**	**12 (26)**	**0 (0)**	**3 (6)**	**6 (13)**	**1 (2)**	**0 (0)**	**2 (4)**	**5 (11)**	**0 (0)**	**0 (0)**	**1 (2)**	**1 (2)**	**0 (0)**	**4 (9)**	**1 (2)**	**5 (11)**
Stemless	148	10	0																	
Stemmed	14,773	336	47	13 (28)	12 (26)	0 (0)	3 (6)	6 (13)	1 (2)	0 (0)	2 (4)	5 (11)	0 (0)	0 (0)	1 (2)	1 (2)	0 (0)	4 (9)	1 (2)	5 (11)
Pyrocarbon Ball	**20**	**0**	**0**																	
Unclassifiable	**3,339**	**169**	**26**	**2 (8)**	**4 (15)**	**5 (19)**	**1 (4)**	**2 (8)**	**2 (8)**	**2 (8)**	**0 (0)**	**0 (0)**	**2 (8)**	**2 (8)**	**0 (0)**	**1 (4)**	**2 (8)**	**2 (8)**	**1 (4)**	**6 (23)**

Note: Percentage based on denominator from MDSv7 returns.

The NJR now uses MDSv7 to collect more granular data on both indications and revision surgery. Table 3.62 (a) and (b) (pages 195 and 196) therefore gives a breakdown of the number of primaries that were subsequently revised since the introduction of MDSv7, together with the indications for the first revision procedure. Please note, the indications for revision were not always mutually exclusive and surgeons can select more than one reason on NJR MDS forms.

3.7.3 PROMs Oxford Shoulder Scores (OSS) associated with primary shoulder replacement surgery

The Oxford Shoulder Score (OSS) is a validated patient reported outcome measure for use in shoulder surgery. It consists of 12 pain and function items asking about problems that the patient encountered with their shoulder over the preceding four weeks[9]. The score is now coded from 0 to 4 (from 'worst' to 'best') and then summed in line with updated OSS recommendations[10]. The final total score ranges from 0 to 48, with 48 representing the 'best' outcome. Where up to two items were missing, the average of the remaining items can be substituted for the missing values[10]. If more than two items were missing, the results have to be disregarded.

We previously published a three year PROMs pilot in the NJR Annual Report 2016 in which a pre-operative (Q1) OSS and a six months post-operative (Q2) questionnaire had been collected. We presented the results of 3,411 elective patients with a complete Q1 and Q2. The value of this PROMs collection has been realised and the NJR not only intend to continue but have strengthened its collection by also collecting a Q3 (3-year) and Q4 (5-year) score. National mandates are being sought to ensure routine and high compliance rates with Q1 collection which at present is restricting the true potential of this PROMs data in assessing shoulder replacement surgery outcomes.

This year we have been able to link PROMs data to 37,915 of the 37,916 primaries, but the data were incomplete.

Table 3.63 Oxford Shoulder Score (OSS) completion for acute trauma and elective primary shoulder replacements.

	Acute trauma (n=3,457)		Elective (n=34,459)	
	Completed N	Analysable N (%)	Completed N	Analysable N (%)
Pre-operation	361	332 (9.6)	13,592	13,420 (38.9)
6 months post-operation	1,520	1,510 (43.7)	16,071	15,962 (46.3)
36 months post-operation	245	241	2,607	2,580
60 months post-operation	153	152	2,379	2,354

[9] Dawson J, Fitzpatrick R, Carr A, JBJS, 1996: 78-B, 593-600.
[10] Dawson J, Rogers K, Fitzpatrick R and Carr A, Arch Orthop Trauma Surg, 2009, 129:119-123.

Q1 OSS

Of 34,459 elective primaries, complete data were available for 12,672, with a further 748 missing only one or two items. The overall OSS scores for these latter two groups (n=13,420) are illustrated in Figure 3.28 (a); the median pre-operative score was 16 (IQR 11-22).

Completion of Q1 was a median of 0.71 weeks (IQR: 0 to 4.1 weeks) before the primary operation.

Q2 OSS

For the elective post-operative Q2 questionnaire, 15,052 answered all questions and a further 910 missed only one or two. The overall scores for the latter two groups combined (n=15,962) are shown in Figure 3.28 (b); the median 6-month score was 38 (IQR 28-44).

The stated completion dates for Q2 were mainly within a year of surgery, with a median of 29 weeks (IQR: 26-39 weeks) after the primary operation.

A total of 6,562 electives had an OSS at both Q1 and Q2 and this cohort is discussed later in this section. There was evidence of a slight bias in the collection of Q2; Q2 completers had significantly better scores at Q1 but the difference was very small (mean difference 0.35 95% CI 0.07-0.62; P=0.015).

Q3 OSS

For the elective Q3 questionnaires at three years there were 2,389 scores with all questions answered and a further 191 missing only one or two responses giving 2,580 cases; the median 3-year score was 40 (IQR 29-46). A further 27 were unusable as between 3 and 11 items were missing. The stated completion dates were at a median of 160 weeks (IQR 157-167 weeks) after the primary operation for Q3. There were no associated data for the remaining 31,852 procedures although 19,558 would not have passed the three year follow-up stage (34,459 minus 14,901 from the numbers at risk shown in Figure 3.26).

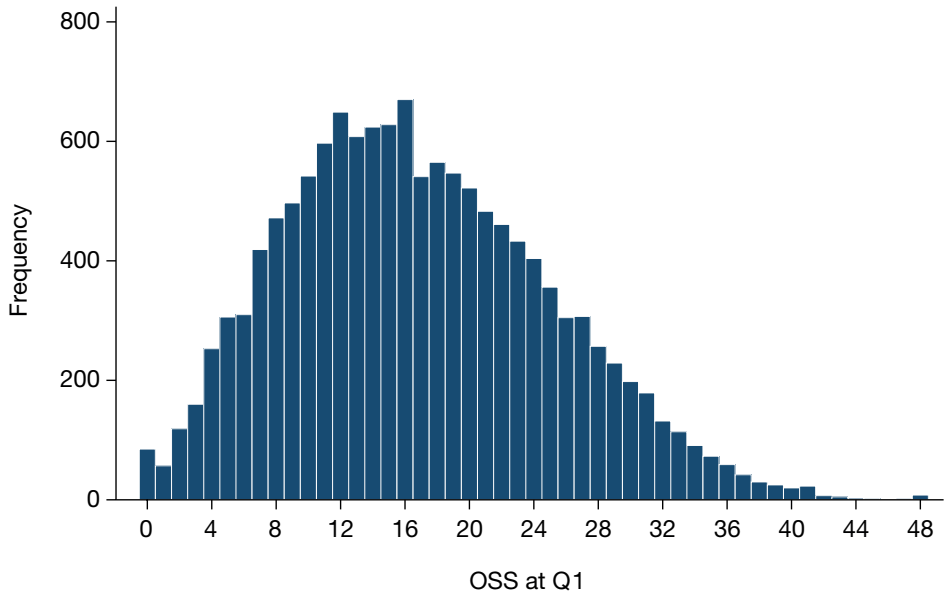
Q4 OSS

For the elective post-operative questionnaire Q4, nominally at five years, 2,178 answered all questions and a further 176 missed only one or two giving 2,354 cases. A further 25 had between 3 and 11 items missing. Whilst there were no data for the remaining 32,080 procedures, 29,149 would not yet have had five years follow-up. The median 5-year score was 39 (IQR 26-45). The stated completion dates were at a median of 263 weeks (IQR: 261-267 weeks) after the primary operation for the Q4.

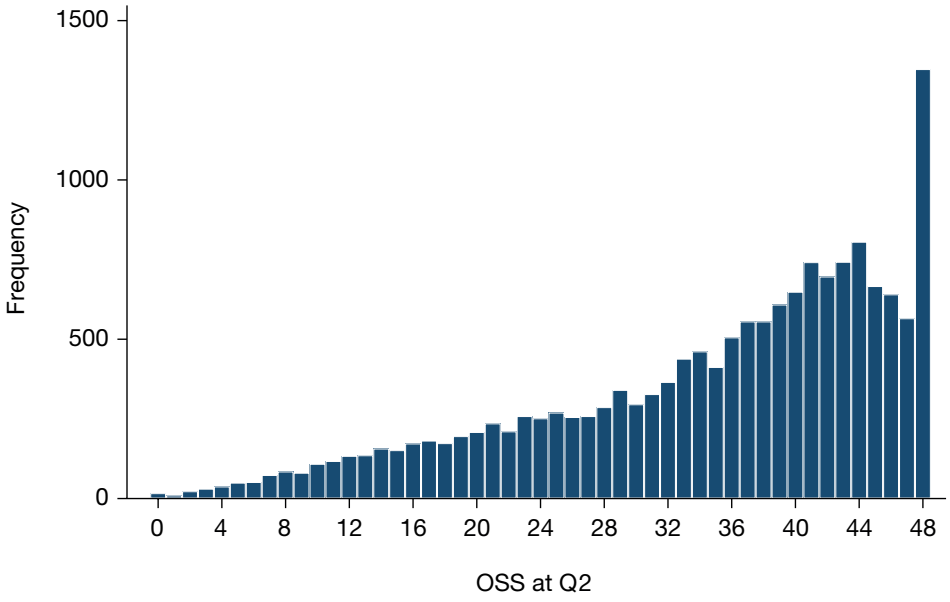
The data identify no patients having completed both a Q3 and a Q4, meaning that to date there are no patients with an entire completed series of Q1, Q2, Q3 and Q4. A total of 6,562 elective patients had fully completed pre (Q1) and post-operative (Q2) OSS total scores and are discussed later; 1,211 of these had fully completed Q1, Q2 and Q3.

In this section, we provide further analysis of the Q1 and Q2 only. Future reports will report on the Q3 and Q4 as the numbers of matched cases increases to a level where more reliable statistical analysis and data presentation is possible.

Figure 3.28 OSS distribution for **elective shoulder primaries** pre- and post- operation.
(a) Pre-operative (Q1) OSS for 13,420 patients



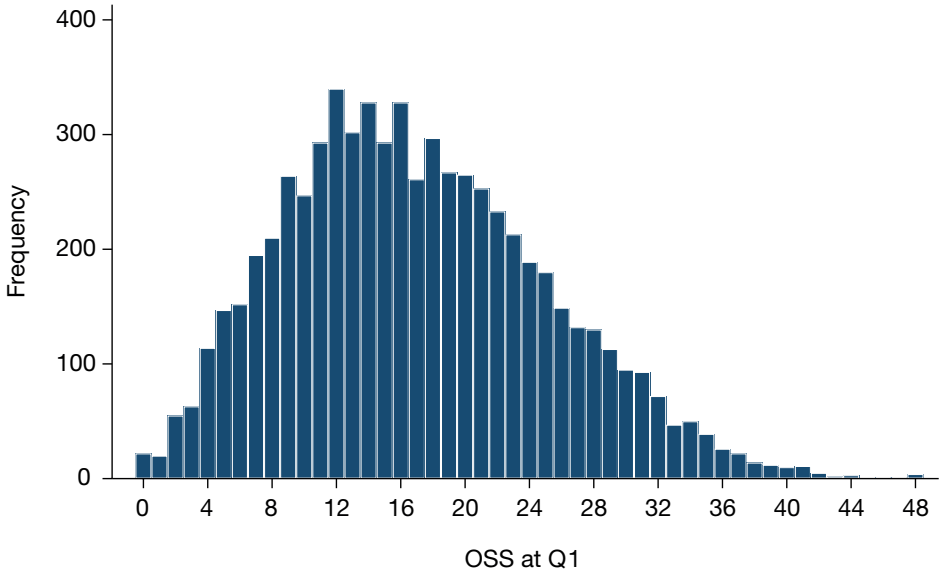
(b) 6 month post-operative (Q2) OSS for 15,962 patients



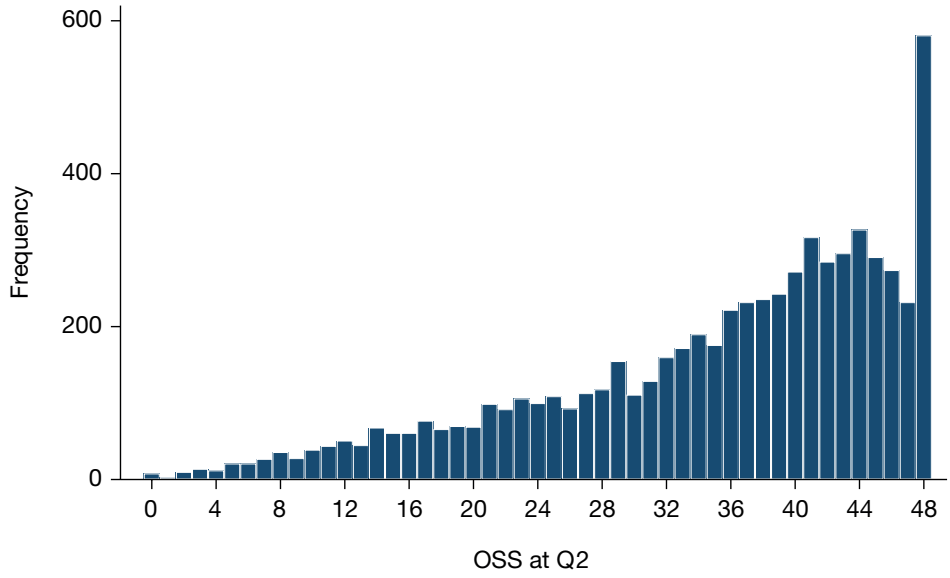
In total, 6,562 elective patients had both pre (Q1) and post-operative (Q2) OSS total scores from fully completed questionnaires. For these we calculated the score increase (post-operative OSS minus pre-operative OSS). Figures 3.29 (a), (b) and (c) show pre- and post- OSS, together with the increase in score, in those with complete data. Figures 3.29 (a) and (b) mirror (a) and (b) of the preceding Figure 3.28, despite only representing a fraction of the cohort. This provides some indication of the representation of the matched Q1 and Q2 cohort. Figure 3.29 (c) shows that there is an overall improvement after surgery. Whilst it is interesting to see the post-operative improvement reflected by the increase in OSS in Figure 3.29 (c), it should be noted that there would be a 'ceiling' effect to the amount of change possible, as there is a maximum value to the score that many patients achieved.

It is worth noting that of these 6,562 matched elective Q1 and Q2 scores, 12% of patients did not attain an improvement in the OSS of at least four points which is considered the minimum score for a clinical difference to be noted. Notably 7% of elective cases had a worse score at six months. Patients with all three main shoulder constructs (proximal humeral hemiarthroplasty, conventional total shoulder and reverse total shoulder replacement) were represented within these 12% of poor patient scores. While the numbers are small and should be interpreted cautiously, of these 6,562 patients, 20% of the 979 elective proximal humeral hemiarthoplasties did not achieve an OSS gain of four points compared to 12% of the 2,834 reverse total shoulder replacements and 8% of the 2,217 conventional total shoulder replacements.

Figure 3.29 OSS distribution for pre- and 6 months post-operation and the change score for those **elective shoulder replacements** with scores at both time points.
(a) Pre-operative (Q1) OSS



(b) 6 months post-operative (Q2) OSS



(c) Change in OSS (post-operative Q2 minus 6 months pre-op Q1)

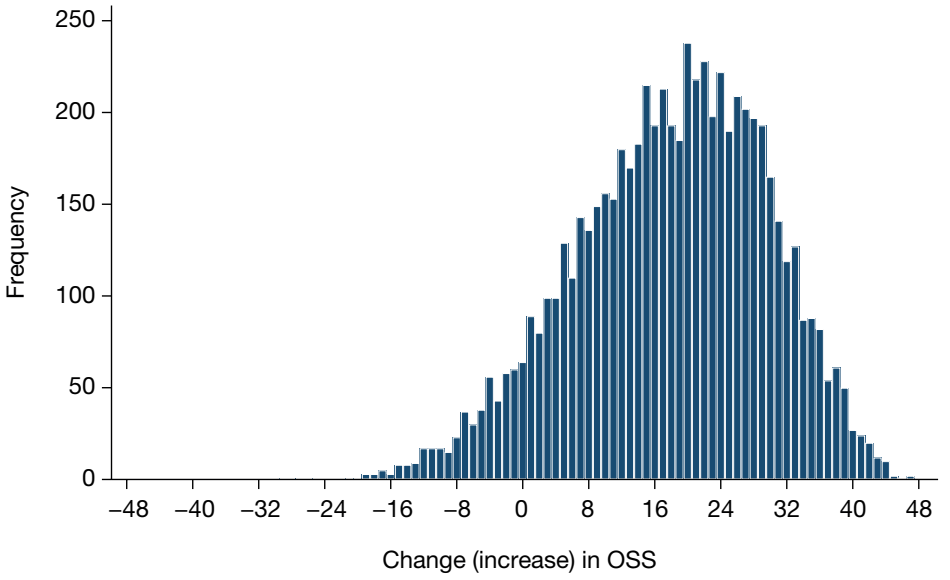


Table 3.64 A summary of available **elective OSS**, pre- (Q1) and post-operation (Q2) together with the change, by **year of the primary**.

