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

HIPS
KNEES
ANKLES
ELBOWS
SHOULDERS
PROMs

14th Annual Report 2017

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

Surgical data to 31 December 2016

ISSN 2054-1821 (Print)

Prepared by

The NJR Editorial Board

NJRSC Members

Michael Green
Mr Peter Howard
Mr Martyn Porter (Chairman, Editorial Board)
Professor Mark Wilkinson
Nick Wishart

NJR RCC Network Representatives

Mr Matthew Porteous (Chairman, RCC Sub-committee)
Mr Adam Watts

Orthopaedic Specialists

Mr Colin Esler
Mr Andy Goldberg
Professor Jonathan Rees

Healthcare Quality Improvement Partnership
NJR Management Team and NJR Communications

James Ludley
Elaine Young

Northgate Public Services
NJR Centre, IT and data management

Victoria McCormack
Anita Mistry
Dr Claire Newell
Dr Martin Pickford
Martin Royall
Mike Swanson

University of Bristol / University of Oxford
NJR Statistical support, analysis and research team

Professor Yoav Ben Shlomo
Professor Ashley Blom
Dr Emma Clark
Kevin Deere
Dr Celia Gregson
Dr Linda Hunt
Dr Andrew Judge
Sofia Mouchti
Professor Andrew Price
Adrian Sayers
Mr Michael Whitehouse

Pad Creative Ltd (design and production)

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 22-23.

Chairman's foreword

Laurel Powers-Freeling, National Joint Registry Chairman

The National Joint Registry's Steering Committee (NJRSC) oversees the work programme of the registry. As Chairman it is always a pleasure to offer a foreword to our Annual Report, now in its 14th edition, and to update on the substantial developments during the previous financial year.

Key work and developments

Improving data quality remains our number one overall strategic priority. With our ever-maturing dataset, it is critically important that the registry is collecting the most relevant, high quality data in order to provide robust evidence to support decision-making in regard to patient safety, standards in quality of care and overall cost effectiveness in joint replacement surgery.

The NJR's national programme, which is aimed at assessing data completeness and quality within the registry, is now in its second year and underpins the NJR's 'Supporting Data Quality Strategy'. The data quality audit has allowed the NJR to compare the records in local hospitals' databases to the registry's records, with the aim of ensuring the accuracy of the number of arthroplasty procedures submitted when compared to the number carried out.

I'm delighted we were able to extend the programme this year to check the quality of data in independent healthcare organisations, giving all hospitals – now in both the NHS and independent sector – the opportunity to demonstrate the highest possible standards of clinical governance, which all are striving to achieve.

We are now able to fully report the audit's findings in year one. These findings can be found on pages 18-20. I would like to offer my thanks on behalf of the NJR to all staff who have worked to complete this important audit and who I hope will enact upon its findings.

Elsewhere, monitoring continues to be a key function of the NJR. Registry data now provides an important

source of evidence for regulators, such as the Care Quality Commission (CQC), to inform their judgements about services, as well as being a fundamental driver to inform improved quality of care for patients. As such, this year we have further reviewed the NJR's processes in monitoring implant and surgeon performance as part of the development of the NJR's 'Accountability and Transparency Model'.

As part of the new model, 'prevention' is now a key element of the NJR's monitoring process. Implemented for the first time this year, 'borderline outlier' notifications were issued, acting to prevent surgeons from becoming 'outliers' by alerting them to deteriorating outcomes and thus enabling them to correct substandard practices and reduce or eliminate poor outcomes. This new function should ensure even greater public confidence in the NJR monitoring process across the orthopaedic sector.

Looking ahead, 'practitioner reflection' will also become a key pillar in the NJR's monitoring process. A bold new approach, which has the endorsement of the BOA and NHS Improvement, will see the NJR monitoring surgeon engagement and reflection on their own practice and performance data. This new process will allow joint replacement surgeons the unique

opportunity to demonstrate and record, via the NJR's Clinician Feedback tool, that they have reviewed their NJR data as part of their appraisal and revalidation, and importantly reflected upon the data. At the time of writing, we are at an exciting juncture but once implemented it will be ground-breaking for the NHS and for patient safety and reassurance.

An additional area of national policy that the NJR continues to support is the ongoing work surrounding the Getting It Right First Time (GIRFT) initiative. GIRFT essentially aims to bring about higher-quality care in hospitals, at lower cost, by reducing unwanted variations in services and practices. The NJR's implant price-benchmarking data has from the outset underpinned the initiative for orthopaedics.

NJR pricing data gives providers the opportunity to benchmark the price they pay for orthopaedic implants against the 'best' national prices achieved. Importantly, NJR data also helps ensure an important clinical context is built into the initiative by providing surgeons access to their individual-level price-benchmarking data. All these services are now inclusive of the NJR's annual subscription charge.

A recent King's Fund report[1] into GIRFT highlighted that clinicians were engaging with the data and acting on the evidence provided. This is an area of work that the NJR will continue to support and work closely with NHS Improvement and the GIRFT team.

Future plans for the coming year 2017/18

Patients and the public can be assured that the NJR is working hard to collect and report upon the most complete, accurate data possible across all hospitals in England, Wales, Northern Ireland and the Isle of Man. In addition to our core schedule of activities, we will:

- Continue to develop NJR information systems, including enhanced Clinician Feedback to aid surgeon appraisal, Supplier Feedback, Management Feedback and Annual Clinical Reports
- Roll out a dedicated NJR data access and research portal to allow researchers to access the NJR dataset via secure access
- Undertake a complete redevelopment of the NJR's main website (www.njrcentre.org.uk)
- Provide further analyses and investigation of NJR PROMs at 3 and 5 years

Acknowledgements

During this reporting period, there have been some changes to the membership of the NJRSC. Professor Andrew Price stepped down from his role as a surgeon member of the committee as he formally became part of the NJR's statistical analysis contractor team. My sincere thanks to Andrew for his valuable contribution in his NJRSC role, we are fortunate to retain his services and abilities in a new capacity. Work is underway with the Department of Health's appointments team to find Andrew's replacement and also to appoint a senior specialist practitioner with an interest in orthopaedics. Mr Martyn Porter, NJR Vice Chair and Medical Director, and Sue Musson, patient representative member, were both granted extensions to their membership of the NJRSC until March 2018 and October 2017, respectively.

This year I have also appreciated the significant contribution made by both Mr Tim Wilton and Mr Ian Winson. As immediate past-BOA president and BOA president respectively, Tim and Ian's engagement as co-opted members of the NJRSC – particularly during this period of change and review of the NJR's monitoring process – has been invaluable. This September when a new president takes up post, I look forward to welcoming him and hope to maintain the support and close links developed with the profession.

Importantly, I would like to end by thanking all members of the NJRSC, and NJR sub-committees, for their valuable contribution and enthusiasm. In particular, my thanks to Mr Martyn Porter, NJR Vice Chair and Medical Director, and to the chairs of each of the NJR sub-committees for their contribution, hard work and insight. Without their dedication, the NJR would not be the world leading and ground-breaking arthroplasty register that it is. I would encourage you to read and review the reports from each committee chairman at www.njrreports.org.uk where they provide strategic oversight and professional awareness into key work areas.

1 Timmins, N., 'Tackling variations in clinical care: Assessing the Getting It Right First Time (GIRFT) programme' (June 2017). www.kingsfund.org.uk (last accessed 10 July 2017).

Finally, my thanks to the NJR management team, in particular our Director of Operations, Elaine Young. Thanks also go to our NJR contractors, Northgate Public Services (UK) Ltd., the University of Bristol, and the communications team based at the Healthcare Quality Improvement Partnership, for all their hard work and efforts throughout the year in progressing the NJR work agenda.

Laurel Powers-Freeling
Chairman, National Joint Registry Steering Committee

Contents

Glossary 193

Part 3 tables

Part 3 figures

Executive summary

Mr Martyn Porter, NJR Medical Director and Chairman, Editorial Board

The National Joint Registry's maturing dataset, now in its 14th year of reporting, offers the orthopaedic community the invaluable ability to see important determinants that influence the outcome and longevity of joint replacement procedures. Monitoring and reporting high quality, robust data suitable for decision-making remains the registry's core mission and I'm delighted to present this year's findings.

To ensure accurate annual reporting the NJR continues to work with many stakeholders including hospitals, industry, and individual surgeons. As outlined by the NJR Chairman in her foreword, the NJR's remit has naturally broadened and the ability for the dataset to drive forward change in other areas has grown – from patient recorded outcome measures (PROMs) to implant price-benchmarking, from research to surgeon accreditation. As well as also being an important source of evidence for regulators, such as the Care Quality Commission (CQC), to inform their judgements about services.

The NJR's Annual Report is a fundamental pillar and showcases how we monitor the performance of implants, hospitals and surgical technique but also how the registry is driving quality improvement in the orthopaedic sector as a whole.

Main headlines for 2016: procedures and data quality

During 2016/17, there were a total of 242,629 cases submitted to the NJR, an increase of over 20,000 on the previous year, which brings the total number of records in the registry to approximately 2.35 million. This is despite concern that the overall number of joint replacement procedures being undertaken was decreasing. The constantly high number of cases submitted per year suggests continuing high levels of patient confidence and clinical performance, in what is a remarkably successful surgical intervention.

The increase in cases submitted during this period could also be in part due to the NJR's sustained programme to improve data quality and compliance in the registry. Namely, this has been the work surrounding the data quality audits rolled-out across all eligible NHS hospitals, and for the first time during this year, independent sector hospitals too. As such, the NJR has been able to work with hospitals to improve their NJR processes, to ensure that all eligible primary and revision joint replacement operations are recorded on the database and put forward for analysis.

Many hospitals work hard to ensure that they record all eligible procedures. However, the completeness of data within the NJR is reliant on the input at the local level, which the audit has highlighted is subject to variation across hospitals.

We are now able to fully report the audit's findings in year one. These findings can be found on pages 18-20. I offered some very early analysis in last year's Annual Report for year one of the audit, which highlighted a really pleasing low overall level of missing records. However, the audit found that the proportion of missing data is greater for revision procedures. The failure of

hospitals to upload revision procedures into the NJR is concerning, as linked revision procedures form the basis of the analyses of implant failure and surgical performance – which fundamentally underpin the core purpose of the NJR.

Put another way, one of the NJR's principal outcomes of interest is revision surgery, an indication of implant failure or surgical performance. This is determined by linking a primary arthroplasty procedure to a secondary procedure, which typically occurs a number of years after the primary procedure. Analyses of revision estimates in this year's Annual Report highlight why compliance with reporting revision surgical procedures is essential to estimate implant failure rates and surgical performance more accurately. Further investigation is underway to ascertain whether these are random events or a systematic under-reporting of revision procedures.

Main headlines for 2016: outcomes

Across all joint procedures recorded in the registry, revision estimates following primary joint replacement procedures remain low. For example, primary total hip replacement revision estimates are less than five percent for the majority of procedures at thirteen years. Knee replacement data in numerous ways mirrors that of hip replacement. Similarly, there are very positive outcomes reflected in the ankle, shoulder, and now for the first time, elbow joint replacement data too.

These outcomes are extremely impressive and underpin the enormous success and reliability of joint replacement surgery. These sorts of results should help drive greater confidence in the public and with commissioners of healthcare, that joint replacement is one of the most effective and cost effective interventions that the NHS has to offer.

Furthermore, data for this year outlines that osteoarthritis is almost exclusively the diagnosis for both primary hip and knee joint replacements, in 90% and 99% of cases respectively. Therefore, we should not lose sight of the fact that joint replacement surgery offers significant benefits – getting patients back to their chosen lifestyle sooner, free from pain with improved mobility.

However, those in the orthopaedic community must continue to note an important trend emerging from the data, which highlights that the patient has an important effect on how long an implant will last. This year's analyses continue to show the increased risk of revision associated with younger patients across all joint procedures recorded in the registry. This is particularly important given the increase in total numbers of younger patients undergoing joint replacement.

As previously outlined by the NJR, if younger patients are most likely to need at least one revision surgery in their lifetime, then we must use the maturing dataset of the NJR to get the first-time surgery as right for the patient as possible.

For example, the revision rate for total hip replacement increases at a faster rate over time for younger patients. To explore this further, this year's report examines the effect of age and gender on hip revision rates across the construct groups for the first time.

Elsewhere with hip replacement data, our analysis confirms that choice of head size is an important factor in determining revision outcome. For both metal-on-polyethylene and ceramic-on-polyethylene bearing choices, higher failure rates are seen with larger head sizes. Importantly, the data indicates head sizes of 36mm and above are associated with increasingly higher failure rates.

Linked to the theme of younger patients, the knee replacement data again continues to show similar trends. Given partial knee replacement surgery is used generally in younger patients, the importance of the effects of patient factors which influence the outcome must be considered. For patients undergoing total knee replacement at the median age (69 years old), the 13-year risk of revision is just over 4%. However, for total knee replacement patients under the age of 60, the risk increases with decreasing age, reaching 10% for those under 55 years old. This pattern is magnified in unicondylar replacement, with patients under the age of 55 facing a 25% chance of revision by 13 years. This has been a consistent finding across all annual reports.

Further improvements to the representation of shoulder replacement data have been made. We have made the distinction for the first time between stemmed and stemless humeral implants, as well as improved representation of data in stem branding to reflect which implants are being used less or more frequently year

on year. Naturally, trauma and elective procedures continue to be separated out.

Elsewhere, we also report on ankle and elbow replacements (Sections 3.7 and 3.9). As these are carried out less frequently and we have a shorter follow-up period (since 2010 and 2012 respectively), data are still at a relatively early stage. However, I am pleased that the British Elbow and Shoulder Society (BESS) and the British Orthopaedic Foot and Ankle Society (BOFAS) continue to work very closely with the NJR to take the collection and analysis of the data forward.

Concluding acknowledgements

As well as the pages of this report, 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 2 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 including patients, regulators, hospitals, industry, individual surgeons and procurement, to ensure accurate annual reporting. To conclude, I would like to thank NJR Chairman, Laurel Powers-Freeling, and all members of the NJR Steering Committee, the Editorial Board and other NJR sub-committees, and the NJR Operational Management and Communications team, all of whom have supported the production of this report, and indeed all the orthopaedic surgeons in hospitals that contribute data. The collective effort ensures that the National Joint Registry maintains its position as the largest and world-leading arthroplasty registry, with a sharp focus on patient safety.

I would like end by acknowledging our NJR Contractors: the hard work undertaken and led by teams at the University of Bristol with support from colleagues at the University of Oxford, who have once again provided excellent provision in terms of analysing the outcomes following primary surgery and the many peer reviewed publications which have been produced from the registry data. I would particularly encourage you to explore the research published since the last annual report on ethnicity and joint replacement[1] and the main cause of death following primary total hip and knee replacement for osteoarthritis[2]. Finally, also to Northgate Public Services Ltd who provide the IT support and expertise for the NJR to achieve these outputs.

Mr Martyn Porter

NJR Medical Director and Chairman, Editorial Board

1 Smith MC, et al., 'Rates of hip and knee joint replacement amongst different ethnic groups in England: an analysis of National Joint Registry data', Osteoarthritis and Cartilage (2017)
2 Hunt, et al., 'Main Cause of Death Following Primary Total Hip and Knee Replacement for Osteoarthritis. A Cohort Study of 26,766 Deaths Following 332,734 Hip Replacements and 29,802 Deaths Following 384,291 Knee Replacements', The Journal of Bone and Joint Surgery (JBJS), (2017).

Part 1

NJR Data Quality Audit

1.1 NJR Data Quality Audit update

In 2015, the NJR began a retrospective data quality audit of hip and knee procedures performed during the financial year 2014/15 (1 April 2014 to 31 March 2015) in NHS hospitals. This was the inaugural year of the programme. By comparing unit data from the local hospital Patient Administration System (PAS) with the data entered in to the NJR, we aimed to investigate the compliance of NHS hospital Trusts and Health Boards' reporting of arthroplasty procedures to the registry.

Unlike many other national audits, there are two principal outcomes of interest to the NJR: 1) mortality, and 2) revision surgery. Similar to other registries, data on mortality is collected via the Office of National Statistics (ONS) and linked to individuals within the NJR. However, more consistent with the primary aims of the NJR, revision surgery (an indication of implant failure or surgical performance) is determined by linking a primary arthroplasty procedure to a secondary procedure, which typically occurs a number of years after the primary procedure. Therefore, compliance with reporting revision surgical procedures is essential to estimate implant failure rates and surgical performance more accurately.

Confidence in the NJR is based on the assumption of high quality data, robust analysis and strong engagement with stakeholders (for example; surgeons, patients, healthcare providers, implant manufacturers, and the MHRA). Whilst the NJR is fully engaged with stakeholders and conducts robust statistical analysis, the completeness of data within the NJR is reliant on the input at unit level, which is subject to variation across trusts and health boards.

It is clear that for surgeons and patients alike, the necessity for having accurate and complete data is an absolute requirement. Data quality and validation are essential components of any audit or scientific research. Quite simply, if the data is incomplete or incorrect, then false conclusions may be drawn from any analysis.

Methodology

All (149) NHS Trusts and Health Boards who report to the NJR were selected for audit. In July 2015, each CEO received correspondence from the NJR inviting them to join the NJR's data checking programme and identify a data quality lead to help hospitals assess data completeness and quality for hip and knee procedures submitted to the NJR for the previous financial year, 2014/15.

Once identified, the Trust or Health Board's data quality lead was then contacted to obtain data on eligible arthroplasty procedures from the local hospital Patient Administration System (PAS), which was subsequently linked to procedures uploaded from local Trusts and Health Boards to the NJR, comparing record for record.

Consistency between the NJR and hospital's PAS was assessed. The process involved Trusts and Health Boards returning a file of patients for whom OPCS4 codes had been locally recorded that suggested they had had a primary or revision hip or knee replacement in the financial year 2014/15. This was matched by the NJR against all the joint replacements that the organisation had submitted to the NJR for the same timeframe. The possible outcomes for each record were:

a. A full match by patient ID, operation date and procedure (recorded OPCS4 codes and in the NJR)

b. Recorded OPCS4 codes but no NJR record identified

c. NJR record identified but no corresponding record or OPCS4 codes in PAS

The total number of procedures identified between the local hospital PAS extract and those uploaded to the NJR was considered as the denominator for calculations.

Details of the unmatched records were returned to the participating hospitals for further analysis. The audit was completed for that organisation when the outcome of this analysis, and any necessary corrections or submission of omissions, were received back by the NJR. On completion of each audit, a NJR Audit Compliance Report was created and sent to the CEO which contained the key findings, recommendations and additional learning points from the audit process. This report provided each Trust and Health Board with their own key learning points to act upon.

The NJR sent repeated communications to Trusts or Health Boards which were slow or unengaged with

the audit and arranged external hospital visits where necessary. The external visits allowed the NJR to understand and rectify the blockage in communication and engagement with the audit, as well as supporting hospital colleagues with the audit process. Alongside this and in the first instance, NJR Regional Clinical Coordinators worked to identify key individuals at each Trust or Health Board to resolve any on-going issues.

Results

Five months after the audit commenced with the initial contact with chief executives, only one Trust had failed to engage in the audit process. A total of 119 (80%) Trusts and Health Boards had completed the audit or were due to receive their NJR Audit Compliance Report. The remaining 29 (19%) were addressing unmatched records, and by April 2017 only eleven trusts had remaining unmatched records to resolve from the FY14/15 audit.

Of the 115 Trusts and Health Boards that had completed their audit by the end of December 2016, a total of 96,604 procedures were matched between the NJR and local PAS extract (outcome (a)).

14,258 procedures were found in the hospital PAS system but not on the NJR (outcome (b)). On further investigation by the units, procedures were found to have been outsourced (25%), identified as not being an NJR procedure (15%), an incorrect patient identifier had been used (12%), or another reason (10%). The remaining 5,332 (38%) records were eligible for NJR entry.

Regarding outcome (c), a total of 7,658 procedures were found to be on the NJR but not on the hospital PAS system. This is of particular significance in the current financial climate. As a simplified example, at around £5,000 per procedure this equates to over £38million in potential lost revenue across the 115 Trusts and Health Boards.

In summary, a total of 101,936 (50,550 hips, 49,686 knees, and 1,700 which could not be defined) procedures were identified between the NJR and local PAS extract. Of these, 89,956 (44,083 hips, 45,873 knees) were indicated to be primary procedures, and 10,280 (6,467 hips, 3,813 knees) were revisions.

95.30% (94.88% hips, 95.70% knees) and 90.95% (91.33% hips, 90.32% knees) of primary and revision procedures were recorded in the NJR respectively.

Procedure	All records	Found in hospital PAS but not on the NJR	Percentage of missing records
Hip Primary	44,083	2,259	5.12%
Hip Revision	6,467	561	8.67%
Knee Primary	45,873	1,973	4.30%
Knee Revision	3,813	369	9.68%
Undefined	1,700	170	
Total	**101,936**	**5,332**	

Note: All records represent the total number of eligible procedures found between the NJR and local hospital PAS; missing NJR records represent cases where the eligible PAS record provided could not be found on the NJR; undefined records refer to PAS records where the joint was not specified.

The audit has found data representing 5.23% of all records missing (entered into PAS but not into the NJR). However, it is also noted that the proportion of missing data is greater for revision procedures (8.67% for hips and 9.68% for knees).

Comparison between the published compliance figures (based on Hospital Episode Statistics and Patient Episode Database for Wales data) and the compliance found during the data quality audit which compared record for record, shows the median dropping slightly

from 97% (IQR 84.5-101.5) to 95.37% (IQR 91.30-97.94). Compliance shows a significantly smaller range following the data quality audit which gives a greater confidence in the reported figures.

The audit also enabled compliance to be measured on a case by case basis (matching individual records across NJR and HES/PEDW), and for this to be compared to published compliance levels for each. Published compliance levels provide a crude assessment as they simply compare total procedures undertaken within a timeframe between HES/PEDW and NJR. Compliance measured on a case by case basis provides a more accurate measure. This assessment highlights compliance for a number of Trusts and Health Boards to be significantly different using the case by case method, than that currently published, with some appearing better and some worse than the published compliance levels would suggest.

Outcomes

Whilst the overall scale of missing records was found to be low (5.23%), the proportion of missing revision records was found to be higher than that for primary procedures. The observed differences suggest systematic under-reporting of revision procedures in the audited Trusts and Health Boards. The ratio of missing primaries for hip and knee replacements is approximately 20:1 and 23:1 respectively, whereas the ratio of missing revision procedures is 12:1 and 10:1 respectively.

When compliance is considered at a Trust or Health Board level, variation in compliance is substantial with high levels of under-reporting of revision procedures by specific units. The failure of local hospitals to upload revision procedures into the NJR is especially problematic, as linked revision procedures form the basis of analyses which investigate implant failure and surgical performance – which fundamentally underpins the primary aim of the NJR.

Audit FY2015/16

The NJR believes that a minimum three year data quality audit programme is required before the NJR and its stakeholders have a greater degree of confidence in the data and its quality.

At the time of writing, the audit for the financial year 2015/16 is concluding and was expanded to include the independent (private) sector whose submission to the NJR has been mandatory since the registry's inception. Early responses to the FY2015/16 audit showed a positive engagement by independent units with strategic involvement at Independent Healthcare Provider Group level. Trusts and Health Boards have been able to build upon their experience of the previous year's audit to improve their processes and datasets.

The NJR was also able to use the lessons learnt from the FY14/15 audit to better identify the data quality leads for each unit and track these contacts and communications. Improvements were made to the previous audit tool and the introduction of a data request template resulted in cleaner data being returned.

Conclusion

High quality complete data is essential for making robust inferences from the NJR. Systematic under-reporting of revision procedures is likely to bias results and reduce the statistical power of the NJR to quickly detect failing implants at higher than expected rates. Although this is true, the large size of the NJR somewhat compensates for this when assessing failure rates at a national level. However, when attempting to sub-divide data by surgeons, the reduction in statistical power and systematic under-reporting of revisions, may be misrepresentative of individual surgeon performance.

In other words, and to put the importance of this into context, if data is missing at random, then comparisons of the NJR data at the level of the implant may still be valid, but comparisons of sub-samples of the NJR, such as surgeon or hospitals, are much more problematic.

Further investigation is required to ascertain whether these are random events or a systematic under-reporting of revision procedures. Analysis of the audit's results in year two will help this and that work is currently underway. Results of both the FY2014/15 and FY2015/16 audits will be updated via the NJR's main website – **www.njrcentre.org.uk.**

Part 1

Annual progress

1.2 Annual Report Introduction

The 14th 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 2016 to 31 March 2017. The report consists of a number of parts which are outlined in the summary table.

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 2016/17 is included below and in both in the Chairman's Foreword and Annual Report Executive Summary.

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

1.3 Annual Progress

As at 31 March 2017, the total number of procedures submitted to the NJR was approximately 2.35 million. In the financial year 2016/17, a total of 242,629 records were submitted which is an increase of 20,857 over the previous year. This is despite concern that the overall number of joint replacement procedures being undertaken was decreasing. Overall key performance indicators demonstrated:

- Patient consent (to allow the recording of their personal details in the NJR) was recorded as 92.1%, a decrease of 1.2% from the previous year. However, the consent rate for Northern Ireland increased to 96.1% from 94.5% in the previous year, while the overall consent rate for England, Wales and the Isle of Man decreased by 1.2%.
- Linkability (the ability to link a patient's primary procedure to a revision procedure) was recorded as 94.2%, a drop of 1% on the previous year.

Whilst a comparison of successive years will show variation, the drop in the rates of the key indicators of consent and linkability may be attributable to the outcomes of the data quality audits that have taken place this year. 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 rate of NHS and, in Northern Ireland, HCN numbers. Please see the data completeness and quality indicators section online for further detail.

Data quality has continued to be a primary focus for the NJR in 2016/17 with the undertaking of the second year's data quality audit across all NHS units and, for the first time, independent sector units. The established NJR Data Quality and Clinical Leads at all Trusts and Health Boards have worked with the audit team at unit level, resulting in a swifter response and improved quality of data. Engagement with the independent sector has also been very encouraging. Please visit www.njrreports.org.uk for further details of the audit.

Further enhancements to the NJR's reporting services have been made in 2016/17. Surgeons are now able to access more information through NJR Clinician Feedback, monitor their patients through a report on both primary and revision procedures and also, within subscribing Trusts and Health Boards, gain access to implant pricing reports. NJR Management Feedback continues to issue an annual report to summarise activity and outcomes at each hospital within a Trust, Health Board or organisation and offers a free price benchmarking service to units providing implant pricing information.

Finally, the NJR remains committed to working for patient safety and driving forward quality in joint replacement surgery.

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

1.4 Summary of content for the NJR Annual Report

Section	Summary	Content	Full information can be found
Part One	Executive summaries, annual progress and FY2016/17 highlights	News and information in executive summaries, committee reports and highlights about the progress of the NJR to 31 March 2017	www.njrreports.org.uk
Part Two	Clinical activity 2016	Statistics on joint replacement activity for hip, knee, ankle, elbow and shoulder activity for the period 1 January to 31 December 2016	www.njrreports.org.uk through interactive reporting
Part Three	Outcomes after joint replacement surgery 2003-2016	Detailed statistical analyses on hip and knee replacement surgery using data from 1 April 2003 to 31 December 2016. 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	www.njrreports.org.uk
Prostheses	Use of prostheses by brand (implants)	Prostheses used in joint replacement surgery 2016 for hip, knee, ankle, elbow and shoulder	www.njrreports.org.uk
Appendices	Information relating to the NJR's governance and operational structure Research	Composition, attendance, declarations of interest for the NJR Steering Committee, sub-committees and terms of reference Published and approved research papers using NJR data	www.njrreports.org.uk

Part 2

Clinical activity 2016 and using the dedicated NJR Reports website

2.1 Clinical activity 2016 overview

Part Two of the NJR's 14th Annual Report can now to 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 2016 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 2016 to 31 December 2016. To be included in the report all procedures must have been entered into the NJR by 28 February 2017.

The following double page spread offers a visual summary of key facts relating to clinical activity during the 2016 calendar year. This can also be downloaded as a waiting room poster via **www.njrreports.org.uk.**

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
- Patient's 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

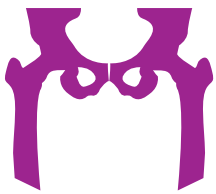
- Components removed during hip revision procedures
- Components used during single-stage hip revision procedures
- Trends in femoral head size and hip articulation

For knees specifically

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

Summary of key facts about joint replacement during the 2016

Hips



recorded on the NJR since April 2003

101,651 replacement procedures

3.5%

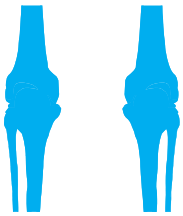
(98,211 in 2015)

60%

average ages:

67.6 69.8

Knees



recorded on the NJR since April 2003

108,713 replacement procedures

3.8%

(104,695 in 2015)

56%

average ages:

69.2 69.6

Shoulders

recorded on the NJR since April 2012

6,967 replacement procedures

12.9%

(6,170 in 2015)

70%

average ages:

69.2 73.9

calendar year

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

90% osteoarthritis

Diagnosis

average BMI

28.8

=

'overweight'

99% osteoarthritis

Diagnosis

average BMI

31.0

=

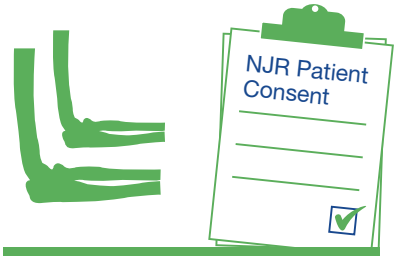
'obese'

55% osteoarthritis

26% cuff tear arthropathy

Diagnosis

Elbows



recorded on the NJR since April 2012

722 replacement procedures

10.2%

(655 in 2015)

72%

average ages:

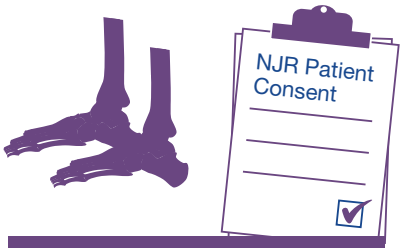
60.3 67.6

31% inflammatory arthropathy

19% osteoarthritis

Diagnosis

Ankles



recorded on the NJR since April 2010

839 replacement procedures

15.6%

(726 in 2015)

61%

average ages:

68.3 66.5

89% osteoarthritis

7% rheumatoid arthritis and other inflammatory joint problems

Diagnosis

For more data on clinical activity during the 2016 calendar year visit www.njrreports.org.uk.

2.2 Navigating the NJR Reports online facility

What can you find at NJR Reports online?

As at 31 March 2017, the total number of procedures recorded in the NJR is now approximately 2.35 million.

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 14th Annual Report presents data on clinical activity during the 2016 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 2016

3.1 Executive summary

Part Three of the 14th Annual Report provides outcome data in relation to hip, knee, shoulder, elbow and ankle replacements. It describes activity between 1 April 2003 and 31 December 2016.

There were 2,284,416 procedures recorded in this period, although 10% of these were excluded because there were insufficient patient details to enable linkage. This relates predominantly to the early years of the registry and was less of a feature in recent years as data quality has improved.

The numbers of primary procedures available for analysis were 890,681 total hip replacements, 975,739 knee replacements, 3,899 ankle replacements, 23,608 shoulder replacements and 2,196 elbow replacements.

Hip replacement procedures

The total number of primary hip replacements performed continues to increase with 87,733 performed in 2016, compared to 86,496 the previous year. The vast majority continue to be performed for osteoarthritis. In 2016, the ratio of women to men receiving hip replacement was 60:40 and the median age at which primary surgery was performed is 69.

Uncemented fixation is still the most common construct used by surgeons comprising 39% of the total number, compared to 30% for cemented replacements. There has been a slight decrease in both these construct types whilst hybrid fixation, mainly using a cemented stem and uncemented cup, continues to grow in popularity, with surgeons using this method in 28% of cases. Metal-on-polyethylene is still the most commonly used bearing construct across cemented, uncemented and hybrid hip replacements, but the usage of ceramic-on-polyethylene bearings continues to grow, reaching 29% of all cases. Metal-on-metal bearings including resurfacing is performed in very low numbers making up less than 1% of all cases in 2016.

In this year's report, a total of 890,681 recorded hip replacements were available for survival analysis, with data collected over 13 years. The cumulative percentage probability of revision after primary hip replacement across all patients is 6.8% at 13 years. The lowest rate of revision continues to be seen in the all cemented construct group, with a cumulative percentage probability of revision of 4.3% at 13 years, with best results within group seen when a ceramic-on-polyethylene bearing is used (3.8%). The survival within the entire hybrid group is calculated at 5.1%, with ceramic-on-ceramic bearings providing best results of any sub-group at 3.3% at 13 years. Reassuringly the most commonly used cemented and hybrid constructs by brand all perform well.

> The total number of primary hip replacements performed continues to increase with 87,733 performed in 2016, compared to 86,496 the previous year. The vast majority continue to be performed for osteoarthritis

For the uncemented construct group the pattern of failure over time is different. The revision rate is approximately double that of all cemented, calculated at 8.7%. Within group, the best survival figures are seen with a ceramic-on-polyethylene bearing, with survival rate improving to 4.5%. If metal-on-metal bearings are excluded, the commonly used constructs by brand perform similarly well.

In this year's analysis the effect of age and gender on revision rates across the construct groups has been presented for the first time. This is particularly relevant given the increase in total numbers of younger patients undergoing joint replacement. Overall, as reported in previous annual reports, the revision rate for total hip replacement increases at a faster rate over time for younger patients. For female patients under 55 the revision rate of 13.5% at 13 years is 2.5 times greater than for women undergoing surgery between 65 and 74 years of age. However the choice of construct does affect revision rate in the younger age group and for women under 55 years a cemented ceramic-on-polyethylene construct gives the best results, with a revision rate of 3.8% at ten years. A similar trend in the relationship of age to revision rates is seen for men, although at 13 years the revision rate for the under 55 group across all bearing types is 10%, approximately 3.5% lower than for women. Again, the best performing construct for the younger patient is a cemented prosthesis, in this case using a

ceramic-on-polyethylene bearing, which provides half the revision rate of cementless fixation using metal-on-polyethylene at all time points. Interestingly, for older patients all construct combinations have similarly good revision outcomes.

Presenting mortality data alongside revision outcomes provides a greater understanding of the outcome of hip replacement, particularly in the older patient. In the vast majority of patients over the age of 75 at implantation, their hip implant will remain unrevised across their remaining lifetime, with very low revision rates seen.

Our analysis confirms that choice of head size is an important factor in determining revision outcome. For both metal-on-polyethylene and ceramic-on-polyethylene bearing choices higher failure rates are seen with larger head sizes, in particular 36mm for cemented and above 36mm for hybrid and cementless. In contrast if a ceramic-on-ceramic bearing construct is used then survival is improved with larger size.

> In this year's analysis the effect of age and gender on revision rates across the construct groups has been presented for the first time. This is particularly relevant given the increase in total numbers of younger patients undergoing joint replacement

Metal-on-metal reconstructions, of either a resurfacing or stemmed variety, continue to fail at higher rates than other bearing choices, with revision rates ranging between 14% and 27% at ten years for the worst performing implant types. However the survival profile for the best performing resurfacing procedures by brand shows lower revisions rates of between 8% and 9%. Overall the net effect of higher revision rates for metal-on-metal procedures has been a dramatic and sustained reduction in their use.

The number of patients who are treated with primary hip replacement after sustaining a fractured neck of femur continues to grow with time. In 2016, 4,260 were performed, representing 4.9% of all total hip procedures. In this group of patients it is encouraging that revision rates are similar to those hip replacements performed for other indications although, as expected, mortality rates are higher.

In 2016, 7,933 revision procedures were performed, with the vast majority being single-stage procedures. The total number of revision procedures available for analysis between 2003 and 2016 is now 97,341. The most commonly recorded indication for revision continues to be aseptic loosening, followed by pain. Within the first year following primary surgery dislocation, fracture and infection are the most common indications for revision, whereas revision for aseptic loosening increases in frequency over the first ten years. The cumulative probability of hip re-revision is approximately 17% at 13 years.

Knee replacement procedures

Between 2003 and 2016 a total of 975,739 knee joint replacements were recorded and are available for analysis. Osteoarthritis remains the most common indication for knee replacement across the whole cohort (96%), with the second most common indication being inflammatory arthritis at 2%.

During 2016, 104,079 knee joint replacements were recorded in the NJR, with 98,147 primary and 5,932 revision procedures. Within primaries, the most common type of reconstruction performed was a total knee replacement, making up 89.7% of procedures. Of this group, the most widely used fixation method remains cementing (84.9%). Uncemented total knee replacement continues to decline in numbers, making up only 2% of the total number implanted. As seen in other years, within the cemented group of total knee replacements fixed bearing unconstrained (62.2%) and posterior-stabilised (19.8%) make up the vast majority of implantations performed. The proportion of unconstrained to posterior-stabilised has remained steady over the last five years, at a ratio of 3:1. Unicompartmental knee replacement (medial and lateral) makes up 9.2% of all knee replacements performed in 2016, with this percentage remaining fairly static over the last ten years. A mobile bearing construct is used in 5.1% of cases and fixed in 4.1%. Patellofemoral replacement account for 1.1% of all knee replacements and similarly this figure has remained static for the last ten years.

> Between 2003 and 2016 a total of 975,739 knee joint replacements were recorded and are available for analysis. Osteoarthritis remains the most common indication for knee replacement across the whole cohort

Patient demographics showing the trend for more women than men to undergo knee replacement continues in all types of knee replacement. The median age at which patients undergo replacement is 70 years for total knee replacement, 64 for unicondylar knee replacement and 58 for patellofemoral replacement. Over the last three years, 1,999 surgeons have undertaken total knee replacements and 820 performed unicondylar knee replacements. The median number of each performed over a three year period is 104 (IQR 26-214) for total knee replacements and 12 (IQR 3-35) for unicondylar replacements. This highlights the continuing trend for some surgeons to perform very few numbers of unicondylar replacements per year.

Survival analysis performed on the 975,739 knee replacements in the NJR was completed out to 13 years. Temporal changes over time show that the rate of change of cumulative percentage chance of revision has remained similar over the period between 2003 and 2013.

The cumulative risk of revision at 13 years for cemented total knee replacement is 4.2%, with unconstrained fixed bearing total knee replacement (the most common construct) recording 3.8% and posterior-stabilised total knee replacement 4.7%. In the cementless class, the figure reached 5.4% but interestingly for uncemented fixed bearing posterior-stabilised total knee replacements the revision rate reaches 12.1% by 13 years, demonstrating that this combination of implant choice puts patients at a greater risk of revision.

Unicondylar replacement revision rates are higher than those for total knee replacements across all times points, with a rate of 16% reached by 13 years post-surgery. The trend is the same regardless of mobile or fixed bearing choice. Patellofemoral joint replacement continues to record the highest failure rate, with the current estimate being 24.2%.

For younger patients, the risk of revision is higher with the same pattern seen for men and women. For a patient at the median age of implantation (69), the 13-year risk of revision is just over 4%. However, for total knee replacement patients under the age of 60, the risk increases with decreasing age, reaching 10% for those under 55 years old. This pattern is magnified in unicondylar replacement, with patients under the age of 55 facing a 25% chance of revision by 13 years. This has been a consistent finding across all annual reports.

> The median age at which patients undergo replacement is 70 years for total knee replacement, 64 for unicondylar knee replacement and 58 for patellofemoral replacement

In 2016, 5,932 revision knee replacements were performed, with the vast majority being single stage revisions. The total number of revisions across all years was 60,680. The most common indications recorded for first revision surgery in total knee replacement remain aseptic loosening, pain, infection and ‘other’ (excluding dislocation, lysis, periprosthetic fracture, implant fracture, instability and malalignment). Indications for first revision surgery in unicompartmental knee replacement follow a broadly similar pattern, with aseptic loosening and pain remaining as the most common specific reason, although rates are higher. Considering all knee replacements within the first year of implantation, infection remains the most common cause of revision, with aseptic loosening becoming more common in later years. The risk of subsequent re-revision is approximately 16% at 13 years across this entire group.

Ankle replacement procedures

In 2016, there were 690 primary ankle replacements entered into the NJR, compared to 602 the year before. Similar data has been collected from 2010 to 2016 and in total 3,899 primary ankle replacements are available for analysis.

From the entire series the ratio of female to male patients was 60:40 and the median age at primary surgery was 68, with a range of 17 to 92 years.

Of the 3,899 primary procedures, the vast majority (89%) of implantations have been uncemented and, with the exception of three recorded hybrid cases, the remaining are cemented.