Year of primary	Potential number	OSS summary		
		Pre-op Q1: Median (IQR), n	Post-op Q2: Median (IQR), n	Change (Q2-Q1): Median (IQR), n
All elective	34,459	16 (11-22), 13,420	38 (28-44), 15,962	19 (10-27), 6,562
2012*	2,411	16 (10-22), 1,103	35 (24-42), 1,629	17 (7-26), 810
2013	4,013	16 (11-23), 1,783	35 (24-42), 1,960	17 (9-24), 931
2014	4,817	16 (11-22), 2,198	38 (27-44), 2,501	19 (11-27), 1,220
2015	5,159	16 (11-23), 2,073	38 (28-43), 838	19 (11-26), 366
2016	5,894	16 (11-23), 2,127	40 (30-45), 1,140	20 (12-28), 446
2017	6,222	16 (11-22), 2,169	38 (29-44), 4,624	19 (10-27), 1,689
2018	5,943	15 (10-22), 1,967	39 (30-44), 3,270	21 (12-28), 1,100

*Includes a few with primary operation dates prior to 2012.

A summary of all available pre- (Q1) and 6 months post-operative (Q2) OSS by year of elective primary, together with the changes is shown in Table 3.64.

Table 3.65 A summary of available **elective OSS**, pre- (Q1) and post-operation (Q2) together with the change, by **patient procedure**.

Primary procedure	Summary of pre- and post- OSS, for complete pairs, by primary patient procedure			
	Number of complete pairs	Pre-op (Q1): Median (IQR)	Pre-op (Q2): Median (IQR)	Change (Q2-Q1): Median (IQR)
Proximal humeral hemiarthroplasty	979	17 (11-23)	34 (23-41)	14 (6-22)
Resurfacing	585	18 (12-24)	34 (23-41)	14 (6-21)
Stemless	112	19 (14-24)	36 (29-42)	14 (6.5-23)
Stemmed	282	15 (10-21)	31 (20-39)	14 (5-21)
Total shoulder replacement	2,217	17 (12-23)	41 (33-45)	21 (13-28)
Resurfacing	111	18 (13-24)	40 (33-46)	20 (12-27)
Stemless	756	18 (12-24)	41 (34-46)	22 (13-28)
Stemmed	1,350	17 (12-23)	41 (33-45)	21 (13-28)
Reverse polarity total shoulder replacement	2,834	15 (10-21)	37 (27-43)	19 (10-27)
Stemless	29	18 (10-23)	38 (29-45)	20 (10-29)
Stemmed	2,805	15 (10-21)	37 (27-43)	19 (10-27)
Pyrocarbon Ball	0			
Unclassifiable	552	16 (11-23)	37 (26-43)	17 (9-25)

The final table in this section, Table 3.65, summarises the OSS changes in the elective patients according to the primary patient procedure.

3.7.4 Mortality after primary shoulder replacement surgery

For this analysis, the second procedure or side of the 26 pairs of bilateral operations performed on the same day (see Table 3.2) were excluded. Of the remaining 37,890 implants, 2,696 of the recipients had died by the end of December 2018.

It remains important to separate mortality rates following acute trauma from mortality rates after elective surgery due to the different populations and risks involved.

Table 3.66 KM estimates of cumulative **mortality** (95% CI) for **acute trauma** and **elective** cases.
Blue italics signify that fewer than 250 cases remained at risk at these time points.

	n	Time since primary					
		30 days	90 days	1 year	3 years	5 years	6 years
All cases	37,890	0.16 (0.12-0.20)	0.38 (0.32-0.45)	1.6 (1.5-1.7)	6.2 (5.9-6.5)	13.2 (12.6-13.7)	16.3 (15.6-17.1)
Acute trauma	3,448	0.67 (0.45-1.01)	1.45 (1.10-1.91)	3.9 (3.3-4.6)	12.0 (10.8-13.4)	23.3 (21.0-25.8)	*27.9 (24.9-31.2)*
Elective	34,442	0.11 (0.08-0.15)	0.27 (0.22-0.33)	1.4 (1.2-1.5)	5.7 (5.4-6.0)	12.2 (11.7-12.8)	15.3 (14.6-16.1)

Note: 30 day and 90 day mortality is reported to two decimal places due to the low mortality rate.

Table 3.66 shows the overall cumulative percentage probability of mortality shown separately for acute trauma and elective cases and shows higher rates in the acute trauma group.

However, this shows all-cause mortality and in extended follow-up beyond the immediate post-operative period, we would expect higher rates in older age groups, and also in men. In the subsequent table, Table 3.67 (overleaf), the larger elective group has been sub-divided by gender and age; the number remains too small for further breakdown in the acute trauma cases.

Table 3.67 KM estimates of cumulative **mortality** (95% CI) for **elective** cases by **age** and **gender**. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

Age at primary (years)*	Males							Females						
	n	Time since primary						n	Time since primary					
		30 days	90 days	1 year	3 years	5 years	6 years		30 days	90 days	1 year	3 years	5 years	6 years
<55	1,146	0	0	0.7 (0.3-1.4)	2.4 (1.5-3.7)	*5.0 (3.4-7.3)*	*5.7 (3.8-8.5)*	941	0	0.11 (0.02-0.77)	0.5 (0.2-1.2)	1.9 (1.2-3.3)	*5.6 (3.7-8.3)*	*6.2 (4.1-9.2)*
55-64	1,948	0.15 (0.05-0.48)	0.31 (0.14-0.70)	1.4 (0.9-2.0)	3.8 (2.9-5.0)	5.5 (4.2-7.1)	*6.7 (4.8-9.4)*	2,457	0.04 (0.01-0.29)	0.08 (0.02-0.33)	0.4 (0.2-0.8)	2.1 (1.5-2.9)	5.0 (3.8-6.5)	*7.4 (5.6-9.6)*
65-74	4,012	0.05 (0.01-0.20)	0.25 (0.14-0.47)	1.1 (0.8-1.5)	4.1 (3.4-5.0)	9.5 (8.1-11.1)	*11.8 (10.0-13.9)*	8,925	0.04 (0.02-0.12)	0.17 (0.10-0.28)	0.8 (0.6-1.0)	3.5 (3.1-4.0)	7.8 (6.9-8.7)	9.8 (8.6-11.0)
75+	3,290	0.34 (0.19-0.60)	0.65 (0.42-1.00)	3.0 (2.5-3.7)	11.3 (10.1-12.8)	23.6 (21.3-26.1)	*29.0 (25.9-32.4)*	11,717	0.14 (0.08-0.22)	0.32 (0.23-0.44)	1.7 (1.5-2.0)	8.0 (7.5-8.7)	17.7 (16.6-18.8)	22.3 (20.8-23.9)

*Excludes six cases where the NHS number was not traced therefore the age could not be validated.
Note: 30 day and 90 day mortality is reported to two decimal places due to the low mortality rate.

3.7.5 Conclusions

In this report, we document the continued patterns of use of primary and revision shoulder replacements. The shoulder implant data recorded in the NJR has again undergone external checks and validation this year. The new Minimum Data Set (v7) has been in use since June 2018 and contains more detail on indication and implant types.

We remain unable to present any analysis on glenoids as database improvements need to be finalised before these can be reliably examined.

There are now 37,916 shoulder replacements in the NJR. Patterns of use are becoming clear and revision rates out to six years can be inspected. We continue to collect PROMs so that patient outcomes in terms of pain and function can also be assessed alongside revision rates.

Reverse total shoulder replacement made up 57% of all shoulder replacements in 2018 and the patterns of use observed in previous reports continue. This high level of use across indications indicates a growing confidence in this implant and a rapid change of practice in the UK despite limited high level outcome evidence. Proximal humeral hemiarthroplasty continues to decline in numbers, while conventional total shoulder replacement is stable.

Revision rates this year do not alter the pattern observed last year. Revision rates in younger patients continue to be high and are now around 10% at four years in both genders. This is an important finding to be shared with young patients who wish to have a shoulder replacement. In next year's report we hope to provide a further breakdown of this group by implant type.

The NJR does not currently capture information on pre-operative glenoid type, and information on this confounding factor will be needed in the future for more robust comparative analysis of implant group performance. However, at present both conventional and reverse total shoulder replacement demonstrate the lowest revision rates at five and six years. More elective proximal humeral hemiarthoplasties are being revised earlier and while it can be argued this is an easier operation to perform, the PROMs data in this report does suggest lower change scores are being achieved in the specific patient groups that receive a hemiarthoplasty.

This year we presented the PROMs data we have available. This includes a Q1 (pre-op), Q2 (6 months post-surgery), Q3 (3 years) and Q4 (5 years) Oxford Shoulder Score. The data remains incomplete and strategies are being developed to improve this in the future. However, a large Q1 and Q2 matched elective cohort of 6,562 patients is now available. It demonstrates shoulder replacement surgery results in substantial improvements in pain and function of patients. The best improvements can be achieved in patients suitable for conventional shoulder replacement, followed by those suitable for reverse shoulder replacement, followed by those receiving a proximal humeral hemiarthoplasty.

We did previously note in the 2016 report that 8% of elective patients had a worse PROMs score six months post-surgery than they did pre-surgery. Similarly, with this bigger cohort, 7% of patients having an elective shoulder replacement had a worse PROMs score at six months, while a further 5% had less than the minimal change in the Oxford Shoulder Score PROM to notice a meaningful difference in pain and function. This suggests more research is needed to understand which patients do well and which do not after each type of shoulder replacement surgery.

Overall, the volume of shoulders in the NJR continues to grow rapidly and presents an opportunity for outcomes to be assessed both by revision and by PROMs. We anticipate this will lead to more meaningful analysis and provision of useful information for patients, surgeons and other stakeholders.

Part 3

3.8 In-depth studies

The NJR encourages the use of the NJR dataset to maximise its value to patients and the wider health community, providing datasets to both internal NJR studies and external researchers. Used in conjunction with datasets from other orthopaedic registries, the NJR is also able to support research internationally.

Since 2010 the NJR has run a rolling Research Fellowship programme in partnership with the Royal College of Surgeons of England. This fellowship supports orthopaedic trainees undertaking research into joint replacement and allows them to contribute to the analysis of registry data.

Here we present summaries of six in-depth studies, including two led by an NJR Research Fellow using data from international registries.

3.8.1 Comparing survival modelling approaches for personalised outcome prediction after joint replacement: a study using data from the National Joint Registry for England & Wales

Full paper details:

Estimating an Individual's Probability of Revision Surgery After Knee Replacement: A Comparison of Modeling Approaches Using a National Dataset.

Aram P, Trela-Larsen L, Sayers A, Hills AF, Blom AW, McCloskey EV, Kadirkamanathan V, Wilkinson JM. American Journal of Epidemiology. 2018 Oct 1;187(10):2252-2262. DOI: https://doi.org/10.1093/aje/kwy121 PMID: 29893799

Funding – Arthritis Resarch UK grant 20894.

Background

Evidence-based decision-making in the setting of joint replacement surgery, where such decisions are preference-sensitive, would enable the patient to arrive at an informed choice amongst several alternative treatments. The development of a personalised decision aid in this setting requires the generation of a survival model that incorporates individual characteristics, prosthesis choice and other fixed and modifiable risk factors. The choice of such models is potentially large, including semi-parametric Cox models, parametric survival models, flexible parametric survival (FP) models, and random survival forests (RSF). These models, with the exception of the Cox model, can be adapted to provide an estimate of the absolute risk of the outcome of interest for each individual. We used the NJR dataset to examine the accuracy of these methods for the development of an absolute risk algorithm for prosthesis revision in patients undergoing knee replacement.

Study population

Our base dataset was 787,106 knee replacements carried out in England and Wales between April 2003 and September 2015. We excluded procedures where osteoarthritis was not the only indication for surgery (29,918), body mass index (BMI) was below 15 or above 55 kg/m^2 (2,485), those aged younger than 30 or older than 100 years (262), or ASA grade 4 or 5 (2,782), indicating severe co-morbidities. Due to differences in characteristics of patients undergoing the various knee replacement procedures, separate models were constructed for each of the procedures being considered: total knee replacement (TKR), unicondylar knee replacement (UKR), or patellofemoral replacement (PFR).

Outcome and co-variates

The outcome of interest in our survival models was time to first revision surgery. We linked primary knee replacement procedures to revision procedures recorded in the NJR using a unique patient identifier and side. Analysis co-variates included age, BMI, sex, American Society of Anesthesiologists (ASA) grade, chemical and mechanical thromboprophylaxis, and operation type.

Modelling approaches

Several models for predicting prosthesis survivorship after knee replacement surgery for osteoarthritis, including parametric and non-parametric methods, were constructed and compared using a variety of metrics via repeated five-fold cross-validation.

Results

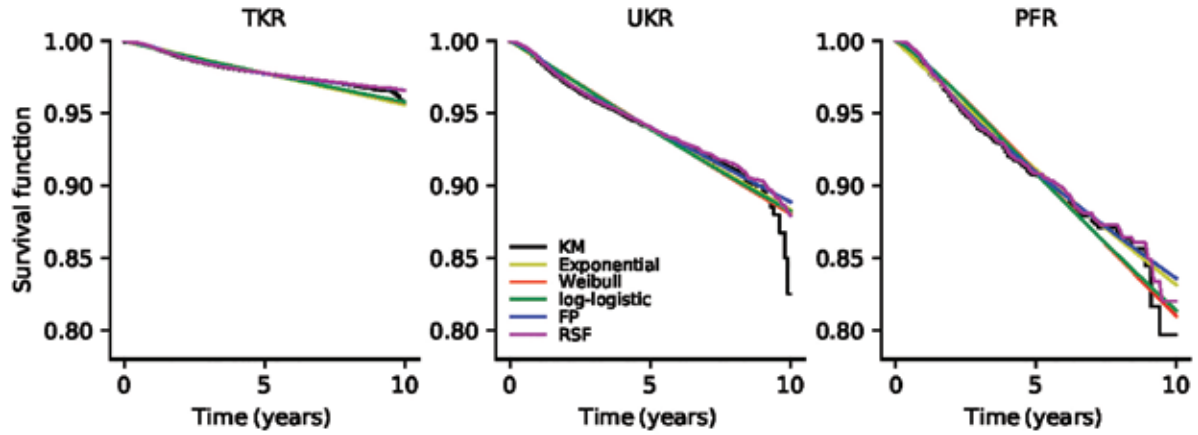
A flexible parametric survival model along with random survival forest (RSF), most accurately captured the observed survival probability. The concordance index for the flexible parametric model was the highest:

70.5% (95% CI 70.2-70.7) for total knee replacement (TKR), 63.9% (95% CI 63.4-64.3) for unicondylar knee replacement (UKR) and 58.9% (95% CI 58.6-59.2) for patellofemoral replacement (PFR). In terms of calibration, the average observed-to-predicted ratios for the flexible parametric model (TKR: 1.13; UKR: 1.13; PFR: 1.03) were closer to unity than the RSF approach (TKR: 1.44; UKR: 1.20; PFR: 1.07).

The hazard ratios from the parametric proportional-hazards models were in close agreement to the Cox semi-parametric model as expected.

The averaged predicted survival curves over all individuals along with the observed (Kaplan-Meier) curve over time are plotted in Figure 3.30. The results show that the FP survival model and the RSF method can capture the observed survival probabilities accurately. These plots also suggest that there is insufficient information after year eight, thus only data up to eight years was used in subsequent analyses.

Figure 3.30 Average predicted survival curves over time for each of the tested models.