A total of 229 consultants, working in 269 units carried out these procedures, with 44% of surgeons performing over ten procedures and 56% less than ten, over the six year period.

Between 2010 and 2016, there were 153 revision procedures, including 24 conversions to arthrodesis. The estimated rate of revision at six years was 7.7% (95% CI 5.94-8.47).

In 2016, the Infinity (30%), Box (18%) and Zenith (15%) were the most widely used brands, making up over half of all implantations.

Shoulder replacement procedures

There are now 23,608 primary shoulder replacements in the NJR with 5,944 procedures performed in 2016, with the number performed each year continuing to increase. In 2016 these procedures were performed in 338 units, with 12 as the median number per unit (IQR 5-23). The total number of consultants performing the procedures was 476, with a median per consultant of 9 (IQR 4-18).

> There are now 23,608 primary shoulder replacements in the NJR with 5,944 procedures performed in 2016, with the number performed each year continuing to increase

A total of 21,570 cases were performed as part of elective care. The most common indications for surgery were osteoarthritis and cuff tear arthropathy, sometimes combined in a small proportion of patients (522). For elective cases the majority of the replacements were performed on women (70%) and the median age at the primary operation was 73 years (IQR 67-79 years), with an overall range of 17-99 years.

In 2,038 cases the indication was acute trauma. In this group of patients, 77% were female and 23% male, with a combined median age at surgery of 74 (IQR 67-80 years).

The most frequently used implant type is the reverse polarity total shoulder arthroplasty (42%), followed by total conventional shoulder arthroplasty (30%) and hemi-arthroplasty (13%). The vast majority of these primary cases were stemmed. Resurfacing humeral hemi-arthroplasty or resurfacing total shoulder arthroplasty was performed in 13% of cases.

The cumulative percentage probability of revision at four years for elective primary cases was 4.2% and 3.9% for trauma cases. In elective cases, the rate increases for patients under the age of 65 to 7.6% in men and 6.4% in women. After four years, total conventional shoulder arthroplasty and reverse shoulder arthroplasty had the lowest revision rate for elective shoulder replacement, although caution in interpretation is required as the differences seen may reflect threshold for revision and do not take account of functional outcome. In both elective and trauma procedures, the most common causes of revision were instability and cuff insufficiency.

> In both elective and trauma procedures, the most common causes of revision were instability and cuff insufficiency

Elbow replacement procedures

A total of 2,196 primary elbow replacement procedures have been recorded in the NJR between April 2012 and December 2016, including total, radial head and lateral resurfacing replacements. In 2016, a total of 513 procedures were performed, which is a slight decrease from the year before, although the general trend since 2012 has been an increase in overall numbers recorded.

From the entire series of 2,196 procedures, women (70%) undergo elbow replacement more often than men (30%) and the median age of patients undergoing surgery was 68 (IQR 58-77 years). Trauma accounted

for 31% of all cases. In the 1,511 elective cases, the most common stated indications for elective surgery were other inflammatory arthropathy, osteoarthritis and sequelae of trauma.

> A total of 2,196 primary elbow replacement procedures have been recorded in the NJR between April 2012 and December 2016

Total prosthetic (63%) and radial head replacement (37%) were the prostheses used in trauma cases. In elective care the vast majority of cases were total replacement (95%), with radial head replacement performed in 4% of cases and lateral resurfacing in 1%.

In 2016, there were 210 consultants working in 160 units. They undertook primary elbow replacements with 2 (IQR 1-4) as the median number of cases performed per unit and 2 (IQR 1-3) the median per consultant.

At three years, the cumulative percentage probability of revision, across the entire group, was 4.4% (95% CI 3.3-5.8). In trauma cases the probability of revision was 2.1% (95% CI 1.1-4.2), but no radial head replacements were revised and the revision rate for total replacement was 3.2% (95% CI 1.6-6.3). This contrasts to a three-year revision rate of 5.1% (95% CI 3.7-7.0) when total replacement was performed in the elective setting. The most frequently cited causes of revision in elective care were infection and aseptic loosening.

> From the entire series of 2,196 procedures, women (70%) undergo elbow replacement more often than men (30%) and the median age of patients undergoing surgery was 68

Part 3

3.2 Summary of data sources and linkage

The main outcome analyses in this section relate to primary joint replacements. We included all patients with at least one primary joint replacement carried out between 1 April 2003 and 31 December 2016 inclusive, whose records had been submitted to the NJR by 28 February 2017.

Information governance and patient confidentiality:

NJR data is 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' Information Governance Toolkit. Data linkage to other datasets is approved by the Health Research Agency under Section 251 of the NHS Act 2006. Please visit www.hra.nhs.uk/about-the-hra/our-committees/section-251 for more details.

Data source:

In the early years of the registry, when reporting was not mandated by the Department of Health, we know 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 operations may explain temporal increases in volume (primary and revision), and revision outcomes for hips and knees replacements (see sections 3.4 and 3.6).

More recently primary procedures are less likely to have been missed. The recent 2014/15 NJR data completeness and accuracy audit across 149 NHS trusts reporting to the NJR suggests we may have missed about 5% and 4% of hip and knee primaries respectively.

What is of more serious consequence to our analyses; is the 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 than they actually are. This issue is being addressed by the NJR's Data Quality Sub-committee. Similarly, the 2014/15 data completeness and accuracy audit suggested 9% and 10% of hip and knee revisions had been missed during this period respectively.

As of April 2016, 80% of Trusts and Health Boards had completed the audit, with the remaining actively engaged in completing the 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 power to detect trends. From a national perspective, we believe selective 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, this enables the identification of primary and revision operations within the same individual.

Starting with a total of 2,284,416 NJR source records, 9.3% were lost because no suitable person-level identifier was found (see Figure 3.1 (a)). In around half of these 213,441 procedures (47.8%), the patient had declined to give consent for 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 because there was no tracing service available for them. Although a person-level identifier was available for 95% of operations since the beginning of 2008, in earlier years, the proportion had been much lower (see Figure 3.1 (b)). In 2003/4 for example, it was only 59%, rising to 79% in 2006 and 90% in 2007 (see Figure 3.1 (b)). Therefore, 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.

Among the linkable procedures with person-level identifiers (2,070,781) there were 90,095 (4.4%) revision procedures within the analysis period (2003 to 2016) 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 3.4 and 3.6.

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

A total of 1,574,146 patients had at least one record of a primary joint replacement within the NJR, i.e. hip, knee, ankle, elbow or shoulder. At this stage, information about the primary procedures were 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 final numbers for analysis shown in Tables 3.1 and 3.2.

In Table 3.2, of the 767,965 patients with primary hip operations, 16.0% had documented primaries for both hips (bilateral). Of the 800,477 patients with knee operations, 21.9% were bilateral.

Implant survivorship is mainly described with respect to the lifetime of the primary joint only, i.e. we have looked only at the time to first revision, not the time from a revision operation to any subsequent one. These analyses are described in sections 3.3, 3.5, 3.7, 3.8 and 3.9 for hips, knees, ankles, shoulders and elbows.

In sections 3.4 and 3.6, we provide an overview of further revisions following the first hip or knee revision procedure. We have also included revisions to a joint replacement where the associated primary had not been documented in the NJR.

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 did not have prior replacements 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. Patients may also have more than one type of implant.

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 washout for suspected infection and secondary patella resurfacing of an existing total or unicondylar knee replacement.

Figure 3.1 (a)

Initial numbers of procedures for analysis.

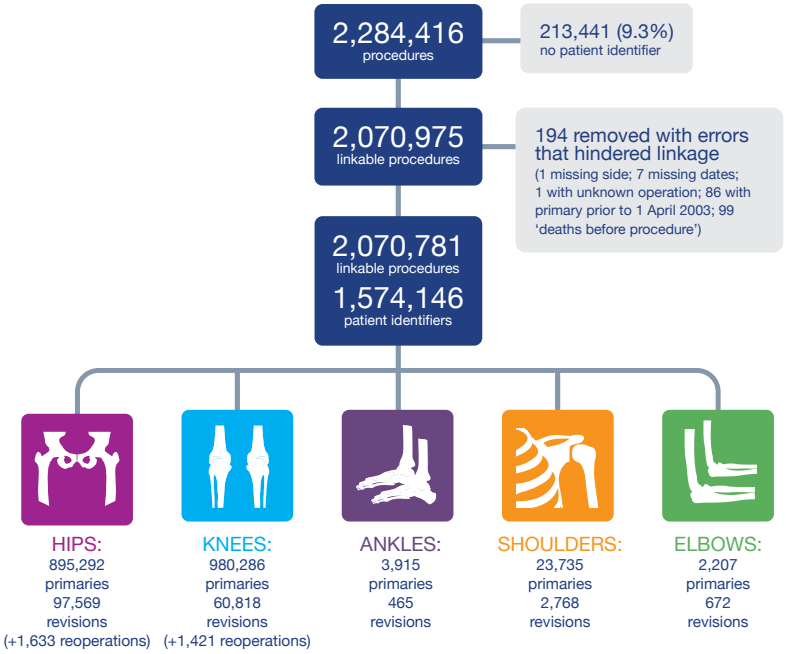
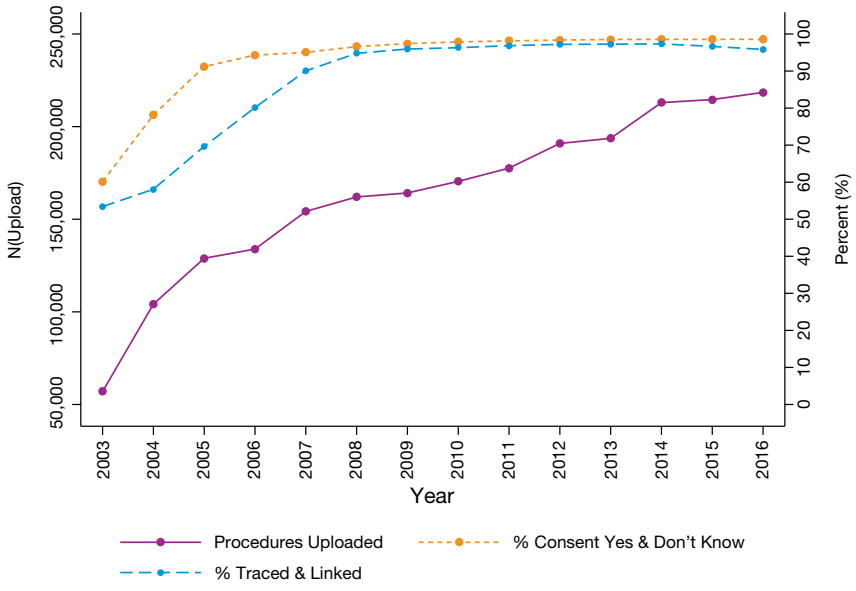


Figure 3.1 (b)

Total volume of uploads to the NJR, percentage of procedures consenting to be included in the NJR, and percentage of patients traced in the NJR, in England and Wales* by year of operation.



* Northern Ireland statistics excluded from figure due to lack of patient tracing agreement.

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 restructed to person-level 1 April 2003 - 31 December 2016 (hips and knees) 1 April 2010* - 31 December 2016 (ankles) 1 April 2012* - 31 December 2016 (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	890,681 hips	975,739 knees	3,899 ankles	23,608 shoulders	2,196 elbows
Number of primaries that were subsequently revised	NJR identified primary-linked first revisions				
	24,103 hips	24,399 knees	153** ankles	582*** shoulders	55**** 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 24 conversions to arthrodesis.

***Shoulder revisions include two excisions and one conversion to arthrodesis

****Elbow revisions includes one excision.

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

	Joints				
	Hips	Knees	Ankles	Shoulders	Elbows
Number of patients	**767,965**	**800,477**	**3,739**	**22,313**	**2,134**
Number (%) of patients with only one primary joint operation	645,249 (84.0%)	625,215 (78.1%)	3,579 (95.7%)	21,018 (94.2%)	2,072 (97.1%)
Number (%) of patients with both a left and right side primary operation but on different dates	118,410 (15.4%)	164,665 (20.6%)	156 (4.2%)	1,275 (5.7%)	61 (2.9%)
Number (%) of patients with both a left and right side operation on the same date (bilateral operations)	4,306 (0.6%)	10,597 (1.3%)	4 (0.1%)	20 (0.1%)	1 (<0.1%)
Total number of primary joints	**890,681**	**975,739**	**3,899**	**23,608**	**2,196**
Number with at least one revision operation linked to the primary	24,103	24,399	153	582	55
Number with more than one revision procedure	3,522*	4,208*	13 (4)**	64 (46)**	11 (6)**

*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 subsequent revision procedures appeared to relate only to that first (i.e. either were just other another stage one or the respective stage two).

Part 3

3.3 Outcomes after primary hip replacement

This section looks at revision and mortality outcomes for all primary hip operations performed between 1 April 2003 and 31 December 2016. Patients operated on at the beginning of the registry therefore had a potential 13.75 years of follow-up.

Details of the patient cohort are given in Tables 3.1 and 3.2 of the preceding section; a total of 890,681 hips were included in our analyses.

Osteoarthritis was given as a documented reason in 820,818 (92.2% of the cohort) and was the sole reason given in 815,257 (91.5%) hip procedures.

Methodological note

Survival analyses have been used throughout, first looking at the need for revision and then looking at mortality. Only the first revision has been considered in this section. The majority of implants did not require revision and survival analysis made use of the information that was available for them, i.e. that they had not been revised up to the end of the follow-up period (the end of 2016) or prior to their death; these observations were regarded as being 'censored' at those times. For mortality, the event was death, censoring only those cases that were still alive at the end of 2016 (and not for any revision procedure).

The survival tables in this report show 'Kaplan-Meier' estimates of the cumulative chance (probability) of revision, or death, at different times from the primary operation. Where possible, the numbers at risk at each anniversary have been added to the figures. These are particularly useful where a group has appeared to plateau; it may simply be because the number of cases fell so low that occurrence of further revisions/deaths became unlikely. The Kaplan-Meier estimates shown have been multiplied by 100, therefore they estimate the cumulative percentage probability.

In the case of revisions, no attempt has been made to adjust for the competing risk of death. The likely impact of mortality was reported in the 11th Annual Report (published September 2014).

Terminology note

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 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.

3.3.1 Overview of primary hip surgery

Table 3.3 shows the breakdown of cases by method of fixation and within each fixation sub-group, by bearing surface.

The most commonly used operation type overall remains cemented metal-on-polyethylene (87.1% of all cemented primaries, 30.4% of all primaries).

Table 3.3 Numbers and percentages of primary hip replacements of each fixation type and by bearing surface.

Fixation	Number (%)	Bearing surface within fixation group	Number (%)
All cases	890,681 (100%)		890,681 (100%)
All cemented	310,596 (34.9%)	MoP	270,476 (30.4%)
		MoM	1,098 (0.1%)
		CoP	33,041 (3.7%)
		Others/unsure	5,981 (0.7%)
All uncemented	347,587 (39.0%)	MoP	133,873 (15.0%)
		MoM	28,816 (3.2%)
		CoP	64,644 (7.3%)
		CoC	113,185 (12.7%)
		CoM	2,155 (0.2%)
		Others/unsure	4,914 (0.6%)
All hybrid	170,589 (19.2%)	MoP	105,619 (11.9%)
		MoM	2,188 (0.2%)
		CoP	37,294 (4.2%)
		CoC	23,206 (2.6%)
		Others/unsure	2,282 (0.3%)
All reverse hybrid	22,552 (2.5%)	MoP	15,255 (1.7%)
		CoP	7,200 (0.8%)
		Others/unsure	97 (<0.1%)
All resurfacing	39,318 (4.4%)	(MoM)	39,318 (4.4%)
Unsure	39 (<0.1%)	Unsure	39 (not applicable)

Table 3.4 and Figure 3.2 show the distributions across fixation groups for each year of primary operation and Figures 3.3 (a) to (d) show distributions across bearing surface of each fixation group. Trends of implant usage are interesting in that the decline in cemented implants between 2003 and 2009 has arrested and is now stable at around a third of cases. Conversely, although the use of uncemented implants has decreased since 2010, they still remain the most widely used compared to other implants. Hybrid implants continue to steadily increase in popularity and now account for a fifth of cases.

With regard to bearing surfaces, metal-on-polyethylene is still the most widely used, with ceramic-on-polyethylene following close behind; while the use of ceramic-on-ceramic is declining. The use of metal-on-metal stemmed implants has virtually ceased, with the proportion of metal-on-metal resurfacing implants decreasing from a peak of 10.8% in 2006 to account for only 0.7% of implants in 2016.

Table 3.4 Percentages of primary hip replacements in each calendar year that use each fixation type and for each fixation group*.

Fixation/ bearing	2003 n=14,454	2004 n=28,057	2005 n=40,575	2006 n=48,485	2007 n=60,761	2008 n=67,128	2009 n=68,104	2010 n=70,619	2011 n=73,632	2012 n=77,775	2013 n=79,885	2014 n=86,977	2015 n=86,496	2016 n=87,733
All cemented	60.3	53.9	48.2	42.4	39.4	34.0	31.7	31.3	32.2	32.8	33.1	31.9	30.9	29.6
Cemented by bearing surface:														
MoP	55.4	49.0	43.7	38.1	35.5	30.1	28.1	27.1	27.5	28.4	28.3	27.0	25.9	24.7
MoM	0.1	0.4	0.4	0.4	0.4	0.4	0.1	<0.1(31)	<0.1(8)	0.0	0.0	0.0	<0.1(2)	<0.1(1)
CoP	2.7	3.2	3.0	2.9	2.5	2.7	2.8	3.2	3.5	4.0	4.4	4.6	4.8	4.8
Others/ unsure	2.0	1.3	1.2	1.0	1.1	0.8	0.6	0.9	1.2	0.5	0.4	0.3	0.2	0.1
All uncemented	16.9	21.5	25.8	30.2	33.4	39.4	43.2	45.8	45.0	44.9	42.6	40.9	39.4	38.5
Uncemented by bearing surface:														
MoP	6.2	9.1	9.9	10.3	10.8	13.1	15.1	16.9	17.2	17.9	17.6	17.1	16.4	16.2
MoM	1.3	2.2	5.5	8.4	10.3	10.9	8.0	3.2	0.4	0.1	<0.1(4)	<0.1(1)	0.0	<0.1(12)
CoP	5.0	5.1	5.1	4.4	4.0	3.9	4.7	5.6	6.1	7.3	8.3	9.6	11.4	12.6
CoC	3.5	4.2	4.4	6.2	7.3	10.1	13.6	18.1	20.1	19.3	16.4	14.0	11.4	9.6
CoM	0.0	<0.1(1)	<0.1(1)	<0.1(7)	0.1	0.4	0.9	1.1	0.5	0.1	<0.1(27)	<0.1(6)	<0.1(1)	<0.1(2)
Others/ unsure	0.8	0.8	0.9	0.9	0.9	1.0	0.9	0.9	0.7	0.3	0.2	0.2	0.2	0.1
All hybrid	12.3	13.6	14.4	15.6	15.2	15.3	15.9	16.3	17.2	17.8	20.3	23.2	25.7	28.1
Hybrid by bearing surface:														
MoP	8.3	9.3	9.5	10.0	10.0	10.0	10.5	10.9	11.6	11.7	12.3	13.6	14.6	15.5
MoM	0.7	0.5	0.5	0.7	0.8	0.8	0.4	0.2	<0.1(32)	<0.1(4)	0.0	0.0	0.0	<0.1(7)
CoP	1.5	1.5	1.2	1.2	1.0	1.3	1.8	1.9	2.2	3.1	5.1	7.1	8.9	10.7
CoC	1.2	1.9	2.8	3.2	3.0	2.7	2.9	3.0	3.1	2.9	2.7	2.4	2.1	1.7
Others/ unsure	0.7	0.4	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1
All reverse hybrid	0.6	0.8	0.9	1.0	1.6	2.4	2.6	2.8	3.1	3.1	3.0	3.1	3.1	3.0
Reverse hybrid by bearing surface:														
MoP	0.3	0.6	0.7	0.8	1.1	1.7	1.8	1.9	2.2	2.0	2.0	2.0	2.1	2.0
CoP	0.2	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
Others/ unsure	<0.1(1)	<0.1(6)	<0.1(4)	<0.1(7)	<0.1(10)	<0.1(15)	<0.1(14)	<0.1(16)	<0.1(6)	<0.1(3)	<0.1(5)	<0.1(5)	<0.1(3)	<0.1(2)
All resurfacing (MoM)	9.8	10.1	10.6	10.8	10.3	8.9	6.6	3.9	2.5	1.4	1.1	0.9	0.9	0.7
All unsure	<0.1(2)	0.1	<0.1(1)	0.0	<0.1(1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All types	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Percentages calculated as percentage of total yearly operations. Where percentage is less than 0.1 the actual number of procedures is included in parenthesis. 0.0 represents no procedures with this bearing type.

Figure 3.2

Temporal changes in percentages of each fixation method used in primary hip replacements.

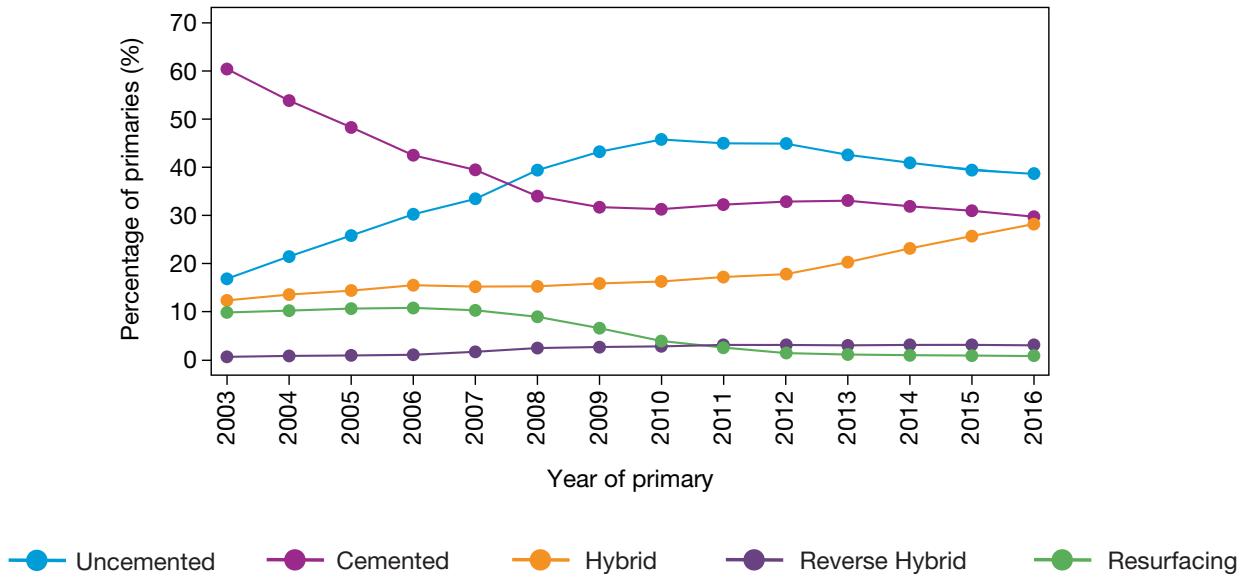


Figure 3.3 (a)

Temporal changes in percentages of each bearing surface used in **cemented** primary hip replacements.

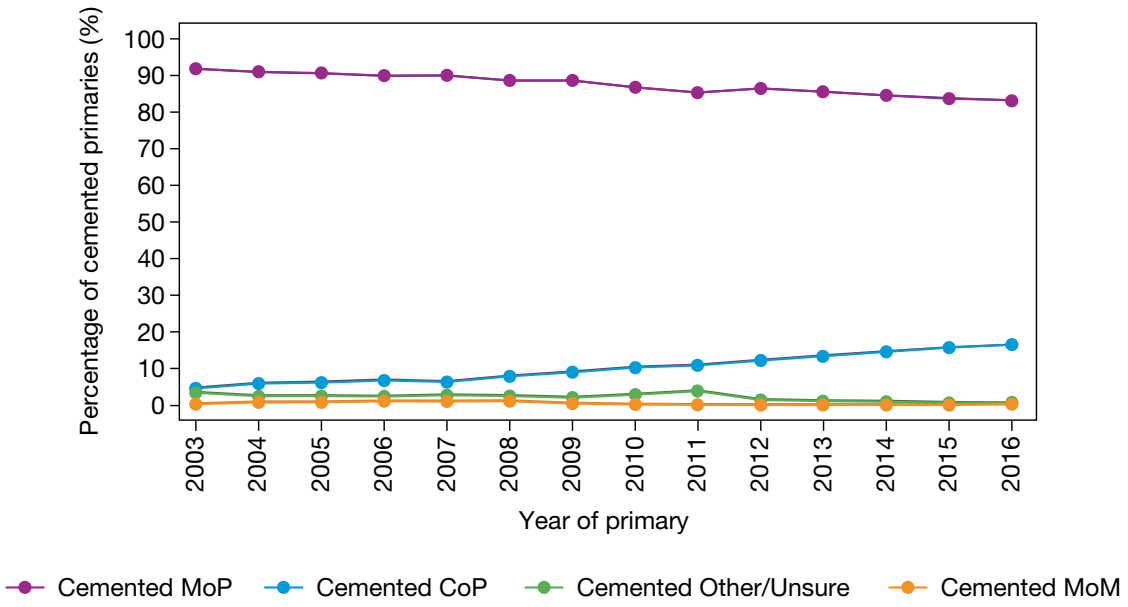


Figure 3.3 (b)

Temporal changes in percentages of each bearing surface used in **uncemented** primary hip replacements.

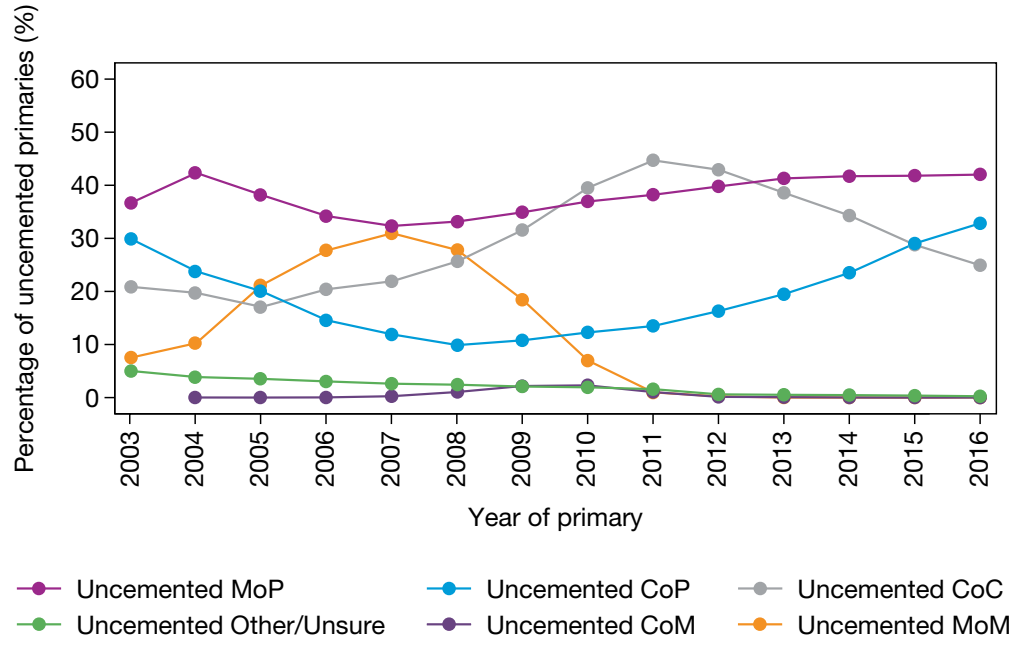


Figure 3.3 (c)

Temporal changes in percentages of each bearing surface used in **hybrid** primary hip replacements.

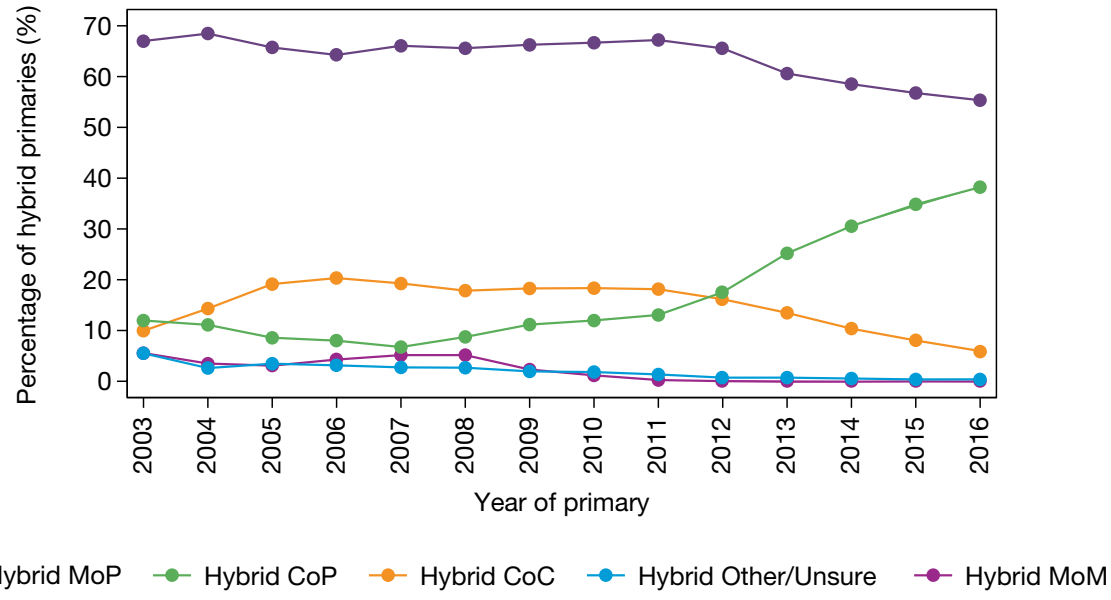
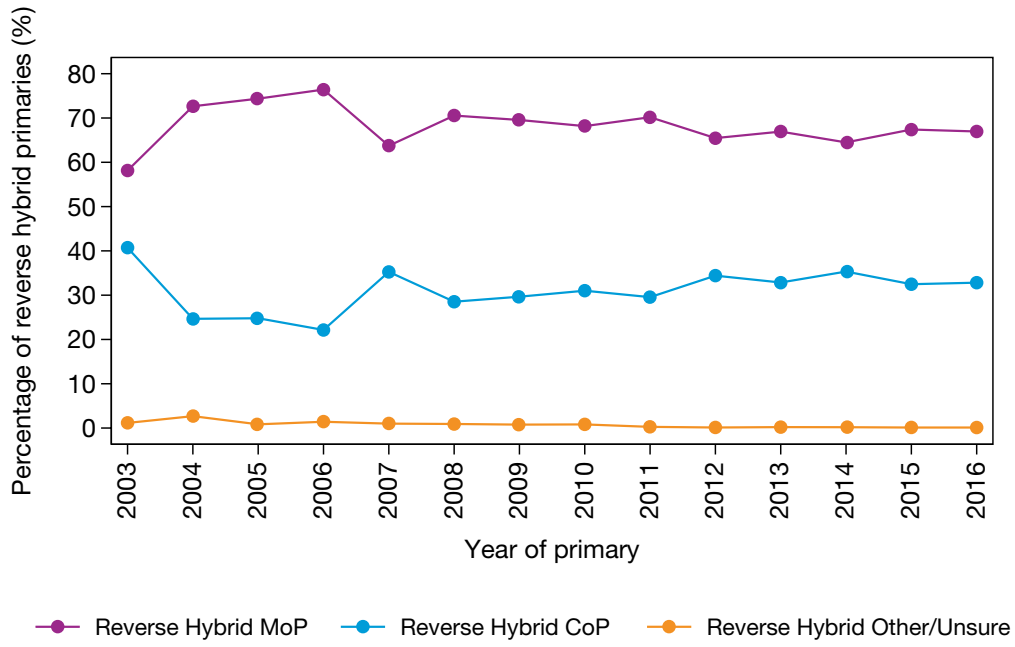


Figure 3.3 (d)

Temporal changes in percentages of each bearing surface used in **reverse hybrid** primary hip replacements.



Within the whole registry, all the 890,681 primary hip replacement procedures contributing to our analyses were carried out by a total of 3,331 consultant surgeons working across 468 units. Over the last three years (1 January 2014 to 31 December 2016), 261,206 primary hip procedures (representing 29.3% of the current registry) were performed by 2,205 consultant surgeons working across 416 units. Looking at caseload over this three-year period, the median number of primary procedures per consultant surgeon was 54 (inter-quartile range (IQR) 4-178) and the median number of procedures per unit was 547.5 (IQR 257.5-867). A proportion of consultants will have just qualified over this period, and some may have retired, therefore their apparent caseload would be lower.

The majority of hip primary procedures were carried out on women (females 59.8%: males 40.2%). The median age at primary operation was 69 (IQR 61-76) years[1], overall range 10-105 years.

Table 3.5 provides a breakdown of fixation type by age and gender with further division by bearing surfaces within each fixation sub-group.

Patients receiving resurfacing and ceramic-on-ceramic bearings tended to be younger than the other groups but the age ranges were wide. Those receiving resurfacings were more likely to be men.

[1] Omitting 207 cases where the NHS number was not traceable, therefore the age was not verifiable.

Table 3.5 Distribution of age at primary hip replacement (in years) and gender, for all procedures and for each type of fixation and bearing surface.

Fixation	By bearing surface within fixation group	n	Age (years)*			Percentage (%) males**
			Median (IQR***)	Minimum	Maximum	
All cases		890,681	69 (61-76)	7	105	40.2
All cemented		310,596	74 (68-79)	7	103	33.7
Cemented and						
	MoP	270,476	75 (69-80)	15	103	33.0
	MoM	1,098	64 (57-72)	25	98	46.9
	CoP	33,041	65 (58-71)	14	101	38.7
	Others/unsure	5,981	72 (65-78)	7	102	36.2
All uncemented		347,587	65 (58-72)	11	105	44.3
Uncemented and						
	MoP	133,873	71 (65-77)	12	101	40.9
	MoM	28,816	64 (57-70)	13	105	50.6
	CoP	64,644	64 (58-70)	13	100	44.8
	CoC	113,185	60 (53-66)	11	100	46.6
	CoM	2,155	63 (56-69)	20	92	42.4
	Others/unsure	4,914	66 (58-73)	17	96	42.8
All hybrid		170,589	70 (63-77)	12	105	37.0
Hybrid and						
	MoP	105,619	73 (68-79)	12	105	34.9
	MoM	2,188	64 (56-72)	18	95	48.0
	CoP	37,294	66 (59-72)	14	97	39.7
	CoC	23,206	60 (53-66)	13	93	40.9
	Others/unsure	2,282	69 (61-77)	16	94	36.1
All reverse hybrid		22,552	71 (64-77)	13	100	35.9
Reverse hybrid and						
	MoP	15,255	73 (68-78)	13	100	34.2
	CoP	7,200	64 (58-69)	16	94	39.6
	Others/unsure	97	69 (61-76)	30	93	32.0
All resurfacing (MoM)		39,318	55 (48-60)	12	95	71.3
Unsure		39	69 (56-75)	18	83	38.5

* Excludes 207 cases with unverifiable ages. **Excludes one with uncertain gender. *** IQR=interquartile range

3.3.2 Revisions after primary hip surgery

Figures 3.4 (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 3.4 (a) plots each Kaplan-Meier survival curve with a common origin, i.e. time zero is equal to the year of operation. Figure 3.4 (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 and 5 years has also been highlighted. Figure 3.4 (b) separates each year allowing changes in failure rates to be clearly identified. If revision surgery and timing of revision surgery were static across time we would expect all 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 to 2008 and then reduces for operations occurring between 2009 and 2016. The differences may be partly a result of under-reporting in the earlier years of the registry, but most probably reflect the usage of metal-on-metal, which peaked in 2008 and then fell (see Table 3.4). Further investigation is needed.

Table 3.6 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, 7, 10, 11 and 13 years from the primary operation together with 95% Confidence Intervals (95% CI). Results at 13 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. 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% Confidence Interval 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. Kaplan-Meier estimates are not shown at all when the numbers at risk fell below ten.

Please note that the rates for 'resurfacing' throughout Section 3.3 still include the ASR system unless explicitly stated otherwise.

Figures 3.5 to 3.8 illustrate the differences between the various bearing surface sub-groups for cemented, uncemented, hybrid and reverse hybrid hips, respectively. These continue to show the worst outcome for metal-on-metal bearings, which, in uncemented hips (Figure 3.6), fared worse than resurfacings. The failure rates for ceramic-on-polyethylene bearings were particularly low and it is encouraging that these are becoming more widely used with time.

In Table 3.6 and Figures 3.5 to 3.8, all age groups and genders were combined. In Figures 3.9 (a) and 3.9 (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 3.9 (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 rate. In Figure 3.9 (b), implants with metal-on-metal (or uncertain) bearing surfaces and resurfacings have been excluded. The revision rates for the younger women are much reduced; an age trend is seen in both genders but rates for women are lower than for men across the entire age spectrum.

Where group sizes permitted (overall group size>10,000), Table 3.7 further expands Table 3.6 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, 7, 10 and 13 years after the primary operation. These refine results in our 2016 report, but now with larger numbers of cases and therefore generally narrower Confidence Intervals.

Figure 3.4 (a)

Temporal changes in revision rates after primary hip replacement: Kaplan-Meier estimates of cumulative percentage probability of revision for each year of primary operation.

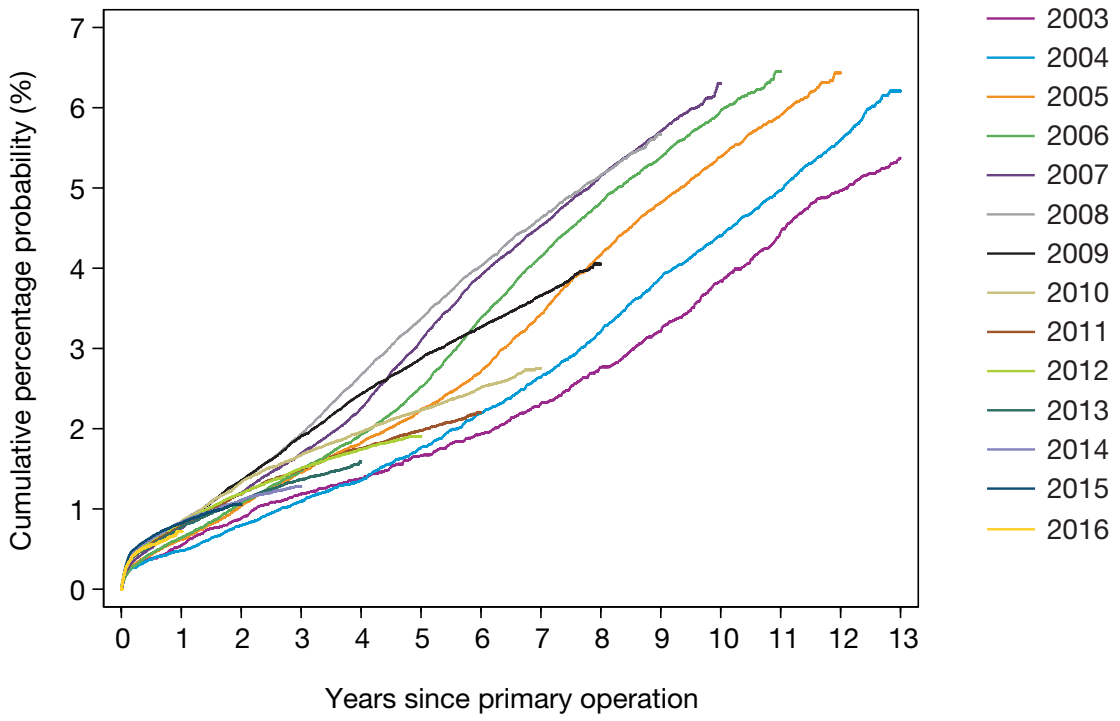


Figure 3.4 (b)

Temporal changes in revision rates after primary hip replacement: Kaplan-Meier estimates of cumulative percentage probability of revision for each year of primary operation with failure rates at 1, 3, and 5 years indicated.