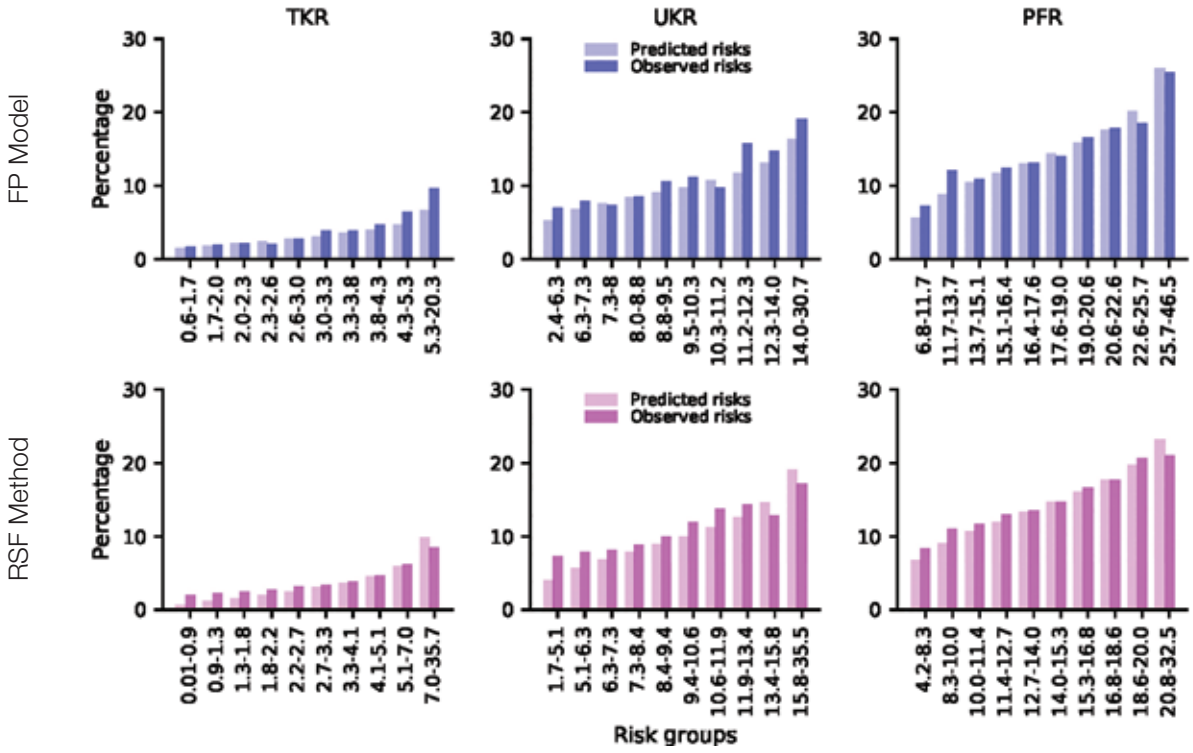
Cross validation

Only the FP model and RSF approach were considered for further comparison given their performance in the previous analysis. The integrated Brier score of the FP model over eight years was 0.020 for TKR (95% CI 0.020-0.020), 0.052 (95% CI 0.052-0.052) for UKR and 0.074 (95% CI 0.073-0.075) for PFR. For the RSF approach the Brier score was 0.020 (95% CI 0.020-0.020) for TKR, 0.052 (95% CI 0.052-0.052) for UKR and 0.073 (95% CI 0.072-0.074) for PFR.

When examining the discriminative ability of the models at eight years, the concordance index of the FP model was 70.5% for TKR (95% CI 70.2%-70.7%), 63.9% for UKR (95% CI 63.4%-64.3%) and 58.9% for PFR (95% CI 58.6%-59.2%). For the RSF method this fell to 66.0% (95% CI 65.5%-66.6%) for TKR, 61.6% (95% CI 61.0-62.1) for UKR and 57.9% (95% CI 57.5%-58.2%) for PFR.

Calibration was assessed by dividing data into deciles of predicted risk of experiencing prosthesis failure within eight years. Calibration plots were then constructed (Figure 3.31) to compare observed and average predicted risks for each decile.

Figure 3.31 Comparison of observed versus predicted risk for prosthesis failure by risk decile group.



The average observed-to-predicted ratios for FP model (Purple, TKR: 1.13; UKR: 1.13; PFR: 1.03) are closer to unity compared to the RSF approach (Pink, TKR: 1.44; UKR: 1.20; PFR: 1.07).

Interpretation

Here we present a comprehensive comparative evaluation of standard survivorship models for knee replacement using the world's largest knee replacement clinical dataset, with the aim of informing the development of personalised decision tool. A variety of performance metrics were used to evaluate the generated models. Amongst commonly used algorithms, the flexible parametric model provides the most accurate prediction of individualised outcome for prosthesis survival. This approach shows better overall performance compared to other tested parametric methods, and better discrimination and calibration compared to the RSF approach.

3.8.2 Long term survival of hip replacements: a systematic review and meta-analysis

Full paper details:

How long does a hip replacement last? A systematic review and meta-analysis of case-series and national registry reports with greater than 15 years follow-up.

J.T. Evans, J.P. Evans, R.W. Walker, A.W. Blom, M.R. Whitehouse, A. Sayers

The Lancet, February 2019. Lancet 2019; 393, 647-654. DOI: https://doi.org/10.1016/S0140-6736(18)31665-9

Background

One of the questions most frequently asked in an elective hip clinic is simply "How long will my hip replacement last?" Whilst the survival of hip replacements has been extensively researched using various datasets, definitions of exposure and outcome vary and results are presented in different ways across heterogenous populations. The two main sources of data regarding hip replacement survival are articles (typically case-series) reported in medical journals and national registry reports. We aimed to put ourselves in the position of a patient, with the resources of a university, to provide a simple and generalisable answer to this question.

Methods

We defined long-term as greater than 15 years. The exposure was individual stem-cup combinations and outcome was all-cause revision of any part of the construct as guided by our patient group.

Data sources

We performed a search of Medline and Embase for all articles reporting all-cause construct survivorship of a single construct with a mean follow-up of greater than 15 years. Articles reporting survival of complex primaries, specific indications other than osteoarthritis, revisions or resurfacings were excluded as these are known to exhibit different survival rates. We also reviewed the annual reports for all national registries with greater than 15 years of follow-up. Results were included if survival estimates were provided for individual construct combinations with confidence intervals. Articles reporting survival in national registries were not included in meta-analyses as these would represent duplication of data from annual reports.

Statistical analyses

Data were combined in Stata v15, using a fixed effects model, weighting the contribution of each individual series to the overall estimate based on standard error. Standard error was calculated in reverse from presented confidence intervals. A smaller standard error (more precise study) is typically related to a larger number of hips in a series and a lower proportion that were lost to follow-up or died.

Results

Case-series

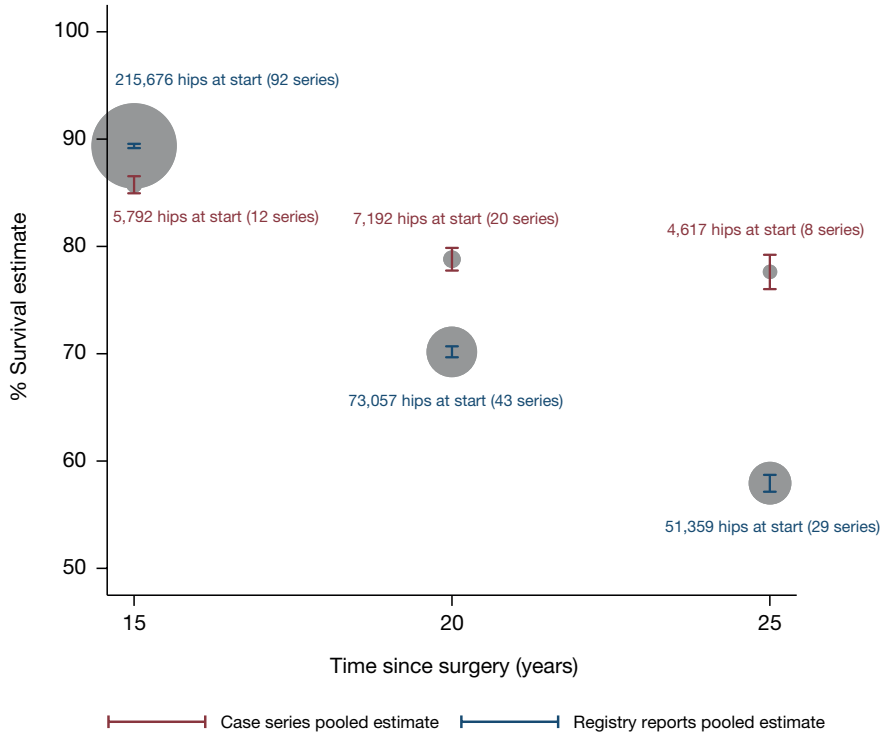
From 2,750 articles identified by our search, only 44 series met our inclusion criteria and provided the confidence intervals required for analyses and these represented 13,212 THRs. Quality assessment using the non-summative scoring system devised by Wylde et al.[11] suggested that overall the case-series were of low quality. Pooled analysis of data showed all-cause survivorship of the construct of 85.7% (95% CI 85.0-86.5) at 15 years, 78.8% (95% CI 77.8-79.9) at 20 years and 77.6% (95% CI 76.0-79.2) at 25 years.

Registry reports

Only the Australian and Finnish arthroplasty registries provided data with sufficient granularity for inclusion in this study. The Australian data extended to 15 years and the Finnish to 25 years of follow-up. We identified 92 series (215,676 THRs) reporting survival at 15 years with 43 series (73,057 THRs) at 20 years and 29 series (51,359 THRs) at 25 years. Pooled analyses showed all-cause construct survivorship of 89.4% (95% CI 89.2-89.6) at 15 years, 70.2% (95% CI 69.7-70.7) at 20 years and 57.9% (95% CI 57.1-58.7) at 25 years.

[11] Wylde V, Beswick AD, Dennis J, Gooberman-Hill R. Post-operative patient-related risk factors for chronic pain after total knee replacement: a systematic review. BMJ Open 2017; 7: e018105.

Figure 3.32 Comparison of pooled survival estimates from case-series and registry reports at 15, 20 and 25 years.



In Figure 3.22, the size of the circle representing each point estimate is proportional to the total number of hip replacements at the start of all the series contributing to that pooled estimate.

Discussion

Until now, we have not had a generalisable answer to the simple question of how long a hip replacement lasts. This study suggests that just over half of hip replacements will last 25 years.

Different hip and knee replacement constructs display different survival patterns and parts of a construct are not independent of each other, so the use of the construct as an exposure is a strength of this study. Comparison of constructs or fixation method was not performed as this would introduce selection bias. Pooling of data, as we have done in this study, inevitably leads to some weaknesses. The most notable limitation of this study is regarding the generalisability of results; although the demographics of patients in the study was similar to those seen in the NJR, all 20 and 25 year data were derived from the Finnish registry which may reduce the generalisability of estimates. Secular trends in implant use also mean that many of the constructs used in this study are no longer in use today.

The results of this study are useful for providing patients with information for informed consent as well as future resource planning and medicolegal work.

Conclusion

Results derived from national registry reports were more conservative and included a far greater number of hip replacements, so we are safest using these for our estimates. Using these data, we estimate that approximately 58% of hip replacements will last 25 years.

3.8.3 Long term survival of knee replacements: a systematic review and meta-analysis

Full paper details:

How long does a knee replacement last? A systematic review and meta-analysis of case-series and national registry reports with greater than 15 years follow-up.

J.T. Evans, J.P. Evans, R.W. Walker, A.W. Blom, M.R. Whitehouse, A. Sayers

The Lancet, February 2019. Lancet 2019; 393, 655-663. DOI: https://doi.org/10.1016/S0140-6736(18)32531-5

Background

When weighing up the decision of whether to undergo knee replacement, patients often ask "How long does a knee replacement last?" As with hip replacement, no single clear and generalisable estimate exists in answer to this question. We aimed to use evidence synthesis techniques, to identify as many available estimates of long-term knee replacement survival as possible and combine them to form a simple answer for both unicondylar and total knee replacement.

Methods

Long-term was defined as greater than 15 years. The exposure was individual total and unicondylar knee replacement constructs and outcome was all-cause revision of any part of the construct as guided by our patient group.

Data sources

We performed a search of Medline and Embase for all articles reporting all-cause construct survivorship of knee replacements series using a single implant with a mean follow-up of greater than 15 years. Articles reporting survival of complex primaries, specific indications other than osteoarthritis or revisions were excluded, as these are known to exhibit different survival rates. We also reviewed the annual reports of national registries and analysed this data separately. Articles reporting survival using data from national registries were not included in meta-analyses as these would represent duplication of data from annual reports.

Statistical analyses

Data were combined in Stata v15, using a fixed effects model, weighting the contribution of each individual series to the overall estimate based on standard error. Standard error was calculated in reverse from presented confidence intervals. A smaller standard error (more precise study) is typically related to a larger number of cases in a series and a lower proportion that were lost to follow-up or died.

Results

Case-series

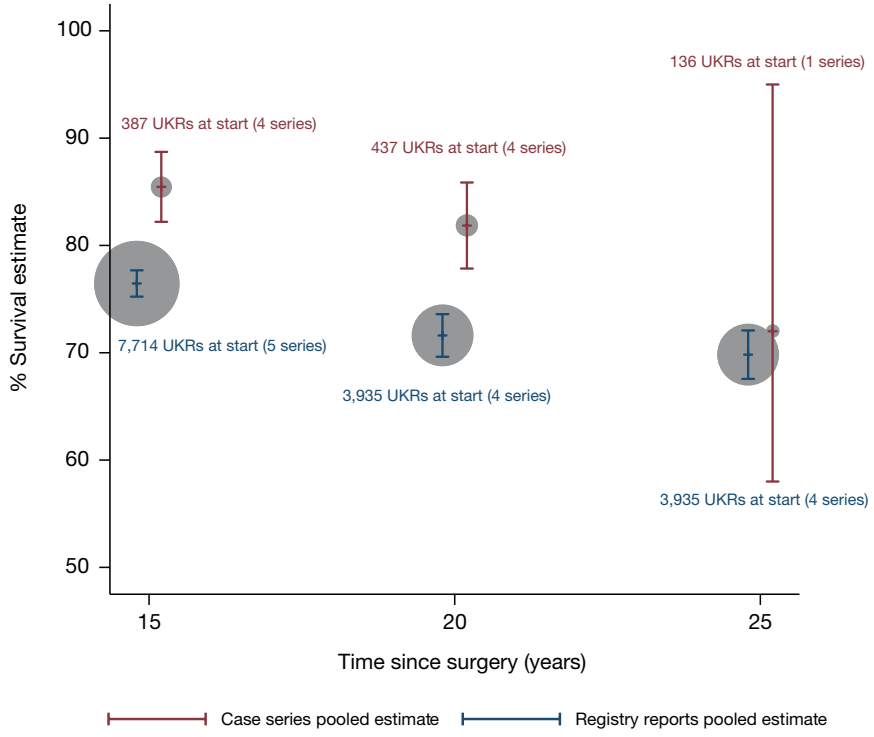
From 2,882 articles identified by our search, only 26 series of TKRs and seven series of UKRs met our inclusion criteria and these represented 6,490 and 742 TKR and UKRs respectively. Pooled analysis of TKR data showed all-cause survivorship of 96.3% (95% CI 95.7-96.9) at 15 years and 94.8% (95% CI 92.5-97.1) at 20 years. Pooled analysis of UKR data showed all-cause survivorship of 85.5% (95% CI 82.2-88.7) at 15 years, 81.9% (95% CI 77.9-85.9) at 20 years and 72.0% (95% CI 58.0-95.0) at 25 years. Quality assessment using the non-summative scoring system devised by Wylde et al.[12] suggested that overall the case-series were of low quality.

[12] Wylde V, Beswick AD, Dennis J, Gooberman-Hill R. Post-operative patient-related risk factors for chronic pain after total knee replacement: a systematic review. BMJ Open 2017; 7: e018105.

Registry reports

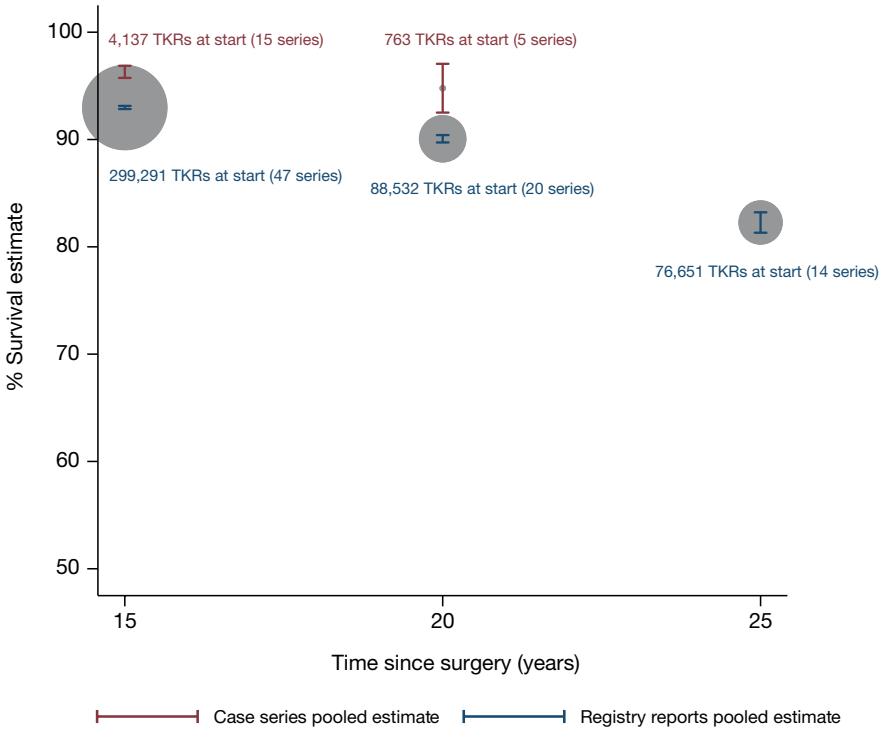
Data on TKRs originated in both the Australian and Finnish registries at 15 years and from the Finnish registry alone at both 20 and 25 years. We identified 47 series (299,291 TKRs) reporting survival at 15 years with 20 series (88,532 TKRs) at 20 years and 14 series (76,651 TKRs) at 25 years. Pooled analyses showed all-cause construct survivorship of 93.0% (95% CI 92.8-93.1) at 15 years, 90.1% (95% CI 89.7-90.4) at 20 years, and 82.3% (95% CI 81.3-83.2) at 25 years. All data regarding unicondylar knee replacements came from the Finnish arthroplasty registry. There were five series (7,714 UKRs) reporting survival at 15 years with four series (3,935 UKRs) at 20 years and four series (3,935 UKRs) at 25 years. Pooled analyses showed all-cause construct survivorship of 76.5% (95% CI 75.2-77.7) at 15 years, 71.6% (95% CI 69.6-73.6) at 20 years, and 69.8% (95% CI 67.6-72.1) at 25 years.