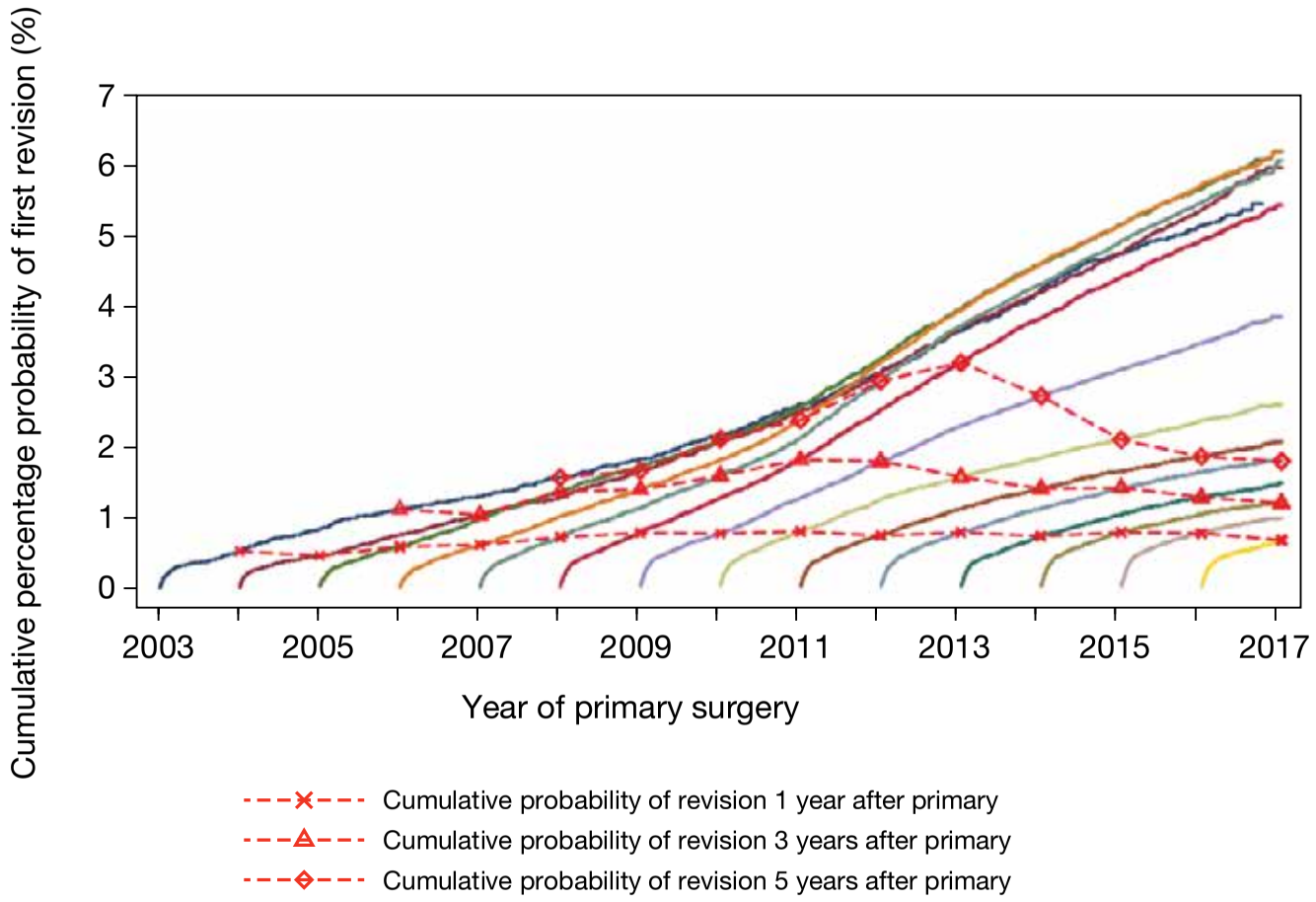


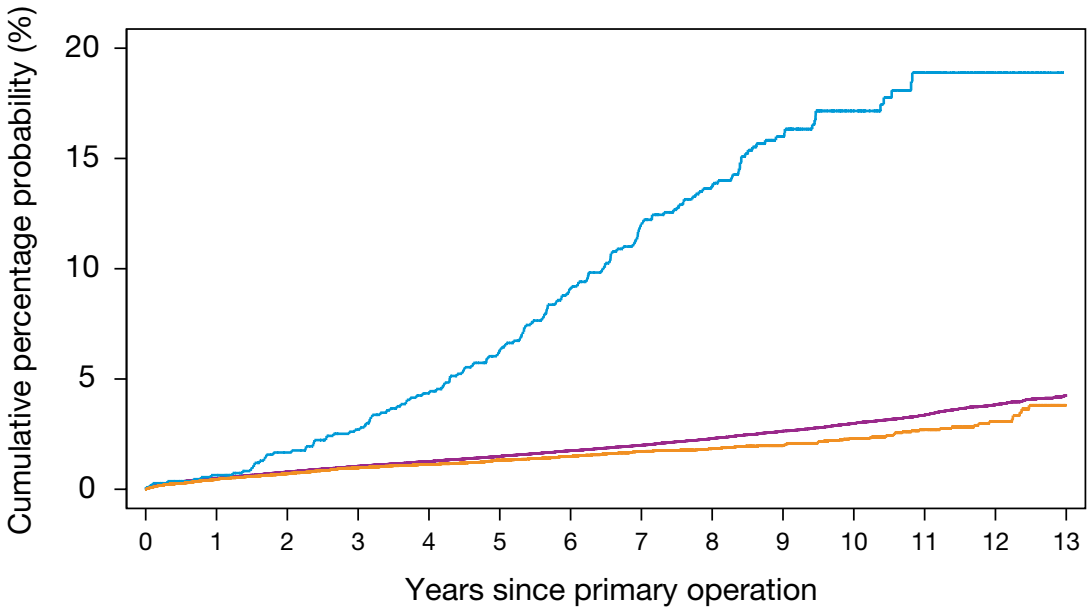
Table 3.6 Kaplan-Meier estimates of the cumulative percentage probability of revision (95% CI) after primary hip replacement, by year from the primary operation, for all cases and by fixation and bearing surface. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

	Cumulative percentage probability of revision (95% CI) at:							
Fixation/ bearing types	n	1 year	3 years	5 years	7 years	10 years	11 years	13 years
All cases*	890,681	0.78 (0.76-0.79)	1.56 (1.53-1.58)	2.41 (2.37-2.44)	3.47 (3.42-3.52)	5.21 (5.13-5.29)	5.74 (5.64-5.83)	6.83 (6.67-6.99)
All cemented	310,596	0.49 (0.47-0.52)	1.05 (1.01-1.09)	1.51 (1.46-1.56)	2.05 (1.98-2.11)	3.05 (2.95-3.14)	3.47 (3.35-3.59)	4.34 (4.14-4.54)
Cemented by bearing surface								
MoP	270,476	0.50 (0.47-0.52)	1.05 (1.01-1.09)	1.50 (1.44-1.55)	2.00 (1.93-2.07)	2.99 (2.89-3.09)	3.37 (3.25-3.50)	4.25 (4.04-4.46)
MoM	1,098	0.64 (0.31-1.34)	2.71 (1.89-3.87)	6.33 (5.01-7.99)	12.00 (10.13-14.18)	17.15 (14.80-19.84)	*18.89 (16.18-21.99)*	*18.89 (16.18-21.99)*
CoP	33,041	0.45 (0.38-0.53)	0.97 (0.86-1.09)	1.32 (1.18-1.48)	1.71 (1.53-1.91)	2.30 (2.03-2.61)	2.70 (2.34-3.11)	3.81 (3.07-4.72)
Others/unsure	5,981	0.58 (0.41-0.81)	1.16 (0.91-1.48)	1.64 (1.33-2.03)	2.43 (2.01-2.94)	3.42 (2.82-4.14)	4.83 (3.90-5.97)	*5.18 (4.16-6.45)*
All uncemented	347,587	0.99 (0.96-1.02)	1.93 (1.88-1.98)	2.99 (2.92-3.05)	4.39 (4.30-4.48)	6.77 (6.61-6.93)	7.36 (7.17-7.55)	8.66 (8.31-9.03)
Uncemented by bearing surface								
MoP	133,873	1.06 (1.01-1.12)	1.78 (1.71-1.86)	2.28 (2.19-2.38)	2.90 (2.78-3.02)	4.18 (3.97-4.39)	4.66 (4.41-4.93)	5.90 (5.37-6.47)
MoM	28,816	1.04 (0.92-1.16)	3.41 (3.21-3.63)	7.52 (7.22-7.84)	12.20 (11.81-12.60)	18.20 (17.66-18.76)	19.40 (18.76-20.05)	*22.14 (20.71-23.65)*
CoP	64,644	0.87 (0.80-0.94)	1.52 (1.42-1.63)	2.04 (1.91-2.18)	2.49 (2.33-2.67)	3.40 (3.14-3.68)	3.67 (3.38-3.99)	4.49 (3.98-5.06)
CoC	113,185	0.95 (0.89-1.01)	1.80 (1.72-1.88)	2.36 (2.26-2.46)	2.88 (2.76-3.00)	3.99 (3.76-4.23)	4.46 (4.16-4.78)	5.69 (4.97-6.50)
CoM	2,155	0.65 (0.39-1.10)	2.83 (2.20-3.63)	4.84 (4.00-5.85)	6.17 (5.18-7.35)			
Others/unsure	4,914	1.33 (1.05-1.70)	2.28 (1.89-2.75)	3.15 (2.68-3.71)	4.12 (3.56-4.77)	5.25 (4.53-6.07)	5.92 (5.03-6.97)	*7.66 (5.95-9.83)*
All hybrids	170,589	0.74 (0.70-0.78)	1.29 (1.23-1.35)	1.86 (1.78-1.94)	2.47 (2.37-2.57)	3.62 (3.46-3.79)	4.07 (3.87-4.29)	5.05 (4.70-5.44)
Hybrids by bearing surface								
MoP	105,619	0.78 (0.72-0.83)	1.32 (1.25-1.40)	1.83 (1.74-1.93)	2.29 (2.17-2.41)	3.40 (3.20-3.62)	3.96 (3.70-4.24)	4.94 (4.49-5.43)
MoM	2,188	0.78 (0.49-1.25)	3.00 (2.35-3.82)	6.52 (5.54-7.67)	11.32 (10.01-12.79)	16.08 (14.36-17.98)	16.60 (14.81-18.60)	*19.46 (16.79-22.49)*
CoP	37,294	0.71 (0.62-0.80)	1.18 (1.06-1.32)	1.53 (1.37-1.72)	1.87 (1.65-2.12)	2.48 (2.11-2.91)	2.64 (2.22-3.13)	*4.21 (3.10-5.70)*
CoC	23,206	0.59 (0.50-0.70)	1.04 (0.91-1.19)	1.57 (1.40-1.76)	2.04 (1.83-2.27)	2.78 (2.47-3.11)	3.13 (2.75-3.56)	*3.31 (2.87-3.82)*
Others/unsure	2,282	1.16 (0.79-1.70)	1.55 (1.11-2.17)	1.96 (1.45-2.66)	2.62 (1.98-3.47)	3.52 (2.68-4.62)	3.52 (2.68-4.62)	*3.87 (2.85-5.24)*
All reverse hybrids	22,552	0.78 (0.68-0.91)	1.50 (1.34-1.68)	2.03 (1.82-2.26)	2.55 (2.28-2.85)	4.00 (3.36-4.76)	4.32 (3.57-5.23)	*5.73 (4.14-7.92)*
Reverse hybrids by bearing surface								
MoP	15,255	0.82 (0.69-0.99)	1.47 (1.27-1.69)	2.02 (1.76-2.30)	2.51 (2.19-2.87)	4.18 (3.37-5.19)	4.37 (3.49-5.46)	*6.64 (4.29-10.21)*
CoP	7,200	0.68 (0.51-0.91)	1.51 (1.23-1.85)	2.00 (1.65-2.43)	2.52 (2.07-3.07)	*3.54 (2.65-4.72)*	*4.20 (2.84-6.20)*	*4.20 (2.84-6.20)*
Others/unsure	97**	*2.08 (0.53-8.08)*	*5.56 (2.35-12.86)*	*5.56 (2.35-12.86)*	*8.40 (4.06-16.93)*	*8.40 (4.06-16.93)*		
All resurfacing (MoM)	39,318	1.24 (1.13-1.35)	3.07 (2.90-3.25)	5.51 (5.28-5.75)	8.18 (7.90-8.47)	11.47 (11.11-11.84)	12.34 (11.94-12.74)	13.98 (13.41-14.57)

* Includes 39 with unsure fixation/bearing surface.
** Wide CI because based on very small group size (n=97).

Figure 3.5

Comparison of cumulative probability of revision (Kaplan-Meier estimates) for **cemented** primary hip replacements with different bearing surfaces.

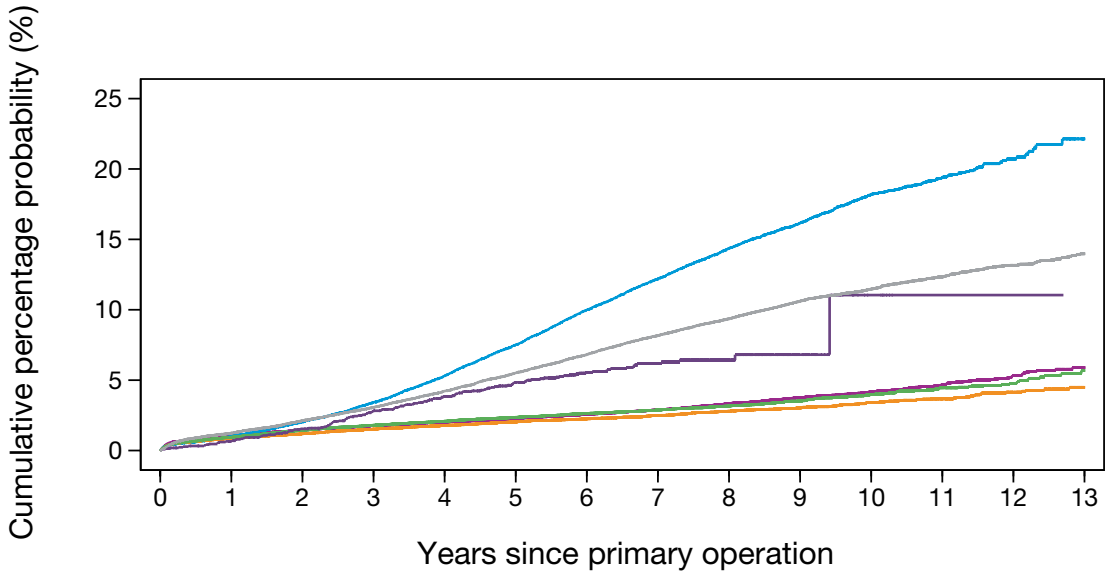


Number at risk

Cemented MoP	270,476	242,126	214,673	186,554	159,779	134,548	111,865	91,418	72,403	54,218	37,084	23,605	12,163	4,184
Cemented MoM	1,098	1,079	1,048	1,020	976	934	873	793	694	494	321	173	78	14
Cemented CoP	33,041	28,423	23,988	19,737	16,129	12,934	10,301	8,022	6,164	4,488	3,131	1,924	937	259

Figure 3.6

Comparison of cumulative probability of revision (Kaplan-Meier estimates) for **uncemented** primary hip replacements with different bearing surfaces.

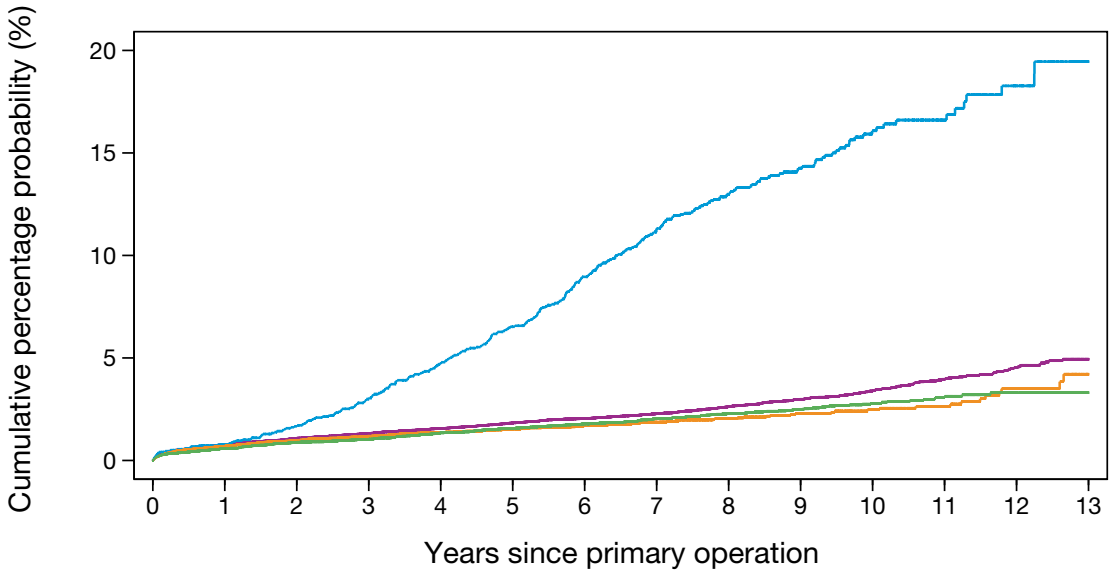


Number at risk

Uncemented MoP	133,873	116,605	100,644	84,375	69,229	54,834	42,228	30,868	21,562	14,098	8,860	5,043	2,189	541
Uncemented MoM	28,816	28,217	27,656	26,900	25,954	24,816	23,386	20,500	15,445	9,576	4,858	2,062	554	117
Uncemented CoP	64,644	52,666	42,380	33,774	26,897	21,086	16,552	12,657	9,584	7,200	5,025	3,209	1,596	522
Uncemented CoC	113,185	103,237	92,499	79,621	66,197	51,211	36,764	24,569	15,867	9,626	5,592	2,933	1,387	400
Uncemented CoM	2,155	2,125	2,087	2,034	1,959	1,860	1,523	840	290	47	7	1	1	0
Resurfacing	39,318	38,098	36,900	35,618	34,223	32,599	30,236	27,116	22,648	17,096	11,569	7,102	3,558	1,178

Figure 3.7

Comparison of cumulative probability of revision (Kaplan-Meier estimates) for **hybrid** primary hip replacements with different bearing surfaces.

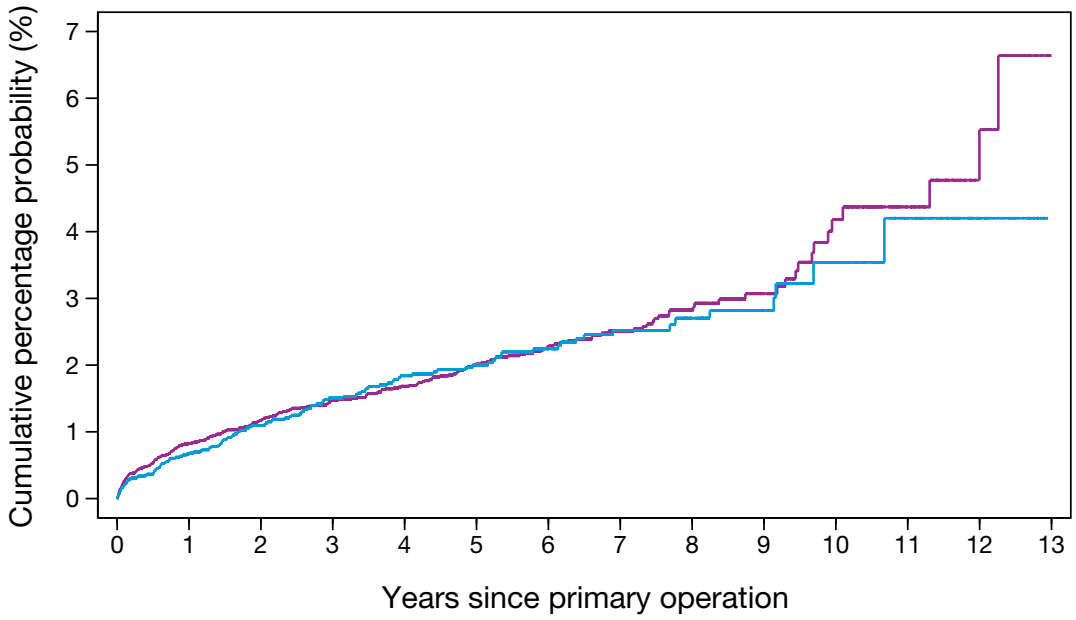


Number at risk

Hybrid MoP	105,619	89,439	75,371	62,342	51,531	41,893	33,194	25,847	19,192	13,474	8,638	5,073	2,424	750
Hybrid MoM	2,188	2,144	2,089	2,023	1,942	1,879	1,763	1,574	1,330	898	525	306	170	65
Hybrid CoP	37,294	27,455	19,594	13,408	9,326	6,920	5,290	3,949	2,817	1,974	1,402	897	487	153
Hybrid CoC	23,206	21,481	19,487	17,298	14,990	12,680	10,391	8,318	6,380	4,661	3,011	1,623	647	149

Figure 3.8

Comparison of cumulative probability of revision (Kaplan-Meier estimates) for **reverse hybrid** primary hip replacements with different bearing surfaces.



Number at risk

Rev. Hyb. MoP	15,255	13,103	11,071	9,158	7,418	5,786	4,232	2,975	1,904	1,019	536	290	125	27
Rev. Hyb. CoP	7,200	6,245	5,303	4,297	3,490	2,677	2,008	1,440	937	527	222	129	65	26

Figure 3.9 (a)

Cumulative probability of revision (Kaplan-Meier) for the whole cohort of primary hip replacements broken down by age separately for each gender.

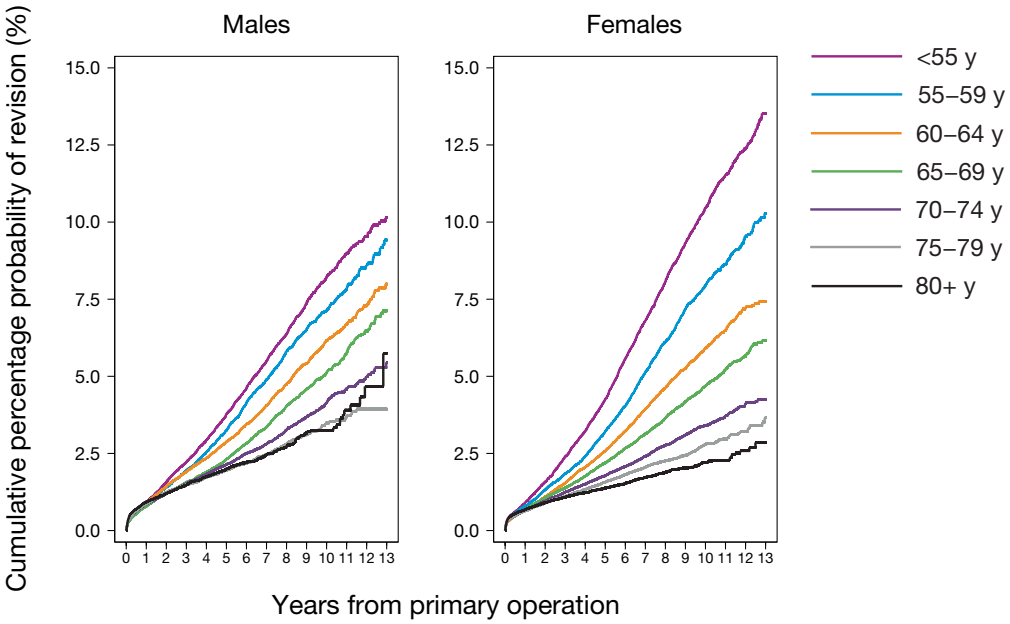


Figure 3.9 (b)

Cumulative probability of revision (Kaplan-Meier) for the whole cohort of primary hip replacements broken down by age separately for each gender, but excluding metal-on-metal (or uncertain) total hip replacement and resurfacings.

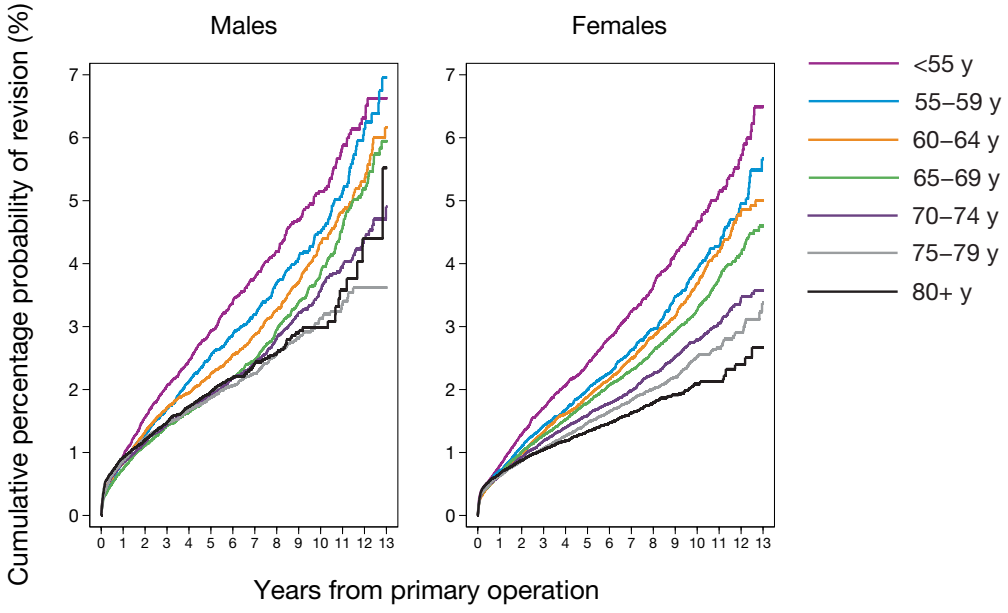


Table 3.7 Kaplan-Meier estimates of the cumulative percentage probability of revision (95% CI), by gender and age, at 1, 3, 5, 7, 10 and 13 years from the primary hip replacement, for each fixation group and main bearing surface. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

Fixation/ bearing types	Age at primary (years)	Males							Females						
		n	Years from primary operation						n	Years from primary operation					
			1 year	3 years	5 years	7 years	10 years	13 years		1 year	3 years	5 years	7 years	10 years	13 years
All cases	<55	53,803	0.91 (0.84-1.00)	2.24 (2.11-2.38)	3.78 (3.60-3.98)	5.51 (5.27-5.77)	8.26 (7.89-8.64)	10.14 (9.54-10.77)	53,757	0.92 (0.84-1.00)	2.40 (2.27-2.55)	4.27 (4.07-4.48)	6.83 (6.55-7.12)	10.48 (10.05-10.93)	13.52 (12.75-14.34)
All cemented	<55	4,377	0.70 (0.48-1.00)	1.91 (1.51-2.41)	2.93 (2.39-3.60)	4.40 (3.64-5.32)	6.54 (5.42-7.88)	*9.34 (7.64-11.39)*	6,588	0.65 (0.48-0.89)	1.61 (1.30-1.98)	2.47 (2.06-2.96)	3.95 (3.34-4.66)	5.85 (4.97-6.88)	*7.67 (6.28-9.33)*
MoP	<55	1,894	0.94 (0.59-1.51)	2.27 (1.64-3.12)	3.33 (2.51-4.41)	4.10 (3.14-5.35)	6.68 (5.16-8.63)	*10.04 (7.75-12.97)*	3,246	0.91 (0.63-1.31)	1.91 (1.47-2.49)	2.57 (2.02-3.27)	3.82 (3.06-4.75)	5.76 (4.67-7.10)	*7.33 (5.83-9.19)*
CoP	<55	2,136	0.55 (0.30-0.99)	1.35 (0.89-2.04)	2.01 (1.39-2.90)	2.87 (1.99-4.13)	*3.48 (2.36-5.12)*	*4.67 (2.97-7.31)*	3,013	0.38 (0.21-0.69)	1.15 (0.79-1.67)	1.88 (1.35-2.62)	2.83 (2.05-3.89)	3.79 (2.68-5.35)	*6.92 (3.90-12.13)*
All uncemented	<55	28,561	0.97 (0.86-1.09)	2.45 (2.26-2.66)	4.01 (3.74-4.29)	5.84 (5.47-6.23)	9.30 (8.65-9.99)	*11.02 (10.03-12.11)*	31,058	0.97 (0.86-1.08)	2.31 (2.14-2.50)	3.90 (3.65-4.17)	5.95 (5.60-6.33)	9.08 (8.49-9.71)	*11.93 (10.66-13.35)*
MoP	<55	3,305	0.99 (0.69-1.40)	2.30 (1.79-2.94)	3.38 (2.69-4.25)	5.02 (4.02-6.25)	6.52 (5.19-8.16)	*7.26 (5.67-9.28)*	4,079	1.23 (0.93-1.63)	2.16 (1.73-2.70)	2.99 (2.43-3.68)	3.66 (2.97-4.50)	4.62 (3.68-5.80)	*8.14 (5.33-12.33)*
MoM	<55	3,241	0.68 (0.45-1.03)	3.52 (2.94-4.22)	7.41 (6.55-8.38)	11.35 (10.28-12.51)	18.26 (16.69-19.97)	*22.04 (19.02-25.47)*	2,365	1.78 (1.32-2.40)	5.71 (4.84-6.72)	12.59 (11.31-14.00)	19.94 (18.36-21.63)	26.96 (25.02-29.02)	*35.27 (29.50-41.79)*
CoP	<55	5,023	1.28 (0.99-1.65)	2.26 (1.82-2.81)	3.27 (2.63-4.07)	3.64 (2.90-4.56)	4.01 (3.15-5.09)	*4.50 (3.32-6.07)*	5,693	0.88 (0.67-1.17)	1.63 (1.29-2.05)	2.35 (1.89-2.93)	3.10 (2.47-3.90)	4.27 (3.24-5.62)	*4.69 (3.45-6.36)*
CoC	<55	16,417	0.93 (0.79-1.09)	2.19 (1.96-2.45)	3.04 (2.74-3.36)	3.79 (3.42-4.21)	5.05 (4.40-5.79)	*6.43 (5.17-7.98)*	18,192	0.81 (0.69-0.96)	1.86 (1.66-2.08)	2.52 (2.27-2.79)	3.26 (2.94-3.62)	4.95 (4.32-5.67)	*5.96 (4.86-7.31)*
All hybrid	<55	7,022	0.91 (0.71-1.17)	1.58 (1.29-1.94)	2.45 (2.03-2.94)	3.98 (3.35-4.73)	6.22 (5.23-7.38)	*8.00 (6.35-10.06)*	9,411	0.67 (0.52-0.86)	1.26 (1.03-1.53)	1.96 (1.65-2.34)	3.09 (2.63-3.62)	4.39 (3.71-5.19)	*6.35 (4.95-8.13)*
MoP	<55	1,304	1.30 (0.80-2.11)	2.31 (1.57-3.39)	3.45 (2.42-4.89)	4.62 (3.27-6.49)	*7.65 (5.44-10.69)*	*11.05 (7.24-16.67)*	1,946	0.87 (0.54-1.42)	1.75 (1.21-2.51)	2.51 (1.81-3.48)	3.42 (2.51-4.65)	5.11 (3.70-7.05)	*7.88 (5.18-11.91)*
CoP	<55	2,530	1.03 (0.69-1.53)	1.53 (1.05-2.24)	1.88 (1.26-2.79)	*2.63 (1.61-4.28)*	*3.13 (1.87-5.22)*	*3.13 (1.87-5.22)*	3,170	0.53 (0.33-0.87)	1.11 (0.75-1.64)	1.52 (1.03-2.25)	2.48 (1.63-3.76)	*3.66 (2.29-5.82)*	*7.85 (2.72-21.54)*
CoC	<55	2,802	0.69 (0.44-1.08)	1.28 (0.91-1.79)	1.84 (1.36-2.49)	2.59 (1.95-3.44)	3.33 (2.47-4.47)	*3.33 (2.47-4.47)*	3,927	0.57 (0.38-0.87)	0.91 (0.64-1.27)	1.36 (1.01-1.84)	2.16 (1.65-2.83)	3.04 (2.30-4.02)	*4.08 (2.90-5.72)*
All reverse hybrid	<55	632	0.80 (0.33-1.92)	1.82 (0.98-3.37)	*1.82 (0.98-3.37)*	*1.82 (0.98-3.37)*	*5.10 (2.03-12.49)*		883	0.83 (0.40-1.74)	1.57 (0.89-2.77)	2.69 (1.64-4.38)	*3.78 (2.34-6.09)*	*5.29 (3.14-8.82)*	
MoP	<55	129	*0*	*2.86 (0.93-8.64)*	*2.86 (0.93-8.64)*	*2.86 (0.93-8.64)*	*2.86 (0.93-8.64)*		197	*0*	*0*	*0.87 (0.12-6.01)*	*3.16 (1.02-9.57)*	*5.09 (1.85-13.65)*	
All resurfacing (MoM)	<55	13,207	0.88 (0.73-1.05)	2.24 (1.99-2.51)	4.12 (3.78-4.49)	5.87 (5.45-6.31)	8.30 (7.75-8.89)	10.10 (9.20-11.07)	5,813	1.33 (1.06-1.65)	4.97 (4.44-5.56)	9.33 (8.60-10.11)	14.38 (13.49-15.33)	20.41 (19.31-21.58)	*24.51 (22.89-26.23)*

Note: Includes cases with unknown fixation/bearing but excludes the 207 cases where the ages were unveritable, plus a further one with uncertain gender.

Fixation/ bearing types	Age at primary (years)	Males							Females						
		n	Years from primary operation						n	Years from primary operation					
			1 year	3 years	5 years	7 years	10 years	13 years		1 year	3 years	5 years	7 years	10 years	13 years
All cases	55-64	89,239	0.90 (0.84-0.97)	1.94 (1.84-2.04)	3.04 (2.91-3.17)	4.40 (4.23-4.58)	6.57 (6.31-6.83)	8.60 (8.12-9.11)	108,096	0.73 (0.68-0.78)	1.67 (1.59-1.75)	2.85 (2.74-2.97)	4.42 (4.27-4.59)	6.74 (6.50-6.98)	8.61 (8.20-9.04)
All cemented	55-64	15,008	0.64 (0.52-0.78)	1.47 (1.28-1.69)	2.06 (1.82-2.33)	2.85 (2.54-3.20)	4.71 (4.21-5.26)	6.66 (5.76-7.71)	24,386	0.44 (0.36-0.53)	1.12 (0.98-1.27)	1.76 (1.58-1.96)	2.58 (2.34-2.84)	4.17 (3.80-4.57)	5.85 (5.21-6.55)
MoP	55-64	9,785	0.64 (0.50-0.83)	1.70 (1.45-2.00)	2.38 (2.07-2.74)	3.18 (2.79-3.62)	5.12 (4.52-5.79)	7.23 (6.19-8.43)	16,945	0.48 (0.39-0.60)	1.20 (1.04-1.39)	1.80 (1.59-2.04)	2.54 (2.27-2.85)	4.13 (3.72-4.59)	5.59 (4.93-6.35)
CoP	55-64	4,593	0.62 (0.43-0.91)	0.91 (0.66-1.25)	1.12 (0.82-1.53)	1.44 (1.06-1.97)	2.20 (1.52-3.17)	*2.72 (1.68-4.39)*	6,685	0.28 (0.18-0.45)	0.76 (0.56-1.04)	1.19 (0.91-1.56)	1.67 (1.28-2.16)	2.47 (1.82-3.33)	*5.23 (3.33-8.17)*
All uncemented	55-64	46,888	0.94 (0.85-1.03)	2.05 (1.91-2.19)	3.26 (3.08-3.45)	4.93 (4.67-5.20)	7.61 (7.19-8.06)	9.74 (8.91-10.64)	54,882	0.84 (0.76-0.92)	1.83 (1.71-1.95)	3.08 (2.91-3.25)	4.85 (4.62-5.10)	7.52 (7.14-7.92)	9.17 (8.51-9.89)
MoP	55-64	11,172	1.03 (0.85-1.24)	2.13 (1.85-2.44)	2.83 (2.49-3.21)	3.73 (3.29-4.22)	5.33 (4.65-6.11)	*7.72 (6.28-9.47)*	14,516	0.81 (0.68-0.97)	1.74 (1.52-1.98)	2.27 (2.01-2.56)	3.04 (2.70-3.41)	4.56 (4.01-5.18)	*6.76 (5.53-8.26)*
MoM	55-64	5,109	0.84 (0.63-1.14)	3.04 (2.61-3.56)	6.56 (5.91-7.29)	10.96 (10.11-11.87)	17.07 (15.84-18.38)	*19.03 (17.33-20.88)*	4,807	0.88 (0.65-1.18)	3.61 (3.11-4.18)	8.91 (8.13-9.76)	15.42 (14.41-16.50)	22.09 (20.77-23.47)	*25.13 (23.01-27.40)*
CoP	55-64	9,842	0.87 (0.70-1.08)	1.52 (1.27-1.83)	2.16 (1.82-2.57)	2.77 (2.32-3.30)	3.56 (2.95-4.29)	*5.48 (4.25-7.06)*	12,037	0.69 (0.56-0.86)	1.44 (1.22-1.70)	2.05 (1.76-2.39)	2.59 (2.23-3.02)	3.92 (3.28-4.67)	*4.58 (3.75-5.61)*
CoC	55-64	19,837	0.94 (0.81-1.09)	1.85 (1.67-2.06)	2.51 (2.27-2.76)	3.07 (2.78-3.39)	4.15 (3.63-4.74)	*6.11 (4.51-8.25)*	22,257	0.90 (0.78-1.03)	1.59 (1.43-1.77)	2.15 (1.95-2.37)	2.63 (2.39-2.91)	3.61 (3.18-4.09)	*4.31 (3.65-5.10)*
All hybrid	55-64	13,962	0.79 (0.66-0.96)	1.55 (1.34-1.79)	2.31 (2.03-2.63)	2.94 (2.59-3.33)	4.50 (3.94-5.13)	*6.71 (5.55-8.11)*	21,467	0.56 (0.47-0.68)	1.15 (1.00-1.31)	1.81 (1.61-2.04)	2.51 (2.25-2.81)	3.59 (3.21-4.01)	5.15 (4.35-6.09)
MoP	55-64	5,009	1.02 (0.77-1.34)	1.78 (1.43-2.22)	2.50 (2.05-3.04)	2.85 (2.34-3.47)	4.69 (3.83-5.73)	*7.59 (5.76-9.97)*	8,537	0.68 (0.52-0.88)	1.18 (0.96-1.45)	1.88 (1.58-2.24)	2.57 (2.18-3.02)	3.50 (2.97-4.12)	*5.18 (4.17-6.44)*
CoP	55-64	4,651	0.67 (0.46-0.96)	1.29 (0.95-1.75)	1.63 (1.19-2.23)	1.89 (1.35-2.63)	*2.85 (1.81-4.47)*	*5.31 (2.98-9.35)*	6,700	0.57 (0.41-0.79)	1.09 (0.83-1.43)	1.36 (1.03-1.79)	1.71 (1.27-2.31)	2.59 (1.81-3.72)	*6.25 (3.17-12.15)*
CoC	55-64	3,778	0.59 (0.39-0.89)	1.09 (0.80-1.49)	1.84 (1.42-2.39)	2.30 (1.79-2.95)	3.00 (2.31-3.90)	*3.54 (2.61-4.81)*	5,552	0.38 (0.25-0.59)	0.90 (0.67-1.20)	1.34 (1.05-1.71)	1.74 (1.38-2.19)	2.25 (1.78-2.85)	*2.64 (1.96-3.54)*
All reverse hybrid	55-64	1,760	0.97 (0.59-1.58)	2.24 (1.58-3.16)	3.09 (2.23-4.26)	3.68 (2.66-5.09)	*6.25 (3.92-9.89)*		2,780	0.79 (0.51-1.20)	1.63 (1.19-2.23)	2.29 (1.72-3.05)	3.03 (2.28-4.00)	*4.84 (3.33-7.00)*	*5.70 (3.70-8.74)*
MoP	55-64	670	0.96 (0.43-2.12)	1.74 (0.94-3.23)	2.98 (1.73-5.11)	*3.48 (2.02-5.96)*	*7.43 (3.78-14.33)*		1,165	1.06 (0.60-1.86)	1.82 (1.16-2.85)	2.88 (1.94-4.25)	3.83 (2.62-5.59)	*7.04 (4.40-11.17)*	
All resurfacing (MoM)	55-64	11,617	1.22 (1.04-1.44)	2.42 (2.15-2.72)	3.96 (3.61-4.34)	5.60 (5.18-6.06)	7.54 (7.01-8.11)	9.36 (8.45-10.37)	4,577	1.62 (1.29-2.03)	4.49 (3.93-5.13)	8.59 (7.81-9.45)	12.91 (11.96-13.94)	17.58 (16.43-18.80)	*21.06 (19.38-22.86)*

Note: Includes cases with unknown fixation/bearing but excludes the 207 cases where the ages were unveritable, plus a further one with uncertain gender.