Figure 3.33 Comparison of pooled survival estimates of unicondylar knee replacements from case-series and registry reports at 15, 20 and 25 years.



In Figure 3.3 the size of the circle representing each point estimate is proportional to the total number of UKRs at the start of all the series contributing to that pooled estimate.

Figure 3.34 Comparison of pooled survival estimates of total knee replacements from case-series and registry reports at 15, 20 and 25 years.



In Figure 3.34 the size of the circle representing each point estimate is proportional to the total number of TKRs at the start of all the series contributing to that pooled estimate.

Discussion

The results of this evidence synthesis suggest that at present there is insufficient evidence to tell us how long a knee replacement lasts, on average. We can comment that in our study population the proportion of both TKR and UKR lasting 25 years was reassuringly high.

Survival is only one measure of success of a knee replacement and evidence suggests that one in five patients with knee replacement still experience pain and/or loss of function. The evidence in this study should only therefore be interpreted in terms of survival and not of success. Both data sources have potential biases unique to their study design, notably around selection bias, publication bias and completeness of follow-up. The more conservative estimates and higher patient numbers seen in registry reports suggest these are the safer ones to use. The generalisability of long-term results from a single registry (Finnish Arthroplasty Registry) to the UK population is not known and future work should focus on international collaboration to provide more generalisable estimates.

The results of this study are useful for providing patients with information for informed consent as well as future resource planning and medicolegal work.

Conclusion

Using currently available data and allowing survival to differ between different implants, we estimate that approximately 82% of TKRs and 70% of UKRs last twenty-five years.

3.8.4 Temporal trends and survivorship of total hip arthroplasty in very young patients: a study using the National Joint Registry dataset

Full paper details:

Temporal trends and survivorship of total hip arthroplasty in very young patients: a study using the National Joint Registry data set.

Metcalfe D, Peterson N, Wilkinson JM, Perry DC.

Published in The Bone & Joint Journal, October 2018. 100-B(10):1320-1329. DOI: https://doi.org/10.1302/0301-620X.100B10.BJJ-2017-1441.R2

Background

There are concerns about the suitability of THA for very young patients due to reduced implant longevity and the potential need for multiple revision procedures. The most recent meta-analysis pooled data from only 736 procedures, despite including 16 studies. Our study aimed to describe the temporal trends and survivorship of THA in very young adult (aged <20 years) patients, as well as to identify factors that are associated with early arthroplasty failure.

Methods

An observational cohort study was performed using data collected from the National Joint Registry (NJR) for England, Wales, Northern Ireland and the Isle of Man. We included all individuals aged ≤20 years old that had a primary THA since the inception of the NJR in 2003.

We extracted patient variables (e.g. age, sex), operation variables (e.g. indication, approach), and surgeon variables (e.g. number of THAs in very young adults and total number of THAs recorded in the NJR). Very young THA frequency was categorized a priori as <5 and >5 cases and overall frequency as <100 and >100 cases. The outcomes available from the NJR were "unrevised", "revised", and "death" together with a separate "time to event" (i.e. outcome or censorship) variable. Patients that did not die or undergo THA revision were censored on 8 March 2017.

Results

There were 769 arthroplasty procedures in 703 patients recorded between 1 April 2003 and 8 March 2017. The median follow-up period (until death, revision, or censorship) was 5.1 (interquartile range (IQR) 2.6-7.8) years with 4,190 person-years available for follow-up across the cohort.

Eight patients died, which resulted in an overall mortality rate of 1.9 per 1000 person-years. There were no deaths within six months of THA and there was no association with operative indication. A total of 35 THAs had been revised at a median follow-up of 5.1 years, which produced a Kaplan-Meier survivorship estimate of 96% (95% confidence interval (CI) 94-98%) at five years.

Figure 3.35 (overleaf) shows trends in use of bearing combinations over time. The proportion of failures was highest in the metal-on-metal (MoM) group (23%) followed by resurfacings (13%), metal-on-polyethylene (MoP) (8%), ceramic-on-polyethylene (CoP) (<4%), and ceramic-on-ceramic (CoC) (2%). These yielded Kaplan-Meier survival estimates for MoM (86%, 95% CI 66-94%), resurfacings (94%, 95% CI 86-98%), MoP (93%, 95% CI 80-98%), CoP (99%, 95% CI 94-99%), and CoC (98%, 95% CI 95-99%) at five years. The most frequent indications for revision were loosening (7/35, 20%), infection (7/35, 20%), wear (6/35, 17%), and pain (5/35, 14%). Table 3.68 identifies bearing combinations that were over-represented in each failure category.

Figure 3.35 Temporal trends in the use of bearing surfaces.

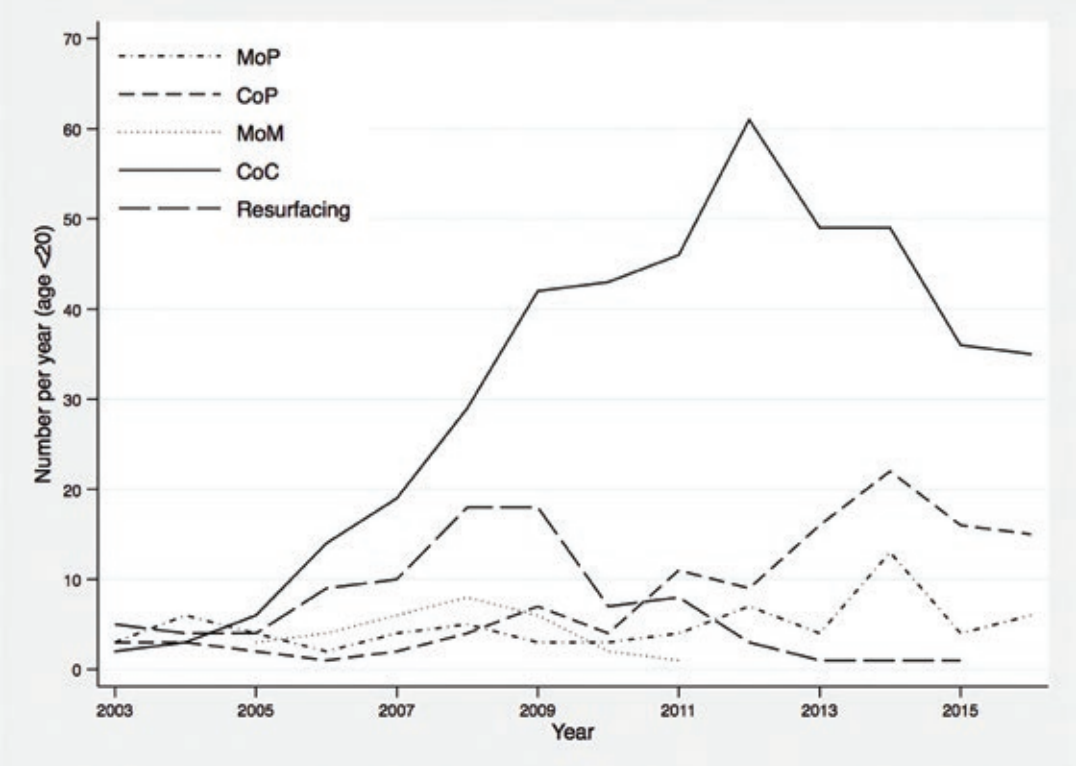


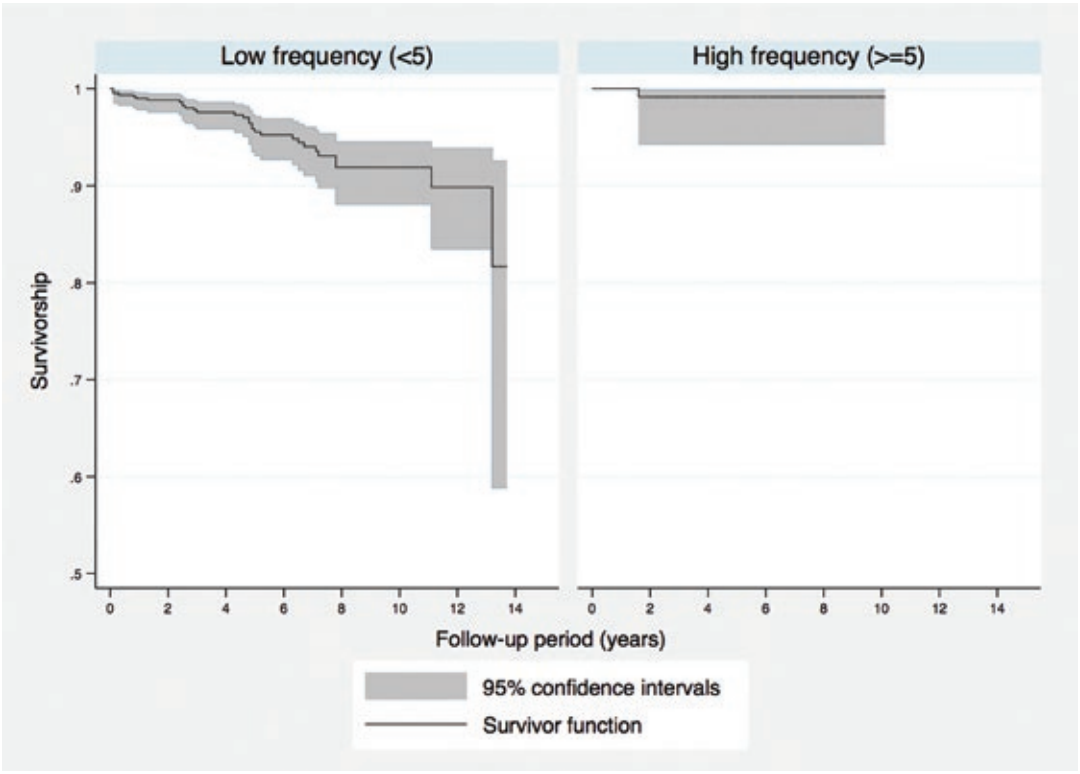
Table 3.68 Bearing surfaces disproportionately represented in each "failure" category.

	Indication for revision								
Bearing	Loosening	Infection	Wear	Pain	Error	Other	Dislocation	Fracture	Total
Ceramic-on-ceramic	-	-	-	-	-	+	-	-	-
Ceramic-on-polyethylene	-	-	-	-	-	-	-	-	-
Metal-on-polyethylene	+	+	-	-	-	-	-	-	+
Metal-on-metal	+	-	+	+	+	-	-	-	+
Resurfacing	+	+	+	+	+	+	+	+	+

+ indicates that a bearing was disproportionately represented in each failure category.
- indicates that the bearing was appropriately or under-represented.
Note: Absolute numbers in each category could not be presented to avoid breaching the data sharing agreement prohibition on potentially disclosive small cells. Confidence intervals were not used in creating this table given the very small numbers involved.

Figure 3.36 shows THAs undertaken by surgeons with a higher number of very young THAs recorded in the NJR were associated with greater implant survival (logrank test P=0.030). A total of 83% of all cases were operated by a surgeon with fewer than five very young THA cases recorded in the NJR. Overall frequency of THAs in the NJR (i.e. all ages) using a threshold of >100 cases was not associated with very young THA survival (logrank test P=0.78).

Figure 3.36 Kaplan-Meier plots showing THA survival by frequency of very young cases recorded in the NJR.



Survivorship was significantly reduced for MoP, MoM, and resurfacing arthroplasty when compared with CoC and CoP (logrank test P=0.002). There was not a significant association between survivorship and type of cup fixation, type of stem fixation, indication, surgical approach, or age.

Discussion

There are limitations to drawing inferences from observational data, even when the source is a well-designed clinical registry. The main limitation for our data is that the median follow-up period was 5.1 years and it will clearly be necessary to continue reporting outcomes from this cohort. We did not have the component level data required to distinguish the different types of polyethylene used in bearings, however there are unmeasured differences between the survival profiles of ultra-high molecular weight polyethylene (UHMWPE) and highly cross-linked polyethylene (XLPE). For these reasons, associations identified by such an observational study cannot be used to assume causal relationships.

It is likely that some surgeons contributing cases to the cohort gained experience of THA in the very young patient before the NJR was established. This meant that we could not infer a true volume-outcome relationship from the observation that implant survival was associated with the number of cases each surgeon contributed to the cohort. However, this might be interpreted as adding to the strength to the association, as the absence of earlier data is likely to bias the data towards the null hypothesis, i.e. reducing the size of the effect. The temporal trends described are likely to represent genuine changes in clinical practice over time.

Conclusion

This study provides strong evidence that reports of high implant failure from procedures undertaken during the last century may not be applicable to contemporary THA, with the overall survival for very young patients undergoing THA exceeding 96% over the subsequent five years.

3.8.5 Risk factors of revision for prosthetic joint infection after primary hip replacement

Full paper details

This article presents independent research funded by the National Institute for Health Research (NIHR) under its 'Programme Grants for Applied Research' programme (RP-PG-1210–12005). This study was supported by the NIHR Biomedical Research Centre at the University Hospitals Bristol NHS Foundation Trust and the University of Bristol.

Risk factors associated with revision for prosthetic joint infection after hip replacement: a prospective observational cohort study.

E. Lenguerrand, M. R. Whitehouse, A. D. Beswick, S. K. Kunutsor, B. Burston, M. Porter, and A. W. Blom

Lancet Infectious Diseases 2018;18(9):1004–14. DOI: http://doi.org/10.1016/S1473-3099(18)30345-1

Background

Although relatively uncommon, prosthetic joint infection (PJI) is a devastating complication of hip replacement and leads to severe pain, poor function, reduced quality of life and even death.

PJI typically occurs early, likely to arise from the surgical episode; or late, primarily due to spread from the bloodstream although these distinctions are not absolute. If we could identify individuals at high risk of PJI, this would help us develop preventative strategies and to optimise detection and follow-up.

We investigated the overall and post-operative period-specific associations of patient, surgical, and healthcare setting factors with the risk of revision due to PJI in 623,253 primary total hip replacements recorded in the NJR.

Methods

We analysed primary hip replacements performed between 1 April 2003 and 31 Dec 2013, and revision procedures due to PJI that occurred after the primary replacement between 1 April 2003 and 31 Dec 2014. Revisions for PJI included debridement and implant retention with modular exchange, a single or a two-stage revision procedure.

We considered the patient characteristics age, sex, ethnicity, BMI, American Society of Anaesthesiologists (ASA) grade, and comorbidities (captured from Hospital Episode statistics (HES) records in the previous five years). Surgical factors included indication for surgery, anaesthesia type, thromboprophylaxis regime, surgical approach, hip replacement type, bearing surface, use of bone graft and occurrence of intraoperative complications. Health system factors included hospital type, funding stream, country, operating surgeon grade, consultant involvement, and volume of hip surgeries (categorised into quartiles) performed by the hospital, operating surgeon and surgeon in charge of the procedure in the preceding 12 months.

Poisson multilevel models accounting for clustering at unit level (random intercept) were used to study

the associations between the risk factors and risk of revision for PJI across the overall follow-up period. Piece-wise exponential multilevel models with period-specific effects were used to assess these associations at 0–3 months, 3–6 months, 6–12 months, 12–24 months, and more than 24 months after the primary procedure. All models are adjusted for age, sex, ASA grade and BMI except the investigations of the comorbidities which were not adjusted for ASA to avoid overadjustment and were restricted to patients operated in England and linked to HES. Adjusted p-values were computed to account for test multiplicity.

Results

A total of 623,253 primary hip procedures were studied and 2,705 primary procedures were subsequently revised for an indication of PJI after a median (IQR) follow-up of 4.6 years (2.6–7.0); 14% (n=372) of these within 3 months, 8% (n=204) in 3–6 months, 14% (n=374) in 6–12 months, 23% (n=612) in 12–24 months, and 42% (n=1143) beyond 24 months. The mean patient age was 68 years (SD 11). The 495,456 surgeries performed in England were linked to HES and used to investigate the effect of comorbidities.