Fixation/ bearing types	Age at primary (years)	Males							Females						
		n	Years from primary operation						n	Years from primary operation					
			1 year	3 years	5 years	7 years	10 years	13 years		1 year	3 years	5 years	7 years	10 years	13 years
All cases	65-74	123,588	0.83 (0.78-0.88)	1.55 (1.48-1.63)	2.24 (2.15-2.34)	3.10 (2.97-3.22)	4.65 (4.46-4.85)	6.33 (5.93-6.77)	189,584	0.67 (0.64-0.71)	1.32 (1.26-1.37)	1.98 (1.91-2.06)	2.76 (2.67-2.86)	4.04 (3.89-4.18)	5.19 (4.93-5.47)
All cemented	65-74	41,510	0.56 (0.49-0.64)	1.14 (1.04-1.25)	1.65 (1.52-1.80)	2.31 (2.14-2.50)	3.58 (3.32-3.87)	5.43 (4.88-6.05)	75,790	0.41 (0.37-0.46)	1.01 (0.93-1.09)	1.47 (1.38-1.57)	1.95 (1.83-2.07)	2.82 (2.65-3.00)	3.90 (3.59-4.23)
MoP	65-74	36,086	0.58 (0.51-0.67)	1.18 (1.07-1.31)	1.69 (1.55-1.85)	2.35 (2.17-2.55)	3.64 (3.35-3.94)	5.54 (4.94-6.21)	67,003	0.40 (0.35-0.45)	0.99 (0.91-1.07)	1.47 (1.37-1.58)	1.95 (1.83-2.08)	2.84 (2.66-3.03)	3.92 (3.60-4.27)
CoP	65-74	4,504	0.40 (0.25-0.64)	0.87 (0.61-1.22)	1.24 (0.90-1.70)	1.52 (1.11-2.08)	2.37 (1.71-3.26)	*3.48 (2.21-5.47)*	7,279	0.52 (0.38-0.73)	1.16 (0.92-1.47)	1.33 (1.06-1.67)	1.55 (1.23-1.95)	1.82 (1.39-2.36)	*2.87 (1.77-4.63)*
All uncemented	65-74	52,498	0.97 (0.89-1.06)	1.82 (1.70-1.94)	2.64 (2.48-2.80)	3.71 (3.50-3.93)	5.70 (5.33-6.08)	*7.69 (6.75-8.77)*	67,779	0.92 (0.85-0.99)	1.70 (1.60-1.81)	2.64 (2.51-2.79)	3.91 (3.72-4.11)	5.97 (5.64-6.31)	7.38 (6.74-8.08)
MoP	65-74	22,964	0.94 (0.82-1.07)	1.70 (1.53-1.89)	2.13 (1.93-2.36)	2.78 (2.51-3.08)	4.38 (3.88-4.94)	*6.02 (5.01-7.24)*	32,804	0.95 (0.85-1.06)	1.57 (1.44-1.72)	2.02 (1.85-2.20)	2.52 (2.31-2.75)	3.62 (3.26-4.02)	*4.68 (3.97-5.51)*
MoM	65-74	4,538	1.06 (0.80-1.41)	2.99 (2.53-3.53)	6.00 (5.33-6.75)	9.28 (8.44-10.20)	13.79 (12.58-15.11)	*14.93 (13.09-17.01)*	4,655	1.10 (0.84-1.44)	3.46 (2.97-4.03)	8.51 (7.74-9.37)	13.73 (12.75-14.79)	20.08 (18.72-21.52)	*25.21 (20.96-30.14)*
CoP	65-74	10,595	0.78 (0.62-0.97)	1.25 (1.04-1.51)	1.48 (1.24-1.78)	1.77 (1.47-2.14)	2.37 (1.90-2.95)	*4.80 (2.88-7.93)*	13,101	0.81 (0.66-0.98)	1.48 (1.27-1.73)	1.94 (1.67-2.25)	2.44 (2.11-2.83)	3.35 (2.85-3.95)	*4.06 (3.20-5.15)*
CoC	65-74	13,366	1.14 (0.97-1.34)	1.86 (1.63-2.11)	2.34 (2.07-2.64)	2.64 (2.34-2.98)	3.57 (2.97-4.28)	*5.98 (3.98-8.94)*	15,901	0.86 (0.73-1.02)	1.48 (1.30-1.69)	1.80 (1.59-2.04)	2.10 (1.85-2.39)	2.66 (2.23-3.17)	*4.10 (2.47-6.78)*
All hybrid	65-74	23,384	0.85 (0.74-0.98)	1.46 (1.30-1.64)	2.04 (1.83-2.27)	2.57 (2.31-2.85)	4.10 (3.65-4.61)	*4.75 (4.14-5.44)*	39,469	0.74 (0.66-0.83)	1.23 (1.11-1.35)	1.76 (1.61-1.93)	2.28 (2.09-2.49)	3.18 (2.88-3.51)	4.39 (3.79-5.07)
MoP	65-74	15,060	0.83 (0.70-1.00)	1.45 (1.26-1.67)	1.99 (1.75-2.27)	2.45 (2.15-2.79)	4.07 (3.53-4.69)	*4.88 (4.13-5.77)*	26,915	0.73 (0.63-0.84)	1.27 (1.13-1.42)	1.76 (1.58-1.95)	2.21 (1.99-2.45)	3.14 (2.80-3.53)	*4.23 (3.60-4.96)*
CoP	65-74	5,296	0.88 (0.65-1.18)	1.44 (1.10-1.89)	1.68 (1.26-2.23)	2.08 (1.51-2.86)	*2.92 (1.94-4.41)*	*2.92 (1.94-4.41)*	8,475	0.74 (0.57-0.96)	1.10 (0.88-1.38)	1.59 (1.25-2.03)	1.74 (1.35-2.23)	1.74 (1.35-2.23)	*2.66 (1.59-4.43)*
CoC	65-74	2,442	0.76 (0.48-1.20)	1.34 (0.94-1.91)	2.03 (1.49-2.76)	2.03 (1.49-2.76)	2.85 (1.99-4.07)		3,293	0.75 (0.50-1.12)	0.94 (0.65-1.34)	1.38 (1.01-1.89)	1.87 (1.38-2.53)	2.82 (2.00-3.97)	
All reverse hybrid	65-74	3,188	0.93 (0.64-1.34)	1.83 (1.38-2.42)	2.35 (1.80-3.06)	3.20 (2.44-4.18)	*4.32 (2.70-6.89)*		5,713	0.55 (0.38-0.78)	1.02 (0.77-1.34)	1.53 (1.19-1.97)	1.87 (1.45-2.41)	*3.63 (2.41-5.44)*	*3.63 (2.41-5.44)*
MoP	65-74	2,185	1.12 (0.74-1.68)	1.99 (1.44-2.75)	2.65 (1.96-3.59)	3.25 (2.39-4.41)	*4.49 (2.50-7.99)*		4,192	0.55 (0.36-0.83)	0.96 (0.69-1.34)	1.43 (1.06-1.94)	1.90 (1.41-2.57)	*4.22 (2.67-6.65)*	
All resurfacing (MoM)	65-74	3,004	1.88 (1.45-2.44)	3.01 (2.45-3.70)	4.44 (3.74-5.27)	6.25 (5.39-7.24)	7.85 (6.82-9.02)	*9.44 (7.99-11.14)*	824	1.95 (1.20-3.16)	3.79 (2.68-5.35)	6.73 (5.20-8.70)	10.71 (8.73-13.12)	16.38 (13.72-19.50)	*17.77 (14.78-21.29)*

Note: Includes cases with unknown fixation/bearing but excludes the 207 cases where the ages were unveritable, plus a further one with uncertain gender.

Fixation/ bearing types	Age at primary (years)	Males							Females						
		n	Years from primary operation						n	Years from primary operation					
			1 year	3 years	5 years	7 years	10 years	13 years		1 year	3 years	5 years	7 years	10 years	13 years
All cases	75+	91,320	0.90 (0.84-0.97)	1.49 (1.41-1.58)	1.98 (1.87-2.09)	2.47 (2.33-2.61)	3.42 (3.19-3.66)	4.38 (3.77-5.09)	181,085	0.67 (0.63-0.70)	1.10 (1.05-1.15)	1.48 (1.42-1.55)	1.90 (1.82-1.99)	2.55 (2.42-2.68)	3.33 (2.99-3.71)
All cemented	75+	43,902	0.69 (0.62-0.78)	1.20 (1.10-1.32)	1.62 (1.49-1.77)	2.04 (1.88-2.23)	2.73 (2.48-3.02)	*3.33 (2.90-3.83)*	98,969	0.41 (0.37-0.45)	0.81 (0.76-0.88)	1.13 (1.06-1.21)	1.48 (1.39-1.58)	2.01 (1.87-2.16)	2.61 (2.29-2.97)
MoP	75+	41,552	0.70 (0.62-0.79)	1.22 (1.11-1.34)	1.64 (1.50-1.79)	2.08 (1.91-2.27)	2.77 (2.51-3.07)	*3.36 (2.91-3.88)*	93,910	0.40 (0.37-0.45)	0.80 (0.74-0.87)	1.12 (1.05-1.21)	1.46 (1.36-1.56)	2.00 (1.86-2.16)	2.61 (2.28-2.99)
CoP	75+	1,565	0.54 (0.27-1.08)	1.09 (0.64-1.85)	1.41 (0.84-2.35)	1.41 (0.84-2.35)	*1.86 (1.00-3.44)*		3,258	0.39 (0.22-0.68)	0.72 (0.46-1.12)	1.04 (0.69-1.57)	1.36 (0.90-2.05)	1.36 (0.90-2.05)	*1.36 (0.90-2.05)*
All uncemented	75+	26,028	1.29 (1.15-1.43)	1.95 (1.78-2.14)	2.59 (2.37-2.83)	3.20 (2.91-3.50)	4.86 (4.26-5.54)	*7.13 (4.01-12.52)*	39,806	1.26 (1.15-1.37)	1.80 (1.67-1.94)	2.32 (2.16-2.49)	3.00 (2.79-3.22)	4.19 (3.80-4.61)	*6.70 (4.56-9.77)*
MoP	75+	17,260	1.34 (1.18-1.53)	2.02 (1.80-2.25)	2.53 (2.27-2.82)	2.95 (2.62-3.32)	3.65 (3.17-4.22)	*7.36 (2.75-18.90)*	27,734	1.26 (1.13-1.40)	1.71 (1.55-1.87)	2.14 (1.95-2.34)	2.58 (2.35-2.84)	3.64 (3.18-4.16)	*4.31 (3.48-5.32)*
MoM	75+	1,693	1.08 (0.68-1.71)	1.97 (1.40-2.78)	3.74 (2.90-4.83)	5.61 (4.52-6.97)	*10.16 (7.92-12.98)*		2,404	1.30 (0.91-1.84)	3.01 (2.38-3.78)	4.84 (4.03-5.81)	7.15 (6.12-8.34)	*9.51 (7.96-11.35)*	
CoP	75+	3,471	1.18 (0.87-1.62)	1.59 (1.20-2.11)	2.18 (1.65-2.88)	2.18 (1.65-2.88)	*3.19 (1.91-5.29)*		4,864	1.01 (0.76-1.34)	1.51 (1.18-1.92)	1.79 (1.41-2.27)	2.03 (1.59-2.60)	2.87 (2.13-3.86)	*3.96 (2.21-7.02)*
CoC	75+	3,127	1.24 (0.91-1.70)	1.96 (1.51-2.53)	2.14 (1.66-2.77)	2.35 (1.81-3.06)	*4.87 (2.80-8.43)*		4,064	1.44 (1.12-1.86)	1.87 (1.49-2.35)	2.12 (1.70-2.64)	2.40 (1.91-3.01)	*3.58 (2.33-5.49)*	
All hybrid	75+	18,675	0.82 (0.70-0.97)	1.47 (1.29-1.68)	1.90 (1.67-2.16)	2.44 (2.13-2.79)	3.55 (2.95-4.28)	*5.57 (4.02-7.69)*	37,157	0.70 (0.62-0.79)	1.09 (0.98-1.21)	1.49 (1.35-1.65)	1.84 (1.66-2.05)	2.36 (2.06-2.69)	*2.96 (2.30-3.81)*
MoP	75+	15,515	0.79 (0.65-0.94)	1.48 (1.28-1.71)	1.92 (1.67-2.22)	2.40 (2.07-2.78)	3.50 (2.85-4.30)	*5.87 (4.10-8.36)*	31,303	0.74 (0.65-0.85)	1.13 (1.01-1.26)	1.50 (1.34-1.67)	1.78 (1.59-1.99)	2.33 (2.01-2.70)	*3.03 (2.28-4.02)*
CoP	75+	2,312	0.90 (0.57-1.41)	1.34 (0.88-2.03)	1.60 (1.06-2.44)	*1.60 (1.06-2.44)*	*1.60 (1.06-2.44)*		4,148	0.52 (0.33-0.81)	0.82 (0.55-1.21)	1.21 (0.79-1.84)	1.21 (0.79-1.84)	*1.21 (0.79-1.84)*	
CoC	75+	471	1.31 (0.59-2.89)	1.56 (0.75-3.25)	*1.93 (0.96-3.89)*	*1.93 (0.96-3.89)*	*3.66 (1.36-9.66)*		941	0.33 (0.11-1.03)	0.91 (0.43-1.92)	1.18 (0.57-2.44)	*1.18 (0.57-2.44)*	*1.74 (0.78-3.86)*	
All reverse hybrid	75+	2,510	1.06 (0.72-1.56)	2.01 (1.48-2.73)	2.30 (1.70-3.10)	2.42 (1.79-3.28)	*2.79 (1.93-4.02)*		5,082	0.75 (0.54-1.04)	1.22 (0.94-1.59)	1.65 (1.28-2.13)	2.14 (1.65-2.77)	*2.25 (1.73-2.94)*	
MoP	75+	2,227	1.15 (0.77-1.71)	2.17 (1.59-2.95)	2.41 (1.76-3.29)	2.41 (1.76-3.29)	*2.82 (1.91-4.16)*		4,487	0.76 (0.54-1.07)	1.24 (0.94-1.64)	1.69 (1.29-2.21)	2.11 (1.59-2.78)	*2.24 (1.68-2.98)*	
All resurfacing (MoM)	75+	202	*2.01 (0.76-5.27)*	*2.01 (0.76-5.27)*	*3.99 (1.91-8.25)*	*6.29 (3.40-11.51)*	*6.29 (3.40-11.51)*		64	*1.61 (0.23-10.90)*	*3.43 (0.87-13.08)*	*5.33 (1.74-15.67)*	*7.53 (2.87-18.98)*	*13.69 (4.98-34.58)*	

Note: Includes cases with unknown fixation/bearing but excludes the 207 cases where the ages were unveritable, plus a further one with uncertain gender.

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

This section updates results from last year's report on the effect of prosthesis head size on the probability of revision following primary surgery. In total, six bearing groups were defined:

(a) Metal-on-polyethylene cemented monobloc cups n=282,044

(b) Metal-on-polyethylene uncemented metal shells with polyethylene liners n=236,122

(c) Metal-on-metal uncemented metal cups or metal shells with metal liners n=30,983

(d) Ceramic-on-polyethylene cemented monobloc cups n=39,710

(e) Ceramic-on-polyethylene uncemented metal shells with polyethylene liners n=100,409

(f) Ceramic-on-ceramic uncemented metal shells with ceramic liners n=133,227

Figures 3.10 (a) to 3.10 (f) show respective percentage cumulative probabilities of revision (Kaplan-Meier) for various head sizes, for each of the above groups with follow-up up to 13 years following the primary operation.

In Figure 3.10 (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.

Figure 3.10 (b.i) shows revision rates for different head sizes for metal-on-polyethylene uncemented metal shell with polyethylene liners. Figure 3.10 (b.ii) shows the same data but with the 44mm head data truncated just prior to ten years from primary operation. This is to allow closer inspection of the difference between the other head sizes. There was a statistically significant effect of head size (overall P<0.001), with head size 44mm showing worse failure rates, but there were small numbers after eight years.

In Figure 3.10 (c) for metal-on-metal uncemented metal cup / metal shell with liners, there was a similar effect of head size (overall P<0.001), with head size 46mm having the worst failure rate during the first ten years of follow-up.

Results were similar for ceramic-on-polyethylene cemented monobloc cups shown in Figure 3.10 (d), with a statistically significant difference between the head sizes overall (P=<0.001) with head size 36mm having the worst failure rate.

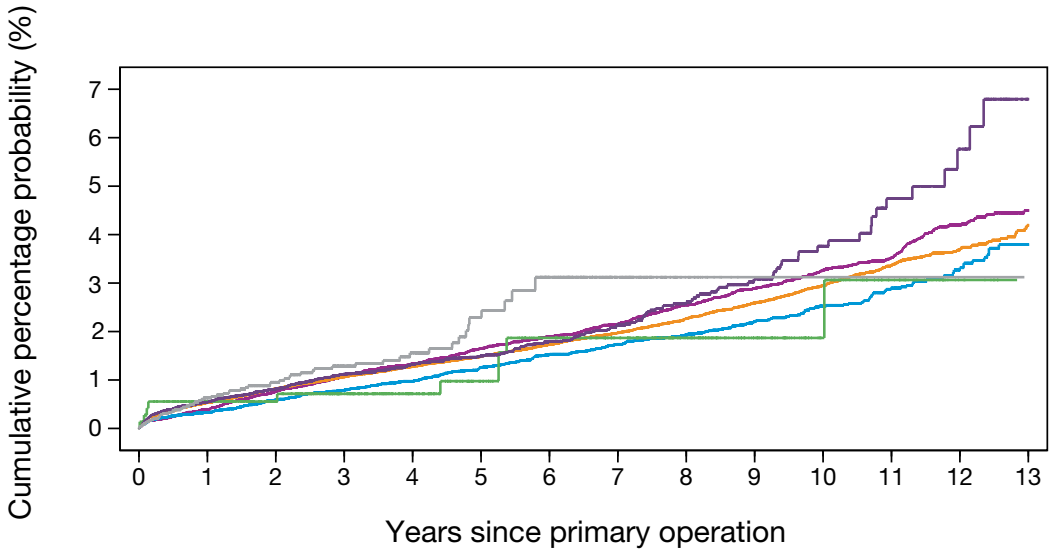
For ceramic-on-polyethylene metal shells used with polyethylene liners (Figure 3.10 (e)), whilst there was a statistically significant difference between the three head sizes shown (P=0.016), the best implant survival was in the intermediate size group (32mm) with 28mm and 36mm showing similar worse outcomes.

Figure 3.10 (f) showed statistically significant differences between all four head sizes shown (P=0.002) for ceramic-on-ceramic uncemented metal shells used with ceramic liners. Head size 40mm showed the best survival rate, though there were small numbers in this bearing group. Head sizes 28mm, 32mm, and 36mm showed similar failure rates but were worse than those of head size 40mm.