Role of patient characteristics

Men were at higher risk of revision for PJI in all time periods. Patients over the age of 70 were at higher risk than those younger than 60 over the entire follow-up period. A high BMI (>30 kg/m^2) had a higher risk than lower BMI (<25 kg/m^2). ASA grades of 2 or more had higher risk than ASA grade 1. The presence of comorbidities including chronic pulmonary disease, diabetes, liver disease, congestive heart failure or connective tissue and rheumatologic diseases led to a higher risk. Patients with diabetes or dementia were at increased risk of early revision for PJI. Patients with liver disease were only at higher risk beyond 24 months.

Role of surgical factors

If the indication for hip replacement was osteoarthritis, there was a lower risk of revision for PJI than other indications. Patients who had hip replacement for a fractured neck of femur (only in the early period), avascular necrosis, or history of previous infection of the operated joint were at increased risk.

The posterior surgical approach led to a lower risk of revision for PJI than other approaches. Hip resurfacings were at lower risk than total hip replacements. In the first three months following surgery, patients who received an uncemented, hybrid or reverse hybrid total hip replacement were at higher risk than those who received a cemented hip replacement but from 3 to 24 months, they were at a lower or similar risk.

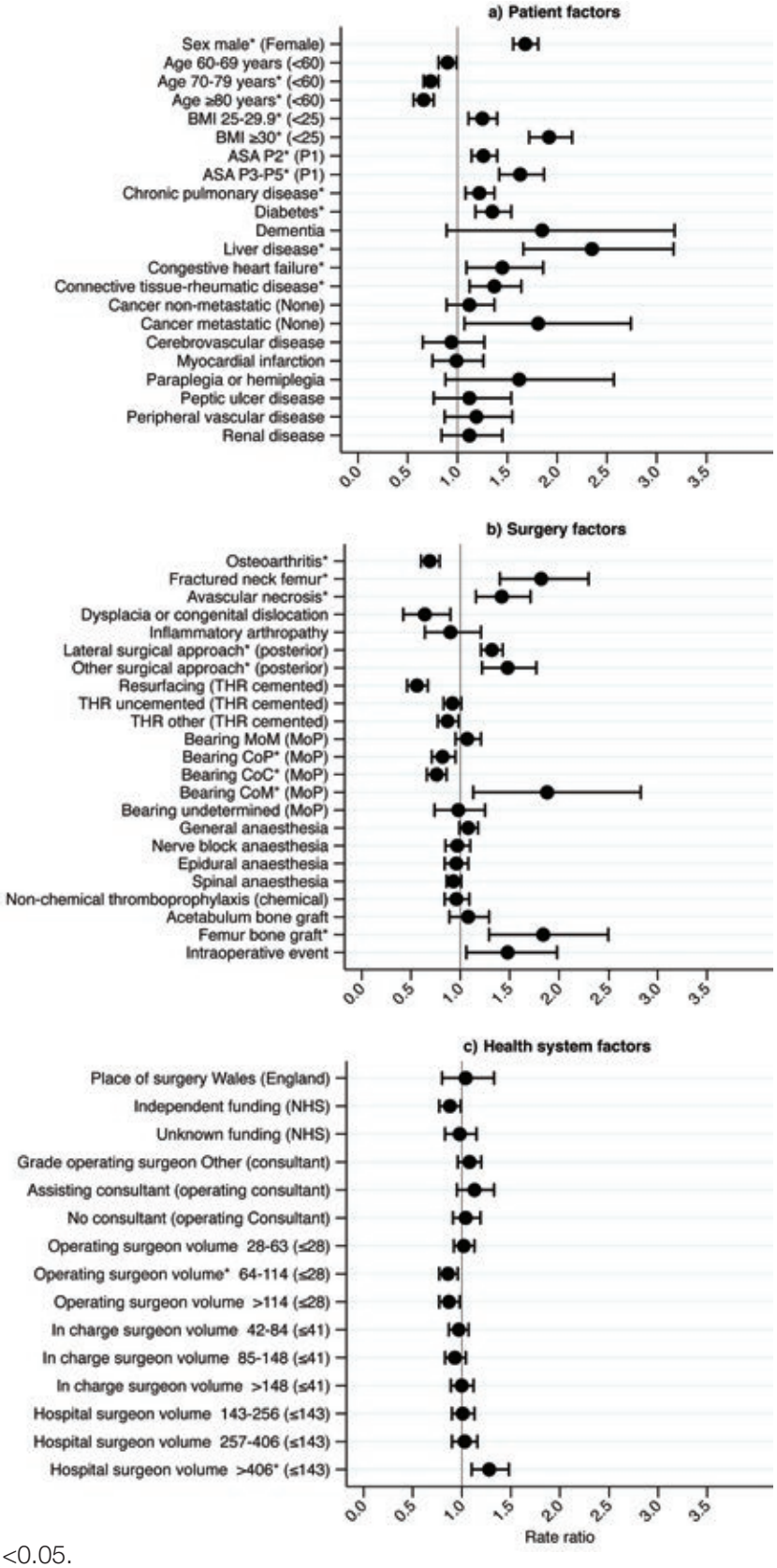
The bearing surface used had no effect within the first three months of surgery. Between 3 and 24 months, metal-on-metal bearings had a lower or similar risk than metal-on-polyethylene; beyond 24 months the risk was higher for metal-on-metal. Ceramic-on-ceramic and ceramic-on-polyethylene surfaces were associated with a lower risk of revision for PJI (from 12 months for ceramic-on-ceramic and 24 months for ceramic-on-polyethylene than metal-on-polyethylene bearings).

Role of health system factors

Anaesthetic technique, thromboprophylaxis regime, use of acetabular bone graft and occurrence of intraoperative complication had little effect on the risk of revision for PJI but use of femoral bone graft increased the risk overall. No difference was observed between England and Wales, nor according to funding source for the primary operation.

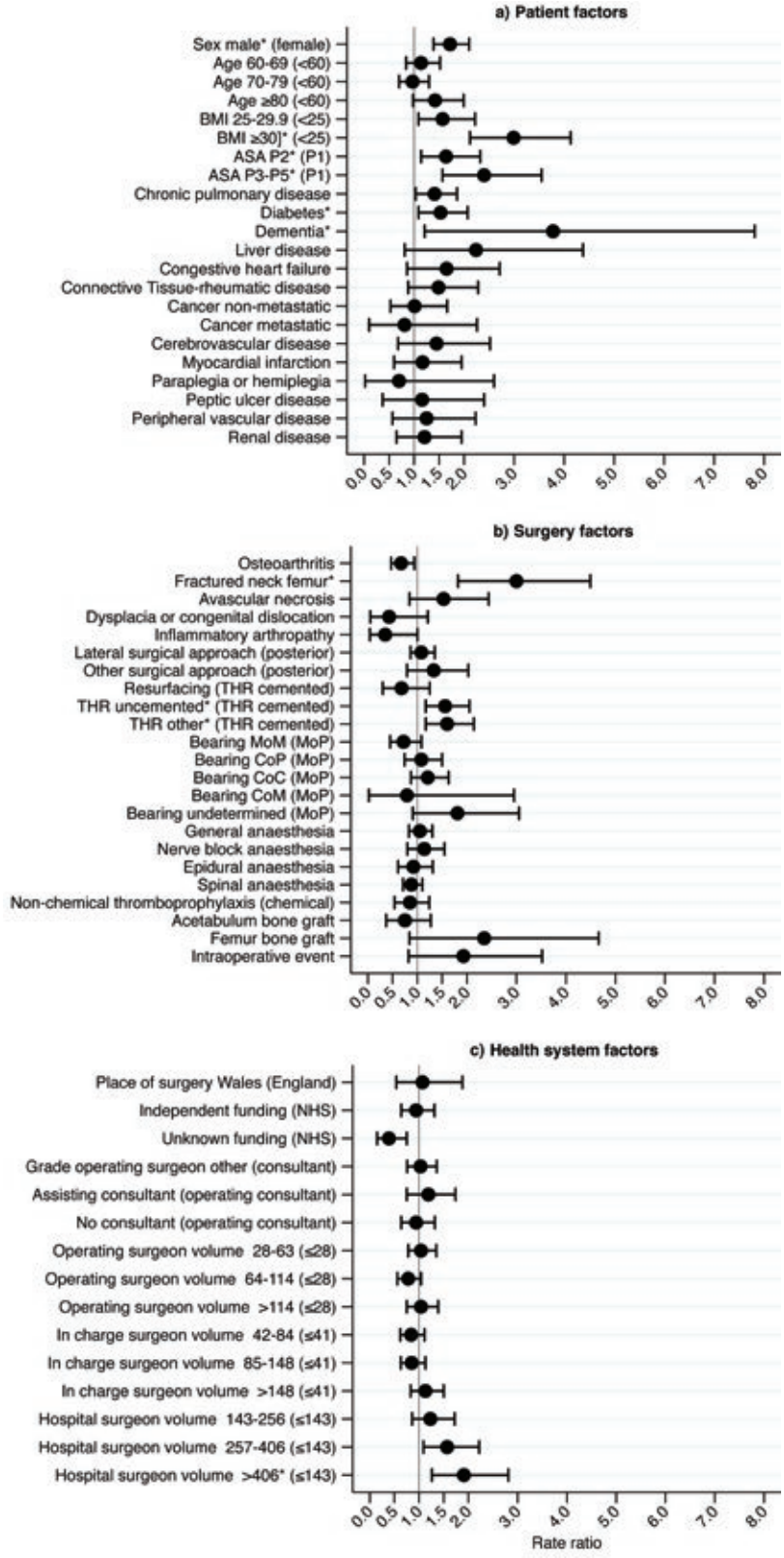
A weak association with surgeon volume was seen with operating surgeons who had performed more than 63 procedures in the preceding 12 months having a lower risk than those who had performed less. This pattern was inconsistent over time. The volume of the surgeon in charge had no effect. For hospitals performing more than 255 hip replacements in the 12 months prior to the procedure, the risk of revision for PJI in the first three months was higher.

Figure 3.37 Risk factors of revision for prosthetic joint infection during the overall post-operative period.



*Adjusted p value <0.05.

Figure 3.38 Risk factors of revision for prosthetic joint infection in the first three post-operative months.



*Adjusted p value <0.05.

Conclusion

This study is the largest and most comprehensive investigation to date of patient, surgical, and healthcare related factors and their association with risk for revision for PJI of the hip. Several modifiable and non-modifiable factors were shown to be associated with the risk of revision for a PJI after a primary hip replacement. The problem is multifactorial, mainly driven by patient and surgical level factors with time-varying effects. The modifiable factors identified in this study should be considered by clinicians in their practice to develop targeted interventions or optimisation strategies to reduce risk. Of equal importance is for clinicians to consider the non-modifiable factors and the factors that exhibit time-specific effects on the risk of PJI, to counsel patients appropriately pre-operatively.

3.8.6 Assessing the non-inferiority of prosthesis constructs used in hip and knee replacements

Full paper details:

Posts of members of the research team were funded by a contract grant from the NJR. These studies were also supported by the NIHR Biomedical Research Centre at the University Hospitals Bristol NHS Foundation Trust and the University of Bristol. Adrian Sayers was funded by an MRC Strategic Skills Fellowship MR/L01226X/1. Both papers are open-access (CC BY 4.0 licence) and as such some data is reproduced unchanged here.

Assessing the non-inferiority of prosthesis constructs used in hip replacement using data from the National Joint Registry of England, Wales, Northern Ireland and the Isle of Man: a benchmarking study.

Deere KC, Whitehouse MR, Porter M, Blom AW, Sayers A.

BMJ Open 2019;9:e026685. DOI: http://dx.doi.org/10.1136/bmjopen-2018-026685

Assessing the non-inferiority of prosthesis constructs used in total and unicondylar knee replacements using data from the National Joint Registry of England, Wales, Northern Ireland and the Isle of Man: a benchmarking study.

Deere KC, Whitehouse MR, Porter M, Blom AW, Sayers A.

BMJ Open 2019;9:e026736. DOI: http://dx.doi.org/10.1136/bmjopen-2018-026736

Background

Hip and knee replacement are clinically and cost-effective interventions, predominantly used to treat end stage degeneration of conditions that affect joints, such as osteoarthritis. Despite the success of the operations, there is variation in performance and one of the functions of the NJR is to monitor implants for poor performance. This has traditionally focused on identifying implants that perform worse than others by a certain amount.

The NJR annual reports highlight the revision rates for hip and knee replacement year on year and it can be seen that in both hip and knee replacements, there has been a decrease in revision rates since 2008/9 suggesting improving outcomes. This means that benchmarks previously set may not be as relevant now as they once were. The increasing numbers of joint replacement in the NJR also allows us to explore details of the constructs that are made when joint replacements are performed; the individual parts are not independent of each other so need to be considered as a whole.

When considering what revision rate outcomes should be compared to, most patients and clinicians would like to be sure that they are receiving one of the best performing options or at least one that is not substantially worse. In order to be sure of the results, there need to be enough cases to analyse for the estimates to be precise enough to draw reliable conclusions. The data presented should also be relevant to the patient making the decision or the patient the clinician is advising and therefore it is important to understand if the results apply to patients of a particular age and gender.

Methods and sources

Using a non-inferiority analysis, the performance of the most widely used hip and knee constructs were compared to the best performing contemporary constructs. Hip constructs were sub-divided by brand, stem, cup and bearing surface. In a separate analysis knee brands were defined by fixation, bearing and constraint.

Hip and knee constructs were identified using NJR data from its inception in April 2003 through to the end of December 2016.

Construct failure was estimated using the 1-Kaplan-Meier method. The Kaplan-Meier estimates, an estimate of net failure, were compared to failure of the best performing construct at 3, 5, 7 and 10 years after the primary procedure. Comparisons were also made, at the same time points, stratified by gender and again by gender and age group. Groups of interest were defined by a construct being non-inferior to the best performing construct with at least 1,000 cases at risk at the time of interest, those with revision rates at least 20% higher (lower confidence interval greater than 20% margin) and those at least 100% worse.

Results

There were 797,178 primary hip procedures included in our analysis. We identified 4,442 different prosthesis construct combinations with at least one use recorded in the NJR. Of these, only 134 constructs had ≥500 procedures at risk at three years. Of these constructs, 44 were shown to be inferior to the best performing construct by at least 100% relative risk. At ten years there were 26 prosthesis constructs with ≥500 procedures at risk. Twelve constructs were inferior to the best performing construct by at least 20% relative risk, one inferior by at least 100%. Similar patterns in performance were seen across all stratifications of our hip analysis.

Figure 3.39 Difference in failure of implanted hip constructs compared with a contemporary reference at ten years, using all stem-cup combinations with ≥500 procedures remaining at risk.

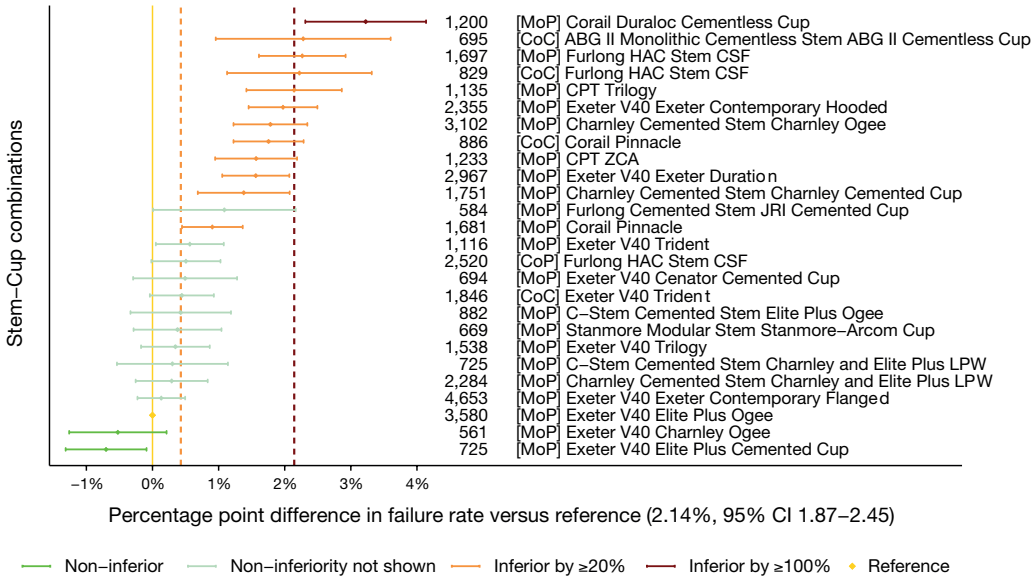
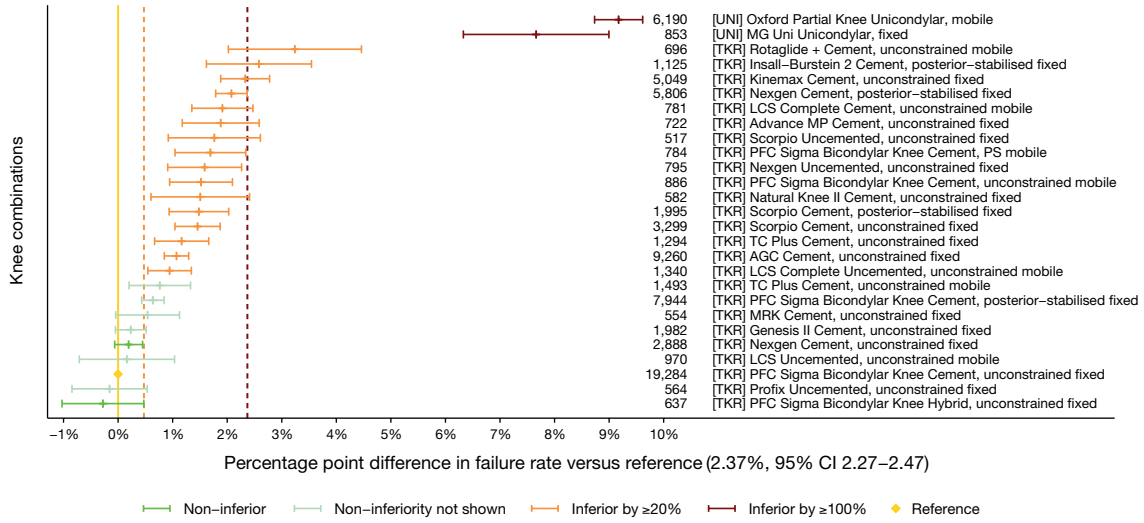


Figure 3.40 Difference in cumulative revision of knee constructs with a contemporary benchmark at ten years, using all total knee and unicondylar replacements with ≥500 procedures remaining at risk.



There were 947,686 primary knee procedures included in our knee analysis, utilising 449 different combinations of brand, fixation, constraint and bearing type. By ten years only 27 different constructs had ≥500 procedures at risk, 18 of which were classified as inferior to the benchmark by at least 20% relative risk of failure. Stratification by gender and age-group revealed similar results by men and women. At seven years in women aged 55–75 years, there were 32 different constructs with ≥500 cases with eight being classified as inferior by at least 20% relative risk. Similarly, in men, there were 27 constructs with ≥500 cases, twelve of which were classified as inferior by at least 20% relative risk.

Figure 3.41 Difference in cumulative revision of knee constructs compared with a contemporary benchmark at seven years in **women** aged between 55 and 75 years, using all total knee and unicondylar replacements with ≥500 procedures remaining at risk.

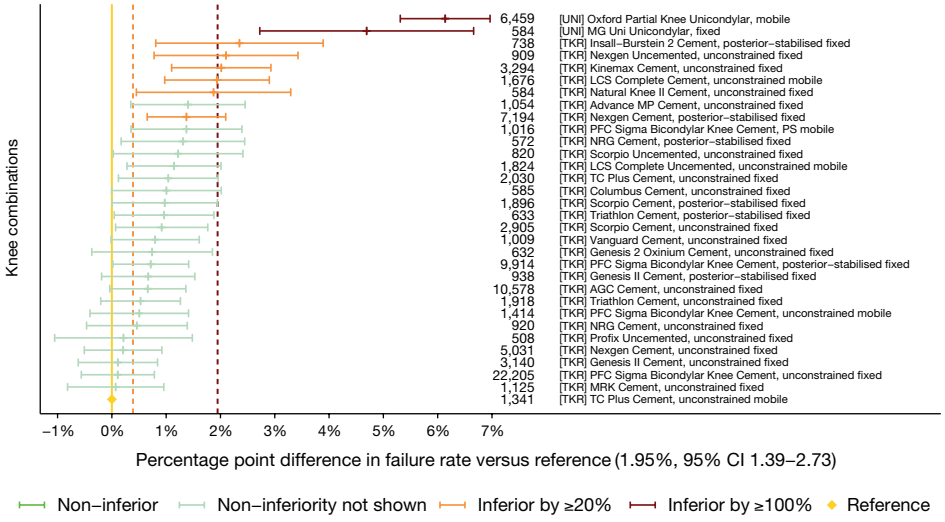
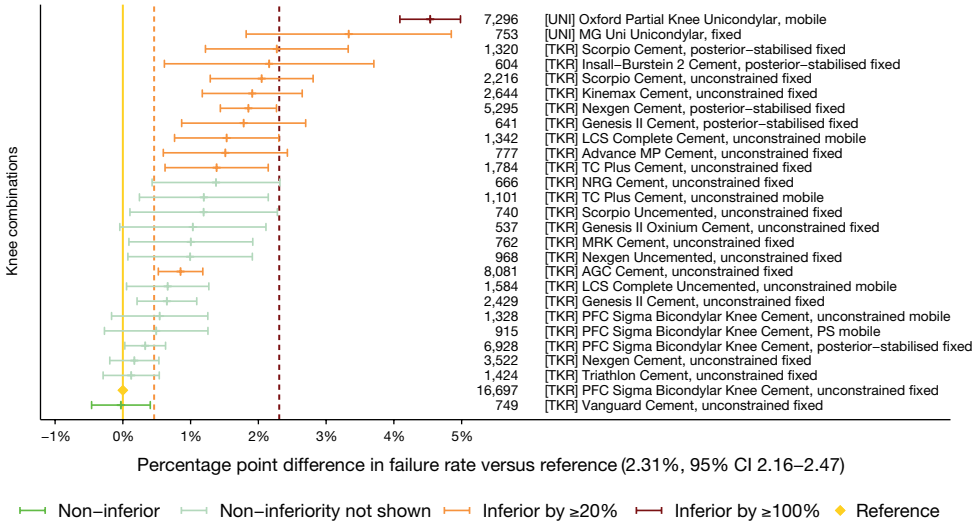


Figure 3.42 Difference in cumulative revision of knee constructs compared with a contemporary benchmark at seven years in **men** aged between 55 and 75 years, using all total knee and unicondylar replacements with ≥500 procedures remaining at risk.



Discussion

These results demonstrate that there is great variability in construct performance. Despite the large number of procedures in these analyses, few prosthesis constructs in each age/gender strata have ≥500 procedures to analyse at any given time point.

In the hip analysis we found that some well-used stems had a wide range of net-failure estimates depending on which acetabular prosthesis they were paired with. The heterogeneity of stem and cup pairing and the subsequent variation in performance is an apt illustration of the need to benchmark constructs as opposed to individual implants which make up the construct.

Our knee analysis has shown that very few knee brand constructs can be demonstrated to be non-inferior to the best performing constructs. The vast majority of constructs have been implanted in too few cases to allow for meaningful analysis.

Whilst the absolute level of failure of commonly used constructs is relatively low, less than 5% in many cases, many of the most widely used constructs have been shown to be inferior to the best performing construct despite achieving the highest reliability rating (a rating of 10A* by ODEP). This raises questions about whether an externally defined and placed benchmark is the optimal way to guide the choice of hip and knee replacements and achieve the lowest revision rates. Revision is only one of the outcomes of interest following joint replacement but along with data on mortality, pain relief, patient reported outcomes and cost effectiveness it is one of the important outcomes to consider.

Conclusion

Product benchmarking has the potential to be highly informative for patients, change the practice of surgeons and influence policy-makers if presented clearly and unambiguously. We are unable to definitively state which constructs are the best choice for all patients, due to selection and confounding. The information presented here illustrates the variability, frequency and performance of different constructs currently used in clinical practice which, in turn, should be used to further inform the consenting process between the patient and the surgeon and to facilitate implant selection.

Part 4

Implant and unit-level activity and outcomes

Part Four of the annual report gives performance and data entry quality indicators for Trusts and Local Health Boards (many of whom comprise more than one hospital) and independent (private) providers in England, Wales, Northern Ireland and the Isle of Man for the 2018 calendar year. Outcomes analysis after hip and knee replacement surgery is also provided for the period 2009 to 2019.

This section now also provides data for implant outliers since 2003 and further information on notification and last usage date.

The full analysis for units can be found in the Part Four online document which is available in the downloads section at www.njrreports.org.uk

4.1 Implant performance

The Implant Scrutiny Committee reports Level 1 outlier implants to the MHRA. Since the committee's formation in 2009 there have been four hip stems, nine hip acetabular (cup) components and 28 hip stem/cup combinations reported. Seven knee brands have been notified.

An implant is considered to be a Level 1 outlier when its Prosthesis Time Incident Rate (PTIR) is more than twice the PTIR of the group, allowing for confidence intervals. These are shown as the number of revisions per 100 prosthesis-years. As of March 2015, we have started to identify the best performing implants, these would have a PTIR less than half that of their group, allowing for confidence intervals. To date no implants have reached that level.

Components and constructs previously reported to MHRA, but no longer at Level 1, are not listed.

Hip implant performance

Table 1 Level 1 outlier stems/femoral components reported to MHRA.

Stem/femoral component name	Numbers implanted	Latest PTIR	Notified as outlier	Last implanted
ASR	2,924	2.8	2010	July 2010
Corin Proxima	105	2.28	2011	September 2009
S-ROM Cementless stem	3,256	1.38	2013	Still in use
Adept Cementless stem	227	1.93	September 2017	November 2010

Table 2 Level 1 outlier acetabular components reported to MHRA.

Cup name	Numbers implanted	Latest PTIR	Notified as outlier	Last implanted
ASR	6,255	3.95	2010	July 2010
Ultima MoM cup	193	1.81	2010	December 2006
seleXys TH+	184	1.87	June 2018	April 2011
M2A38	1,484	1.79	2014	June 2011
R3 with metal liner	150	3.20	2011	December 2011
Pinnacle with metal liner	15,558	1.37	2018	May 2013
Delta One TT	344	1.73	2015	Still in use
Trabecular Metal Revision Shell	320	1.65	2017	Still in use

Table 3 Level 1 outlier stem/cup combinations.

Combination	Numbers implanted	Latest PTIR	Notified as outlier	Last implanted
ASR Resurfacing Head / ASR Resurfacing Cup	2,914	2.79	2010	July 2010
Metafix Stem / Cormet 2000 Resurfacing Cup	173	2.69	2010	February 2011
CPT / Adept Resurfacing Cup	268	3.26	2011	May 2010
Corail / ASR Resurfacing Cup	2,729	5.36	2011	June 2010
CPT / BHR Resurfacing Cup	116	2.52	2011	September 2010
Accolade / Mitch TRH Cup	274	2.63	2011	January 2011
Summit Cementless Stem / ASR Resurfacing Cup	128	4.67	2012	August 2009
CPT / Durom Resurfacing Cup	184	2.38	2012	September 2009
S-Rom Cementless Stem / ASR Resurfacing Cup	147	4.03	2012	February 2010
CPCS / BHR Resurfacing Cup	255	1.45	2012	May 2010
Anthology / BHR Resurfacing Cup	510	3.00	2012	August 2011
SL-Plus Cementless Stem / Cormet 2000 Resurfacing Cup	627	2.22	2013	April 2010
Profemur L Modular / Conserve Plus Resurfacing Cup	159	2.64	2013	June 2010
Bimetric Cementless Stem / M2A 38	1,302	1.83	2014	June 2011
Corin Proxima / Cormet 2000 Resurfacing Cup	102	2.37	2015	September 2009
Synergy Cementless Stem / BHR Resurfacing Cup	1,584	1.96	2016	May 2011
Adept Cementless Stem / Adept Resurfacing Cup	200	2.38	2017	November 2010
Taperloc Cementless Stem / Apollo	147	1.81	2017	February 2018
Exeter V40 / Trabecular Metal Revision Shell	172	1.88	2017	December 2017
CLS Cementless Stem / Adept Resurfacing Cup	218	2.67	2017	March 2011
Spectron / Opera	216	1.02	2018	February 2014
Exeter V40 / Mitch	121	1.34	October 2018	October 2010
Twinsys Cementless Stem / Adept Resurfacing Cup	130	2.05	October 2018	January 2010
CLS Spotorno Cementless Stem / Durom Resurfacing Cup	929	1.57	October 2018	May 2012
CPT / Exceed ABT Cemented	993	1.47	2017	Still in use
S-Rom Cementless Stem / Pinnacle	1,983	1.41	October 2018	Still in use

Best performing hip implants

There are no hip implants or combinations performing statistically less than half their expected PTIR.

Knee implant performance

Table 4 Level 1 outlier implants reported to MHRA. All of these implants have been discontinued.

Knee brand	Numbers implanted	Latest PTIR	Notified as outlier	Last implanted
JRI Bicondylar Knee	247	1.75	2009	November 2008
Tack	231	1.74	2009	August 2008
St Leger	104	1.65	2011	August 2005
Journey Deuce	151	2.81	2014	June 2013
SLK Evo	103	1.77	2016	April 2013
ACS	198	1.82	2017	March 2017
Journey Oxinium	825	1.09	2017	January 2014

Best performing knee implants

There are no knee implants performing statistically less than half their expected PTIR.

4.2 Clinical activity

Overall in 2018, 145 NHS Trusts and Local Health Boards (comprising 250 separate hospitals) and 181 independent hospitals were open and eligible to report patient procedures to the NJR. All units except for two NHS trauma units and one newly opened independent unit submitted data in 2018. The proportion of all hip and knee joint replacements entered into the NJR compared to those entered in HES, is only available by NHS Trust. No data on this is currently available from private providers and figures also exclude units in Northern Ireland as compliance data is not available. Unfortunately finalised compliance figures for Local Health Boards in Wales were not available at time of publication.

- 56.7% of NHS providers in England reported 95% or more of the joint replacements they undertook
- 30.6% of NHS providers in England reported between 80% and 95%
- 12.7% of NHS providers in England reported less than 80%

Of those hospitals submitting data, the proportion of patients who gave permission (consent) for their details to be entered into the NJR were:

NHS hospitals

- 41.1% of NHS hospitals achieved a consent rate of greater than 95%
- 37.9% achieved a consent rate of 80% to 95%
- 21.0% recorded a consent rate of less than 80%

Independent hospitals

- 63.$\dot{3}$% of independent hospitals achieved a consent rate greater than 95%
- 28.$\dot{3}$% achieved a consent rate of 80% to 95%
- 8.$\dot{3}$% recorded a consent rate of less than 80%

There has been a drop in recorded consent for all submitting units when compared to the previous year, with those achieving a higher than 95% rate falling from 55% to 50%. The proportion of all units achieving a higher than 80% consent rate remains consistent and fell by only 1% to 84% in 2018.

Similarly, the proportion of entries in which there is significant data to enable the patient to be linked to an NHS number (linkability) are listed opposite.

NHS hospitals

- 83% achieved a proportion of patients with a linkable NHS number greater than 95%
- 15% achieved a proportion of 80% to 95%
- 2% recorded a proportion of less than 80%

Independent hospitals

- 77% achieved a proportion of patients with a linkable NHS number greater than 95%
- 17% achieved a proportion of 80% to 95%
- 6% recorded a proportion of less than 80%

There has been a drop in linkability from 2017, with the percentage of submitting units achieving over 95% in 2018 falling from 85% to 81%. The proportion achieving a greater than 80% linkability rate is relatively consistent with an overall drop of 1% in 2018.

Note: Independent hospitals might be expected to have lower linkability rates than NHS hospitals, as a proportion of their patients may come from overseas and do not have an NHS number.

4.3 Outlier units for 90-day mortality and revision rates for the period 2009 to 2019

The observed numbers of revisions of hip and knee replacements for each hospital were compared to the numbers expected, given the unit's case-mix in respect of age, gender and reason for primary surgery. Hospitals with a much higher than expected revision rate for hip and knee replacement have been identified. These hospitals had a revision rate that was above the upper of the 99.8% control limits (these limits approximate to +/-3 standard deviations). We would expect 0.2% (i.e. one in 500) to lie outside the control limits by chance, with approximately half of these (one in 1,000) to be above the upper limit.

When examined over the past ten years of the registry, a total of 39 hospitals reported higher than expected rates of revision for knee replacement, and 26 hospitals had higher than expected rates of revision for hip surgery. However, revisions taken only from the last five years of the registry showed only 18 hospitals reporting higher than expected rates for knees, and ten for hips.

The 90-day mortality for primary hip and knee replacement was calculated using the last five years of data for all hospitals by plotting standardised mortality ratios for each hospital against the expected number of deaths. No hospitals had higher than expected mortality rates for either hip or knee replacement.

Note: The case mix for mortality includes age, gender and ASA grade. Trauma cases have been excluded from both the hip and knee mortality analyses together with hips implanted for failed hemi-arthroplasty or for metastatic cancer (the latter only from November 2014 when recording of this reason began). Also, where both left and right side joints were implanted on the same day, only one side was included in the analysis.

Note: Any units identified as potential outliers in Part Four have been notified. All units are provided with an Annual Clinical Report and additionally have access to an online NJR Management Feedback system.

Important note about the outlier hospitals listed

In earlier annual reports, the NJR reported outlying hospitals based on all cases submitted to the NJR since 1 April 2003. To reflect changes in hospital practices and component use, the NJR now reports outlying hospitals based on the last ten years (13 February 2009 to 14 February 2019) and five years of data (13 February 2014 to 14 February 2019 inclusive, the latter date being when the dataset was cut). These cuts of data exclude the majority of withdrawn outlier implants and metal-on-metal total hip replacements from analysis, and thus better represent contemporary practice.

Outliers for Hip mortality rates since 2014[1]
None identified

Outliers for Knee mortality rates since 2014[1]
None identified

Outliers for Hip revision rates, all linked primaries from 2009[1]
Ashtead Hospital (Surrey)
Basingstoke and North Hampshire Hospital
BMI Clementine Churchill Hospital (Middlesex)
BMI Esperance (East Sussex)
BMI The Meriden Hospital (West Midlands)
Clifton Park Hospital (North Yorkshire)
Fitzwilliam Hospital (Cambridgeshire)
Homerton University Hospital
KIMS Hospital (Kent)
Milton Keynes Hospital
Musgrove Park Hospital
North Downs Hospital (Surrey)
Northampton General Hospital (Acute)
Nuffield Health Brighton Hospital (East Sussex)
Ormskirk and District General Hospital
Prince Charles Hospital
Salisbury District Hospital
Shepton Mallet Treatment Centre (Somerset)
Southampton General Hospital
Spire Southampton Hospital (Hampshire)
St Richard's Hospital
Sussex Orthopaedic NHS Treatment Centre
Wansbeck Hospital
Watford General Hospital
Weston General Hospital
Wrexham Maelor Hospital

Outliers for Hip revision rates, all linked primaries from 2014[2]
BMI Bishops Wood Hospital (Middlesex)
Fitzwilliam Hospital (Cambridgeshire)
Milton Keynes Hospital
Nuffield Health Cheltenham Hospital (Gloucestershire)
Ormskirk and District General Hospital
Southampton General Hospital
Spire Hartswood Hospital (Essex)
St Richard's Hospital
Wansbeck Hospital
Weston General Hospital

Note: 1 Date range 13 February 2009 to 14 February 2019 inclusive.
2 Date range 13 February 2014 to 14 February 2019 inclusive.

Outliers for Knee revision rates, all linked primaries from 2009[1]
Ashford Hospital
Basingstoke and North Hampshire Hospital
BMI Bishops Wood Hospital (Middlesex)
BMI Goring Hall Hospital (West Sussex)
BMI Princess Margaret (Berkshire)
BMI The London Independent Hospital (Greater London)
BMI The Meriden Hospital (West Midlands)
Broadgreen Hospital
Charing Cross Hospital
County Hospital Louth
Diana Princess of Wales Hospital
Ealing Hospital
Grantham and District Hospital
Guy's Hospital
Heatherwood Hospital
Hinchingbrooke Hospital
Homerton University Hospital
Horton NHS Treatment Centre (Oxfordshire)
King Edward VII Hospital Sister Agnes (Greater London)
Llandough Hospital
Nevill Hall Hospital
New Hall Hospital (Wiltshire)
Nottingham City Hospital
Nuffield Health Chichester Hospital (West Sussex)
Peterborough City Hospital
South Tyneside District Hospital
Southampton General Hospital
Southampton NHS Treatment Centre (Hampshire)
Southmead Hospital
Spire Hull and East Riding Hospital (East Yorkshire)
Spire Southampton Hospital (Hampshire)
St Albans City Hospital
St Mary's Hospital
St Richard's Hospital
Sussex Orthopaedic NHS Treatment Centre
University College Hospital
University Hospital Aintree
West Cumberland Hospital
York Hospital

Outliers for Knee revision rates, all linked primaries from 2014[2]
Barlborough NHS Treatment Centre (Derbyshire)
BMI Bath Clinic (Avon)
BMI The Meriden Hospital (West Midlands)
BMI The South Cheshire Private Hospital (Cheshire)
Guy's Hospital
Heatherwood Hospital
King Edward VII Hospital Sister Agnes (Greater London)
Leighton Hospital
Lister Hospital
Nuffield Health Chichester Hospital (West Sussex)
Southmead Hospital
Spire Hull and East Riding Hospital (East Yorkshire)
Spire Southampton Hospital (Hampshire)
Springfield Hospital (Essex)
St Mary's Hospital
St Richard's Hospital
Sussex Orthopaedic NHS Treatment Centre
Winfield Hospital (Gloucestershire)

Note: 1 Date range 13 February 2009 to 14 February 2019 inclusive.
2 Date range 13 February 2014 to 14 February 2019 inclusive.

4.4 Better than expected performance

This year we have again listed hospitals where revision rates are statistically better than expected. The lists here show units that lie below the 99.8% control limit which also achieved greater than 90% compliance in the 2015/16 NJR data quality audit. Units with lower data quality compliance are automatically excluded from these lists.

Better than expected for Hip revision rates, all linked primaries from 2009[1]
Calderdale Royal Hospital
Emersons Green NHS Treatment Centre (Avon)
Ipswich Hospital
Luton and Dunstable Hospital
Musgrave Park Hospital
Nuffield Health Derby Hospital (Derbyshire)
Nuffield Health Exeter Hospital (Devon)
Queen Alexandra Hospital
Queen's Hospital Burton Upon Trent
Queen's Medical Centre Nottingham University Hospital
Royal Derby Hospital
Royal Devon and Exeter Hospital (Wonford)
Royal Stoke University Hospital
Royal Surrey County Hospital
Russells Hall Hospital

Better than expected for Hip revision rates, all linked primaries from 2014[2]
BMI Alexandra Hospital Cheadle (Cheshire)
Calderdale Royal Hospital
Emersons Green NHS Treatment Centre (Avon)
Ipswich Hospital
Musgrave Park Hospital
Royal Devon and Exeter Hospital (Wonford)
Royal Surrey County Hospital

Better than expected for Knee revision rates, all linked primaries from 2009[1]
Bishop Auckland Hospital
BMI Priory Hospital (West Midlands)
City Hospital
Colchester General Hospital
Hexham General Hospital
Ipswich Hospital
Musgrave Park Hospital
Norfolk and Norwich Hospital
North Tyneside General Hospital
Nottingham Woodthorpe Hospital (Nottinghamshire)
Nuffield Health Derby Hospital (Derbyshire)
Nuffield Health Ipswich Hospital (Suffolk)
Princess Alexandra Hospital
Royal Derby Hospital
Stepping Hill Hospital
Worcestershire Royal Hospital
Wrightington Hospital

Better than expected for Knee revision rates, all linked primaries from 2014[2]
Hexham General Hospital
Musgrave Park Hospital
Stepping Hill Hospital

Note: 1 Date range 13 February 2009 to 14 February 2019 inclusive.
2 Date range 13 February 2014 to 14 February 2019 inclusive.

Glossary

A	
Acetabular component	The portion of a total hip replacement prosthesis that is inserted into the acetabulum – the socket part of a ball and socket joint.
Acetabular cup	See Acetabular component.
Acetabular prosthesis	See Acetabular component.
Antibiotic-loaded bone cement	See cement.
Arthrodesis	A procedure where the bones of a natural joint are fused together (stiffened).
Arthroplasty	A procedure where a natural joint is reconstructed with an artificial prosthesis.
ABHI	Association of British HealthTech Industries – the UK trade association of medical device suppliers.
ALVAL	Aseptic Lymphocyte-dominated Vasculitis-Associated Lesion. This term is used in the Annual Report to describe the generality of adverse responses to metal debris, but in its strict sense refers to the delayed type-IV hypersensitivity response.
ASA	American Society of Anaesthesiologists scoring system for grading the overall physical condition of the patient, as follows: P1 – fit and healthy; P2 – mild disease, not incapacitating; P3 – incapacitating systemic disease; P4 – life threatening disease; P5 – expected to die within 24 hrs without an operation.
B	
Bearing type	The two surfaces that articulate together in a joint replacement. Options include metal-on-polyethylene, metal-on-metal, ceramic-on-polyethylene, ceramic-on-metal and ceramic-on-ceramic.
Beyond Compliance	A system of post market surveillance initiated in 2013. Under this system a scrutiny committee closely monitors the usage and performance of implants which are new to the market in order that any problems may be quickly identified and that the necessary corrective actions are undertaken in order to protect patient safety.
Bilateral operation	Operation performed on both sides, e.g. left and right knee procedures, carried out on the same day.
BMI	Body mass index. A statistical tool used to estimate a healthy body weight based on an individual's height. The BMI is calculated by dividing a person's weight (kg) by the square of their height (m^2).
BOA	British Orthopaedic Association – the professional body representing orthopaedic surgeons.
Bone cement	See cement.
Brand (of prosthesis)	The brand of a prosthesis (or implant) is the manufacturer's product name, e.g. the Exeter V40 brand for hips, the PFC Sigma brand for knees, the Zenith brand for ankles, the Delta Xtend brand for shoulders and the Coonrad Morrey for elbows.
C	
CQC	Care Quality Commission. Regulators of care provided by the NHS, local authorities, private companies and voluntary organisations.
Case ascertainment	Proportion of all relevant joint replacement procedures performed in England, Wales, Northern Ireland and the Isle of Man that are entered into the NJR.
Case mix	Term used to describe variation in surgical practice, relating to factors such as indications for surgery, patient age and gender.
Cement	The material used to fix cemented joint replacements to bone – polymethyl methacrylate (PMMA). Antibiotic can be added to bone cement to try and reduce the risk of infection.
Cemented	Prostheses designed to be fixed into the bone using cement.
Cementless	Prostheses designed to be fixed into the bone by bony ingrowth or ongrowth, without using cement.
Compliance	The percentage of all total joint procedures that have been entered into the NJR within any given period compared with the expected number of procedures performed. The expected number of procedures is based on the number of procedures submitted to HES and PEDW.

Confidence Interval (CI)	A 'Confidence Interval' (CI) is calculated to accompany anything being estimated from just a random sample of cases, for example the cumulative probability of revision; a CI tells us something about the range of values that the 'true' (population) value can take. Whilst calculated Confidence Intervals by their very nature will vary from sample to sample, calculation of a '95% Confidence Interval' (95% CI) means that 95% of all such calculated intervals should actually contain the 'true' value.
Confounding	Can occur when an attempt to quantify how a particular variable of interest affects outcome is hampered by another variable(s) being related to both the variable of interest and the outcome. For example a comparison of the revision rates between two distinct types of implant may be hampered by the fact that one implant has been used on an older group of patients than the other; age here is a 'confounder' for the relationship between implant type and outcome because revision rate also depends on age. Statistical methods may help to 'adjust' for such confounding variables.
Cox 'proportional hazards' model	A type of multivariable regression model used in survival analysis to look at the simultaneous effects of a number of variables ('predictors') on outcome (first revision or death). The effect of each variable is adjusted for the effects of all the other 'predictor' variables in the model so the Cox model can be used to adjust for 'confounders' (see above). Some regression models used in survival modelling make assumptions about the way the hazard rate changes with time (see 'hazard rate'). The Cox model doesn't make any assumptions about how the hazard rate changes however it does assume that the predictor variables affect the hazard rates in a 'proportional' way; the latter requiring some careful model checking when this method is used.
Cross-linked polyethylene	See modified polyethylene.
Cumulative Incidence Function (CIF)	A different way of estimating failure compared to Kaplan-Meier, see Kaplan-Meier. Also known as observed or crude failure, as the estimate reflects what is seen in practice.
Cup	See Acetabular component.
D	
Data collection periods for annual report analysis	The NJR Annual Report Part One reports on data collected between 1 April 2018 and 31 March 2019 – the 2018/19 financial year. The NJR Annual Report Parts Two and Four analyse data on hip, knee, ankle, elbow, and shoulder procedures undertaken between 1 January and 31 December 2018 inclusive – the 2018 calendar year. The NJR Annual Report Part Three reports on hip, knee, ankle and shoulder and elbow joint replacement revision rates for procedures that took place between 1 April 2003 and 31 December 2018.
DAIR	Debridement And Implant Retention. In cases of infection, the surgeon may debride (surgically clean) the surgical site and retain the joint replacement implants.
DAIR with Modular Exchange	Debridement And Implant Retention with Modular Exchange. In cases of infection where the implants are modular, the surgeon may debride (surgically clean) the surgical site, exchange the modular components (e.g. head, acetabular liner) and retain the non-modular joint replacement implants.
DDH	Developmental dysplasia of the hip. A condition where the hip joint is malformed, usually with a shallow socket (acetabulum), which may cause instability.
DH	Department of Health.
DVT	Deep vein thrombosis. A blood clot that can form in the veins of the leg and is recognised as a significant risk after joint replacement surgery.

E	
Episode	An event involving a patient procedure such as a primary or revision total prosthetic replacement. An episode can also consist of two consecutive procedures, e.g. a stage one of two-stage revision, followed by a stage two of two-stage revision.
Excision arthroplasty	A procedure where the articular ends of the bones are simply excised, so that a gap is created between them, or when a joint replacement is removed and not replaced by another prosthesis.
F	
Femoral component (hip)	Part of a total hip joint that is inserted into the femur (thigh bone) of the patient. It normally consists of a stem and head (ball).
Femoral component (knee)	Portion of a knee prosthesis that is used to replace the articulating surface of the femur (thigh bone).
Femoral head	Spherical portion of the femoral component of the artificial hip replacement.
Femoral prosthesis	Portion of a total joint replacement used to replace damaged parts of the femur (thigh bone).
Femoral stem	The part of a modular femoral component inserted into the femur (thigh bone). It has a femoral head mounted on it to form the complete femoral component.
Funnel plot	A graphical device to compare unit or surgeon performance. Measures of performance (e.g. a ratio of number of observed events to the expected number based on case-mix) are plotted against an interpretable measure of precision. Control limits are shown to indicate acceptable performance. Points outside of the control limits suggest 'special cause' as opposed to 'common cause' variation (see for example D Spiegelhalter, Stats in Medicine, 2005).
G	
Glenoid component	The portion of a total shoulder replacement prosthesis that is inserted into the scapula – the socket part of a ball and socket joint in conventional shoulder replacement or the ball part in reverse shoulder replacement.
H	
Hazard rate	Rate at which 'failures' occur at a given point in time after the operation conditional on 'survival' up to that point. In the case of first revision, for example, this is the rate at which new revisions occur in those previously unrevised.
Head	See Femoral head and/or Humeral head.
Healthcare provider	NHS or independent sector organisation that provides healthcare; in the case of the NJR, orthopaedic hip, knee, ankle, elbow or shoulder replacement surgery.
HES	Hospital Episode Statistics. Data on case mix, procedures, length of stay and other hospital statistics collected routinely by NHS hospitals in England.
HQIP	Healthcare Quality Improvement Partnership. Manages the NJR on behalf of NHS England. Promotes quality in health and social care services and works to increase the impact that clinical audit has nationally.
Humeral component (elbow/distal)	Part of a total elbow joint that is inserted into the humerus (upper arm bone) of the patient to replace the articulating surface of the humerus.
Humeral component (shoulder/proximal)	Part of a total or partial shoulder joint that is inserted into the humerus (upper arm bone) of the patient. It normally consists of a humeral stem and head (ball) in conventional shoulder replacement or a humeral stem and a humeral cup in a reverse shoulder replacement.
Humeral head	Domed head portion of the humeral component of the artificial shoulder replacement attached to the humeral stem.
Humeral prosthesis	Portion of a total joint replacement used to replace damaged parts of the humerus (upper arm bone).
Humeral stem	The part of a modular humeral component inserted into the humerus (upper arm bone). Has a humeral head or humeral cup mounted on it to form the complete humeral component.
Hybrid procedure	Joint replacement procedure in which cement is used to fix one prosthetic component while the other is cementless. For hip procedures, the term hybrid covers both reverse hybrid (cementless stem, cemented socket) and hybrid (cemented stem, cementless socket).

I	
Image/computer-guided surgery	Surgery performed by the surgeon, using real-time images and data computed from these to assist alignment and positioning of prosthetic components.
Independent hospital	A hospital managed by a commercial company that predominantly treats privately-funded patients but does also treat NHS-funded patients.
Index joint	The primary joint replacement that is the subject of an NJR entry.
Indication (for surgery)	The reason for surgery. The NJR system allows for more than one indication to be recorded.
ISTC	Independent sector treatment centre (see Treatment centre).
K	
Kaplan-Meier	Used to estimate the cumulative probability of 'failure' at various times from the primary operation, also known as Net Failure. 'Failure' may be either a first revision or a death, depending on the context. The method properly takes into account 'censored' data. Censorings arise from incomplete follow-up; for revision, for example, a patient may have died or reached the end of the analysis period (end of 2018) without having been revised.
L	
Lateral resurfacing (elbow)	Partial resurfacing of the elbow with a humeral surface replacement component used with a lateral resurfacing head inserted with or without cement.
Linkable percentage	Linkable percentage is the percentage of all relevant procedures that have been entered into the NJR, which may be linked via NHS number to other procedures performed on the same patient.
Linkable procedures	Procedures entered into the NJR database that are linkable to a patient's previous or subsequent procedures by the patient's NHS number.
Linked total elbow	Where the humeral and ulnar parts of a total elbow replacement are physically connected.
LHMoM	Large head metal-on-metal. Where a metal femoral head of 36mm diameter or greater is used in conjunction with a femoral stem, and is articulating with either a metal resurfacing cup or a metal liner in a modular acetabular cup. Resurfacing hip replacements are excluded from this group.
LMWH	Low molecular weight Heparin. A blood-thinning drug used in the prevention and treatment of deep vein thrombosis (DVT).
M	
MDS	Minimum dataset, the set of data fields collected by the NJR. Some of the data fields are mandatory (i.e. they must be filled in). Fields that relate to patients' personal details must only be completed where informed patient consent has been obtained.
MDSv1	Minimum dataset version one, used to collect data from 1 April 2003. MDS version one closed to new data entry on 1 April 2005.
MDSv2	Minimum dataset version two, introduced on 1 April 2004. MDS version two replaced MDS version one as the official dataset on 1 June 2004.
MDSv3	Minimum dataset version three, introduced on 1 November 2007 replacing MDSv2 as the new official dataset.
MDSv4	Minimum dataset version four, introduced on 1 April 2010 replacing MDSv3 as the new official dataset. This dataset has the same hip and knee MDSv3 dataset but includes the data collection for total ankle replacement procedures.
MDSv5	Minimum dataset version five, introduced on 1 April 2012 replacing MDSv4 as the new official dataset. This dataset has the same hip, knee and ankle MDSv4 dataset but includes the data collection for total elbow and total shoulder replacement procedures.

MDSv6	Minimum dataset version six, introduced on 14 November 2014 replacing MDSv5 as the new official dataset. This dataset includes the data collection for hip, knee, ankle, elbow and shoulder replacement procedures.
MDSv7	Minimum dataset version seven, introduced on 4 June 2018 as the new official dataset. This dataset includes reclassification and amendments to data collection for hip, knee, ankle, elbow and shoulder replacement procedures.
MHRA	Medicines and Healthcare products Regulatory Agency – the UK regulatory body for medical devices.
Minimally-invasive surgery	Surgery performed using small incisions (usually less than 10cm). This may require the use of special instruments.
Mixing and matching	Also known as 'cross breeding'. Hip replacement procedure in which a surgeon chooses to implant a femoral component from one manufacturer with an acetabular component from another.
Modified Polyethylene (MP)	Any component made of polyethylene which has been modified in some way in order to improve its performance characteristics. Some of these processes involve chemical changes, such as increasing the cross-linking of the polymer chains or the addition of vitamin E and/or other antioxidants. Others are physical processes such as heat pressing or irradiation in a vacuum or inert gas.
Modular	Component composed of more than one piece, e.g. a modular acetabular cup shell component with a modular cup liner, or femoral stem coupled with a femoral head.
Monobloc	Component composed of, or supplied as, one piece, e.g. a monobloc knee tibial component.
N	
NHS	National Health Service.
NICE	National Institute for Health and Care Excellence.
NICE benchmark	See ODEP ratings.
NJR	National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. The NJR has collected and analysed data on hip and knee replacements since 1 April 2003, on ankle replacements since 1 April 2010 and on elbow replacements and shoulder replacements since April 2012. It covers both the NHS and independent healthcare sectors to ensure complete recording of national activity in England, Wales, Northern Ireland and the Isle of Man.
NJR Centre	National coordinating centre for the NJR.
NJR StatsOnline	Web facility for viewing and downloading NJR statistics on www.njrcentre.org.uk.
O	
ODEP	Orthopaedic Data Evaluation Panel of the NHS Supply Chain. www.odep.org.uk
ODEP ratings	ODEP ratings are the criteria for product categorisation of prostheses for primary total hip and knee replacement against benchmarks. An ODEP rating consists of a number and a letter and a star. The number represents the number of years for which the product's performance has been evidenced. The letter represents the strength of evidence (data) presented by the manufacturer. The star has been added to the rating system following revised guidelines from NICE in February 2014, in which a benchmark revision rate of less than 5% at 10 years was defined. The star is awarded where products are evidenced to comply with this benchmark. A* represents evidence above A and B. Ratings without a star signify compliance with the prior NICE guidance of a replacement rate of less than 10% at 10 years. The same benchmark has been adopted by ODEP for knees. All implants that are used without a 10-year benchmark should be followed up closely. See www.odep.org.uk.
OPCS-4	Office of Population, Censuses and Surveys: Classification of Interventions and Procedures, version 4 – a list of surgical procedures and codes.
Outlier	Data for a surgeon, unit or implant brand that falls outside of acceptable control limits. See also 'Funnel plot'. A Level One implant outlier is defined as having a PTIR of more than twice the group average. A Level Two implant outlier is defined as having a PTIR of 1.5 times the group average.

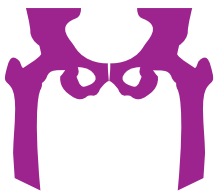
P	
Pantalar (ankle)	Affecting the whole talus, i.e. the ankle (tibio talar) joint, the subtalar (talo calcaneal) joint and the talonavicular joint.
Patella resurfacing	Replacement of the surface of the patella (knee cap) with a prosthesis.
Patellofemoral knee	Procedure involving replacement of the trochlear and replacement resurfacing of the patella.
Patellofemoral prosthesis	Two-piece knee prosthesis that provides a prosthetic (knee) articulation surface between the patella and trochlear.
Patient consent	Patient personal details may only be submitted to the NJR where explicit informed patient consent has been given or where patient consent has not been recorded. If a patient declines to give consent, only the anonymous operation and implant data may be submitted.
Patient physical status	See ASA.
Patient procedure	Type of procedure carried out on a patient, e.g. primary total prosthetic replacement using cement.
Patient-time	The total of the lengths of time a cohort of patients were 'at risk'. In the calculation of PTIRs for revision, for example, each individual patient's time is measured from the date of the primary operation to the date of first revision or, if there has been no revision, the date of patient's death or the last observation date. The individual time intervals are then added together.
PDS	The NHS Personal Demographics Service is the national electronic database of NHS patient demographic details. The NJR uses the PDS Demographics Batch Service (DBS) to source missing NHS numbers and to determine when patients recorded on the NJR have died.
PEDW	Patient Episode Database for Wales. The Welsh equivalent to Hospital Episode Statistics (HES) in England.
Primary hip/knee/ankle/elbow/ shoulder replacement	The first time a joint replacement operation is performed on any individual joint in a patient.
Procedure	A single operation. See also Primary hip/knee/ankle/elbow/ shoulder replacement and Revision hip/knee/ankle/elbow/shoulder replacement.
Prosthesis	Orthopaedic implant used in joint replacement procedures, e.g. a total hip, a unicondylar knee, a total ankle, a reverse shoulder or a radial head replacement.
Prosthesis-time	The total of the lengths of time a cohort of prostheses were 'at risk'. In the calculation of PTIRs for revision, for example, each individual prosthesis time is measured from the date of the primary operation to the date of first revision or, if there has been no revision, the date of patient's death or the last observation date. The individual time intervals are then added together.
PROMs	Patient Reported Outcome Measures.
PTIR	PTIR Prosthesis-Time Incidence Rate. The total number of events (e.g. first revisions) divided by the total of the lengths of times the prosthesis was at risk (see 'Prosthesis-time').
Pulmonary embolism	A pulmonary embolism is a blockage in the pulmonary artery, which is the blood vessel that carries blood from the heart to the lungs.
R	
Radial head component (elbow)	Part of a partial elbow joint that is inserted into the radius (outer lower arm bone) of the patient to replace the articulating surface of the radial head. May be monobloc or modular.
Resurfacing (hip)	Resurfacing of the femoral head with a surface replacement femoral prosthesis and insertion of a monobloc acetabular cup, with or without cement.
Resurfacing (shoulder)	Resurfacing of the humeral head with a surface replacement humeral prosthesis inserted, with or without cement.
Reverse shoulder replacement	Replacement of the shoulder joint where a glenoid head is attached to the scapula and the humeral cup to the humerus.
Revision burden	The proportion of revision procedures carried out as a percentage of the total number of surgeries on that particular joint.
Revision hip/knee/ankle/elbow/ shoulder replacement	Operation performed to add, remove or modify one or more components or conduct a DAIR of a total joint prosthesis.

S	
Shoulder hemi-arthroplasty	Replacement of the humeral head with a humeral stem and head or shoulder resurfacing component which articulates with the natural glenoid.
Single-stage revision	A revision carried out in a single operation.
SOAL	Lower Layer Super Output Areas. Geographical areas for the collection and publication of small area statistics. These are designed to contain a minimum population of 1,000 and a mean population size of 1,500. Please also see Office for National Statistics at www.ons.gov.uk.
Subtalar	The joints between the talus and the calcaneum, also known as the talocalcaneal joints.
Surgical approach	Method used by a surgeon to gain access to, and expose, the joint.
Survival (or failure) analysis	Statistical methods to look at time to a defined failure 'event' (for example either first revision or death); see Kaplan-Meier estimates and Cox 'proportional hazards' models. These methods can take into account cases with incomplete follow-up ('censored' observations).
T	
Talar component	Portion of an ankle prosthesis that is used to replace the articulating surface of the talus at the ankle joint.
TAR	Total ankle replacement (total ankle arthroplasty). Replacement of both tibial and talar surfaces, with or without cement.
TED stockings	Thrombo embolic deterrent (TED) stockings. Elasticised stockings that can be worn by patients following surgery and which may help reduce the risk of deep vein thrombosis (DVT).
THR	Total hip replacement (total hip arthroplasty). Replacement of the femoral head with a stemmed femoral prosthesis and insertion of an acetabular cup, with or without cement.
Thromboprophylaxis	Drug or other post-operative regime prescribed to patients with the aim of preventing blood clot formation, usually deep vein thrombosis (DVT), in the post-operative period.
Tibial component (knee)	Portion of a knee prosthesis that is used to replace the articulating surface of the tibia (shin bone) at the knee joint. May be modular or monobloc (one piece).
Tibial component (ankle)	Portion of an ankle prosthesis that is used to replace the articulating surface of the tibia (shin bone) at the ankle joint.
TKR	Total knee replacement (total knee arthroplasty). Replacement of both tibial and femoral condyles (with or without resurfacing of the patella), with or without cement.
Total condylar knee	Type of knee prosthesis that replaces the complete contact area between the femur and the tibia of a patient's knee.
Treatment centre	Treatment centres are dedicated units that offer elective and short-stay surgery and diagnostic procedures in specialties such as ophthalmology, orthopaedic and other conditions. These include hip, knee, ankle, elbow, and shoulder replacements. Treatment centres may be privately funded (independent sector treatment centre – ISTC). NHS Treatment Centres exist but their data is included in those of the English NHS Trusts and Welsh Local Health Boards to which they are attached.
Trochanter	Bony protuberance of the femur, found on its upper outer aspect.
Trochanteric osteotomy	Temporary incision of the trochanter, used to aid exposure of hip joint during some types of total hip replacement.
Two-stage revision	A revision procedure carried out as two operations, often used in the treatment of deep infection.
Type (of prosthesis)	Type of prosthesis is the generic description of a prosthesis, e.g. modular cemented stem (hip), patellofemoral joint (knee), talar component (ankle), reverse shoulder (shoulder) and radial head replacement (elbow).

U	
Ulnar component (elbow)	Part of a total elbow joint that is inserted into the ulna (inner lower arm bone) of the patient to replace the articulating surface of the ulna. May be linked or unlinked.
Uncemented	See cementless.
Unicondylar arthroplasty	Replacement of one tibial condyle and one femoral condyle in the knee, with or without resurfacing of the patella.
Unicondylar knee replacement	See Unicondylar arthroplasty.
Unilateral operation	Operation performed on one side only, e.g. left hip.
Unlinked total elbow	Where the humeral and ulnar parts of a total elbow replacement are not physically connected.

Summary of key facts about joint replacement during the 2018

Hips



recorded on the NJR since April 2003

106,116 replacement procedures

0.8%

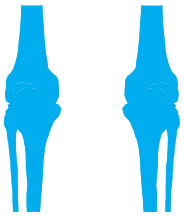
(105,306 in 2017)

60%

average ages:

67.6 70.0

Knees



recorded on the NJR since April 2003

109,540 replacement procedures

2.9%

(112,836 in 2017)

56%

average ages:

69.3 69.7

Shoulders

recorded on the NJR since April 2012

7,677 replacement procedures

2.0%

(7,525 in 2017)

69%

average ages:

69.4 74.1

calendar year

National Joint Registry
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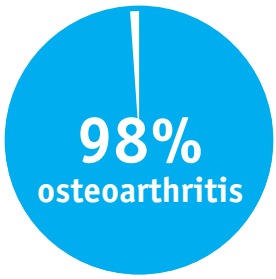
Diagnosis

average BMI

28.7

=

'overweight'



Diagnosis

average BMI

30.8

=

'obese'

52%
osteoarthritis

26%
cuff tear arthropathy

Diagnosis

Elbows

recorded on the NJR since April 2012

899
replacement procedures

10.6%
(813 in 2017)

71%

average ages:

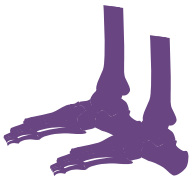
59.9 66.8

25%
inflammatory arthropathy

17%
osteoarthritis

Diagnosis

Ankles



recorded on the NJR since April 2010

1,004
replacement procedures

13.3%
(886 in 2017)

62%

average ages:

69.4 66.9

91%
osteoarthritis

8%
rheumatoid arthritis and other inflammatory joint problems

Diagnosis

For more data on clinical activity during the 2018 calendar year visit www.njrreports.org.uk

Notes:

Data collection

The National Joint Registry (NJR) produces this report using data collected, collated and provided by third parties. As a result of this the NJR takes no responsibility for the accuracy, currency, reliability and correctness of any data used or referred to in this report, nor for the accuracy, currency, reliability and correctness of links or references to other information sources and disclaims all warranties in relation to such data, links and references to the maximum extent permitted by legislation.

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Information governance and patient confidentiality

The NJR ensures that all patient data is processed and handled in line with international and UK standards and within UK and European legislation: protecting and applying strict controls on the use of patient data is of the highest importance.

NJR data is collected via a web-based data entry application and stored and processed in Northgate Public Services' (NPS) data centre. In addition to being accredited to ISO 27001 and ISO 9001, NPS is also compliant with the NHS Data Security and Protection Toolkit.

For research and analysis purposes, NJR data is annually linked to data from other healthcare systems using patient identifiers, principally a patient's NHS number. These other datasets include the Hospital Episodes Statistics (HES) service, data from the NHS England Patient Reported Outcomes Measures (PROMs) programme, and data from the Office of National Statistics (all provided by NHS Digital), and the Patient Episode Database Wales (PEDW) (provided by NHS Wales Informatics Service). The purpose of linking to these data sets is to expand and broaden the type of analyses that the NJR can undertake without having to collect additional data. This linkage has been approved by the Health Research Authority under Section 251 of the NHS Act 2006 on the basis of improving patient safety and patient outcomes: the support provides the legal basis for undertaking the linkage of NJR data to the health data sets listed above.

Once the datasets have been linked, patient identifiable data are removed from the new dataset so that it is not possible to identify any patient. This data is then made available to the NJR's statistics and analysis team at the University of Bristol/University of Oxford whose processing of the data is compliant with the NHS Data Security and Protection Toolkit. The work undertaken by the University of Bristol is directed by the NJR's Steering Committee and the NJR's Editorial Board and the results of the analyses are published in the NJR's Annual Report and in professional journals. All published data is based on anonymised data, this means that no patient could be identified.

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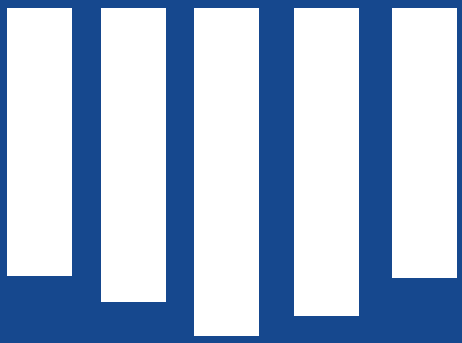

Every effort was made at the time of publication to ensure that the information contained in this report was accurate. If amendments or corrections are required after publication, they will be published on the NJR website at www.njrcentre.org.uk and on the dedicated NJR Reports website at www.njrreports.org.uk.

At www.njrreports.org.uk, this document is available to download in PDF format along with additional data and information on NJR progress and developments, clinical activity and implant and unit-level activity and outcomes.

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