Figure 3.10 (a)

Effect of head size on cumulative revision rates after primary hip replacement using different bearing groups (only head sizes used in >500 hips are shown):

(a) **Metal-on-polyethylene cemented monobloc cups**



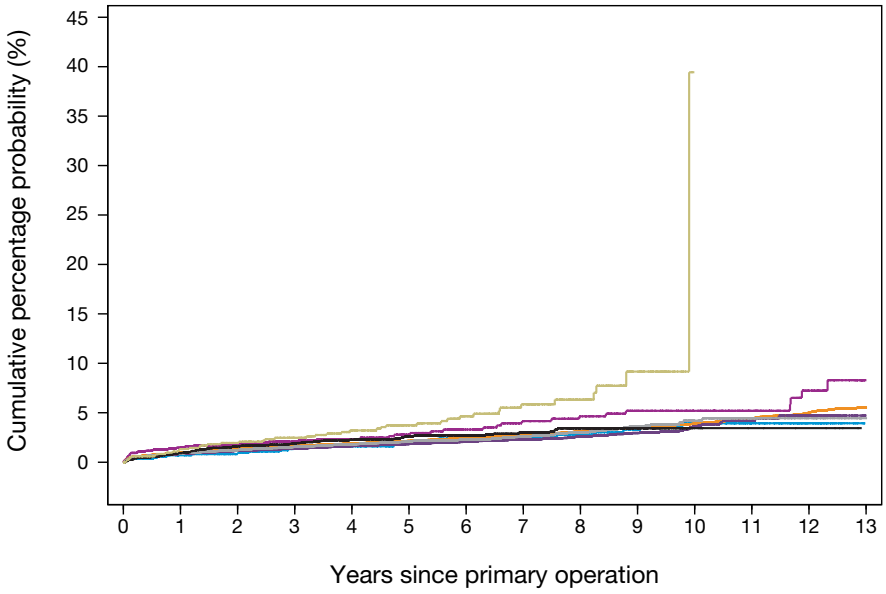
Number at risk

Head size = 22.25mm	33,604	32,120	30,587	28,893	26,823	24,437	21,938	19,282	16,505	13,665	10,558	7,546	4,506	1,742
Head size = 26mm	18,584	17,931	17,259	16,324	15,176	13,853	12,367	10,968	9,208	7,384	5,561	3,889	2,125	724
Head size = 28mm	177,774	161,098	144,101	125,736	107,688	90,373	74,086	59,138	45,446	32,216	20,391	11,852	5,371	1,667
Head size = 30mm	722	683	629	524	412	346	305	258	188	128	82	47	13	4
Head size = 32mm	46,923	37,124	28,387	20,796	14,699	9,782	6,454	4,107	2,517	1,555	859	456	220	63
Head size = 36mm	4,365	3,454	2,672	1,875	1,199	647	299	117	18	1	1	1	1	0

Figure 3.10 (b)

Effect of head size on cumulative revision rates after primary hip replacement using different bearing groups (only head sizes used in >500 hips are shown):

(b.i) **Metal-on-polyethylene uncemented metal shells with polyethylene liners**



Number at risk

Head size = 22.25mm	1,510	1,217	1,013	850	702	592	501	429	374	322	259	190	113	40
Head size = 26mm	866	827	783	737	682	628	560	483	418	339	255	173	92	22
Head size = 28mm	93,202	85,875	78,663	71,043	63,530	55,633	47,420	39,078	30,829	22,468	15,011	8,954	4,096	1,185
Head size = 32mm	88,377	71,243	56,065	41,871	30,272	21,056	14,036	8,741	4,890	2,485	1,197	458	154	13
Head size = 36mm	47,765	39,734	32,878	26,287	20,283	14,404	9,371	5,346	2,472	1,060	392	134	59	12
Head size = 40mm	3,403	3,255	3,082	2,872	2,624	2,170	1,690	1,174	701	230	16	8	6	0
Head size = 44mm	842	805	773	703	606	488	382	263	155	46	0	0	0	0

(b.ii) **Metal-on-polyethylene with truncated data for head size 44mm**

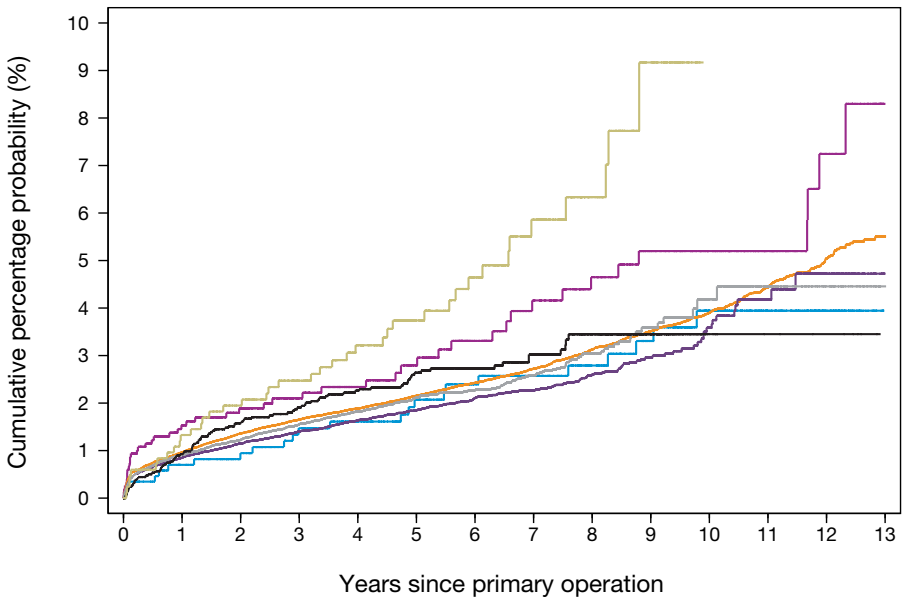
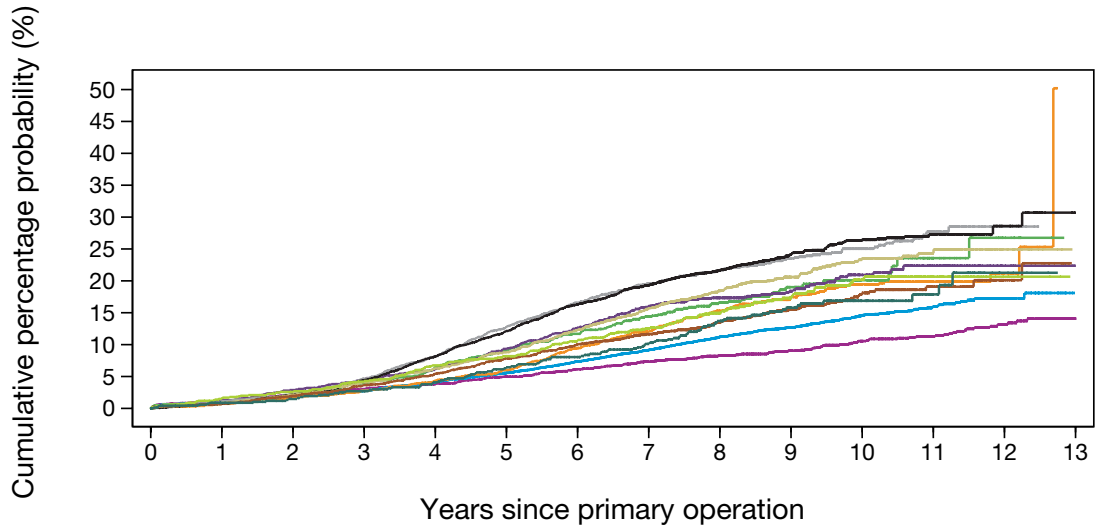


Figure 3.10 (c)

Effect of head size on cumulative revision rates after primary hip replacement using different bearing groups (only head sizes used in >500 hips are shown):

(c) **Metal-on-metal uncemented metal cups or metal shells with metal liners**



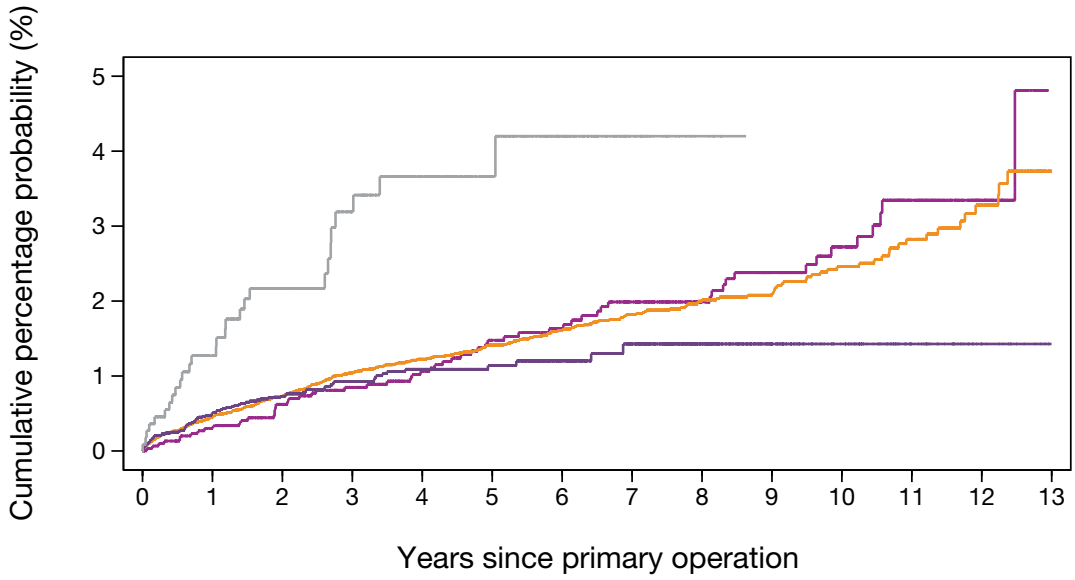
Number at risk

Head size = 28mm	2,262	2,220	2,190	2,149	2,107	1,997	1,867	1,701	1,441	1,148	803	591	331	106
Head size = 36mm	12,939	12,623	12,355	12,049	11,633	11,191	10,599	9,147	6,541	3,862	1,831	703	162	25
Head size = 38mm	1,525	1,504	1,479	1,442	1,399	1,345	1,266	1,124	976	750	456	222	36	0
Head size = 40mm	892	870	842	816	779	740	706	625	431	183	95	33	11	1
Head size = 42mm	1,191	1,171	1,143	1,114	1,089	1,040	987	857	696	452	226	92	22	4
Head size = 44mm	1,964	1,932	1,900	1,834	1,748	1,639	1,529	1,364	1,045	585	298	115	29	2
Head size = 46mm	3,389	3,334	3,260	3,154	2,992	2,826	2,622	2,349	1,886	1,198	590	201	41	13
Head size = 48mm	2,263	2,230	2,190	2,111	2,029	1,949	1,815	1,582	1,206	698	323	126	22	3
Head size = 50mm	2,248	2,214	2,164	2,094	2,027	1,940	1,846	1,651	1,290	808	381	151	40	14
Head size = 52mm	1,010	988	972	944	908	883	823	720	537	328	170	57	9	2
Head size = 54mm	684	668	653	634	615	589	561	498	394	263	139	60	17	11

Figure 3.10 (d)

Effect of head size on cumulative revision rates after primary hip replacement using different bearing groups (only head sizes used in >500 hips are shown):

(d) **Ceramic-on-polyethylene cemented monobloc cups**



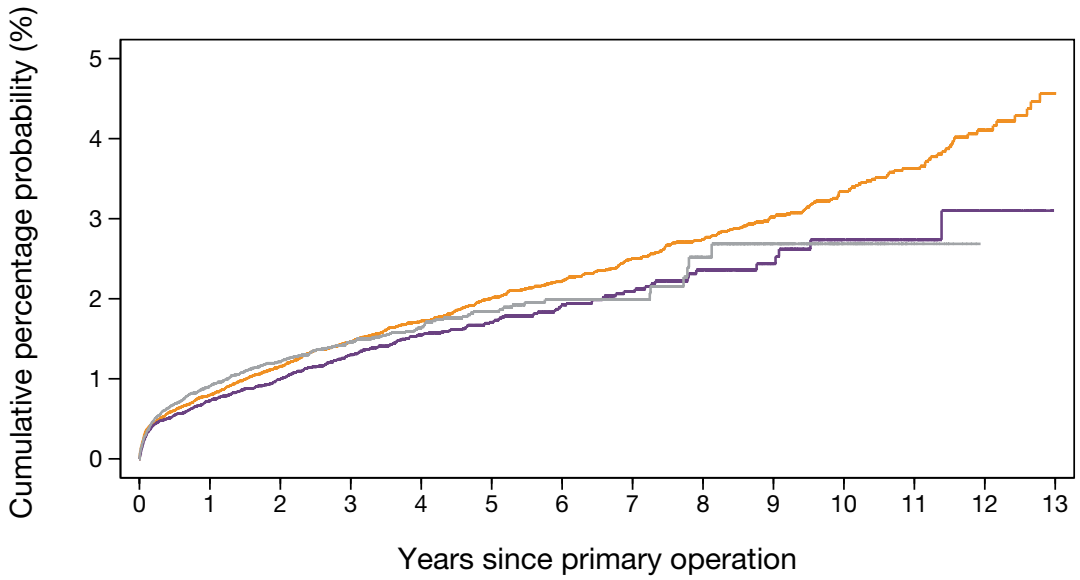
Number at risk

Head size = 22.25mm	3,030	2,904	2,713	2,484	2,254	2,011	1,750	1,533	1,311	1,038	747	448	177	0
Head size = 28mm	25,760	22,779	19,822	16,742	13,995	11,435	9,201	7,137	5,372	3,787	2,488	1,548	804	278
Head size = 32mm	9,801	7,738	5,842	4,152	2,907	1,906	1,212	721	378	169	103	49	19	6
Head size = 36mm	1,114	833	602	431	302	182	97	32	6	0	0	0	0	0

Figure 3.10 (e)

Effect of head size on cumulative revision rates after primary hip replacement using different bearing groups (only head sizes used in >500 hips are shown):

(e) **Ceramic-on-polyethylene uncemented metal shells with polyethylene liners**



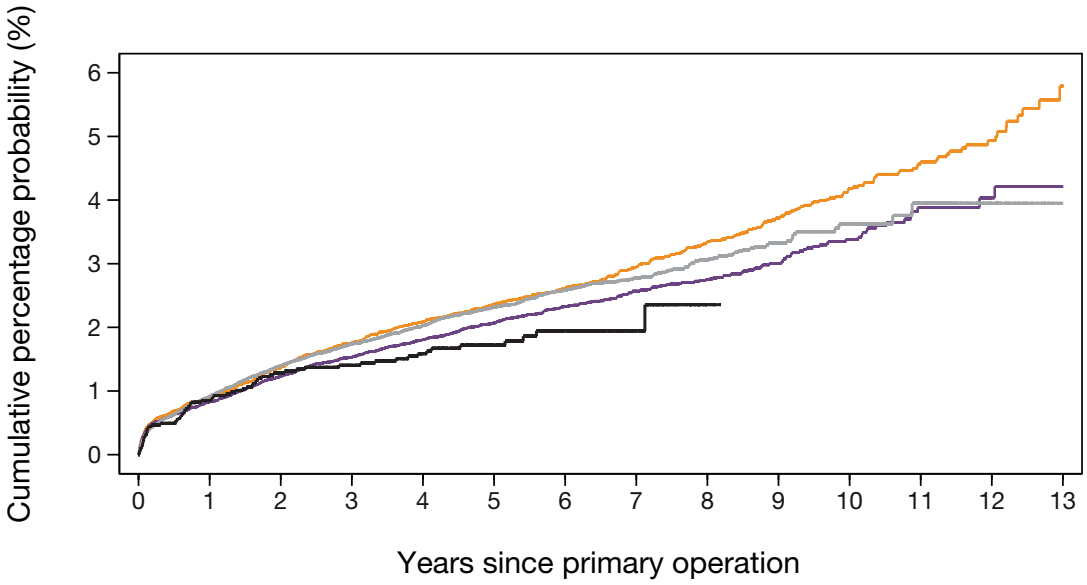
Number at risk

Head size = 28mm	28,484	25,293	22,604	19,971	17,783	15,649	13,594	11,586	9,535	7,548	5,462	3,589	1,890	640
Head size = 32mm	41,126	30,729	22,237	15,640	10,959	7,709	5,269	3,247	1,923	1,087	663	375	141	30
Head size = 36mm	30,262	22,373	15,717	10,482	6,598	3,971	2,461	1,401	643	291	114	16	0	0

Figure 3.10 (f)

Effect of head size on cumulative revision rates after primary hip replacement using different bearing groups (only head sizes used in >500 hips are shown):

(f) **Ceramic-on-ceramic uncemented metal shells with ceramic liners**



Number at risk

Head size = 28mm	17,751	16,988	16,185	15,185	14,081	12,732	11,066	9,379	7,780	6,049	4,300	2,708	1,381	390
Head size = 32mm	41,867	38,425	34,616	30,144	25,417	20,284	15,348	11,315	7,929	5,154	2,970	1,431	543	134
Head size = 36mm	69,507	62,738	55,236	46,331	37,390	27,800	18,959	11,597	6,446	3,036	1,307	402	103	21
Head size = 40mm	4,089	3,793	3,473	3,018	2,410	1,604	868	279	15	0	0	0	0	0

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

Table 3.8 shows Kaplan-Meier estimates of the cumulative percentage probability of revision (for any reason) for the main stem-cup brands.

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 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.

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.

Sub-groups with more than 10,000 procedures in Table 3.8 have been further divided by bearing surface. Table 3.9 shows the estimated cumulative percentage probabilities for the resulting fixation/bearing sub-groups provided there were more than 1,000 procedures.

Note: no further sub-divisions were made for Charnley Cemented Stem/Charnley Cemented Cup, as all the procedures described in Table 3.8 were Cemented MoP. Similarly, the majority of the cemented CPT/ZCA and Exeter V40/Exeter Duration combinations shown in Table 3.8 were MoP.

Table 3.8 Kaplan-Meier estimates of the cumulative percentage probability of revision (95% CI) at 1, 3, 5, 7, 10, and 13 years after the primary hip replacement operation, for the most commonly used cup-stem brand combinations (group sizes >2,500, or >1,000 in the case of resurfacings). *Blue italics indicate that fewer than 250 cases remained at risk at these time points.*

Stem/cup brand	n	Median (IQR) age at primary	Percentage (%) males	Cumulative percentage probability of revision (95% CI) at:					
				1 year	3 years	5 years	7 years	10 years	13 years
Cemented									
Charnley Cemented Stem / Charnley Ogee	10,076	73 (67-78)	38%	0.37 (0.27-0.52)	1.18 (0.98-1.42)	1.88 (1.62-2.18)	2.49 (2.18-2.85)	3.93 (3.48-4.43)	5.28 (4.57-6.10)
Charnley Cemented Stem / Charnley Cemented Cup	4,510	72 (66-78)	38%	0.31 (0.19-0.53)	1.11 (0.83-1.46)	1.72 (1.37-2.16)	2.31 (1.89-2.83)	3.52 (2.94-4.21)	4.90 (4.02-5.98)
Charnley Cemented Stem / Charnley and Elite Plus LPW	6,590	74 (68-79)	29%	0.34 (0.22-0.51)	0.72 (0.53-0.96)	1.12 (0.88-1.42)	1.51 (1.22-1.86)	2.43 (2.01-2.94)	2.90 (2.38-3.52)
C-Stem Cemented Stem / Elite Plus Ogee	4,912	72 (66-77)	40%	0.36 (0.22-0.57)	0.82 (0.60-1.14)	1.08 (0.81-1.45)	1.44 (1.10-1.89)	2.31 (1.78-3.00)	2.85 (2.13-3.80)
C-Stem Cemented Stem / Marathon	6,025	67 (59-75)	41%	0.37 (0.24-0.57)	0.96 (0.71-1.30)	1.28 (0.95-1.72)	2.07 (1.44-2.97)		
MS-30 / Original ME Muller Low Profile C	3,164	74 (67-80)	31%	0.22 (0.11-0.47)	0.49 (0.29-0.83)	0.81 (0.52-1.26)	1.07 (0.69-1.65)	*1.65 (1.01-2.70)*	*2.57 (1.19-5.50)*
Muller Straight Stem Original / ME Muller Low Profile C	2,644	74 (69-79)	30%	0.46 (0.26-0.81)	0.88 (0.58-1.36)	1.13 (0.76-1.68)	1.94 (1.36-2.77)	2.34 (1.64-3.33)	*3.10 (2.01-4.78)*
Stanmore Modular Stem / Stanmore-Arcom Cup	5,181	75 (70-80)	29%	0.43 (0.29-0.66)	1.11 (0.85-1.45)	1.59 (1.26-2.00)	1.95 (1.56-2.43)	2.45 (1.95-3.07)	*4.10 (3.00-5.58)*
CPT / Elite Plus Ogee	2,955	73 (67-79)	36%	0.65 (0.42-1.02)	1.42 (1.04-1.93)	1.90 (1.44-2.51)	2.39 (1.83-3.12)	3.15 (2.36-4.21)	*3.53 (2.53-4.91)*
CPT / ZCA	12,996	76 (71-81)	30%	0.78 (0.64-0.95)	1.34 (1.14-1.57)	2.01 (1.74-2.32)	2.57 (2.24-2.94)	3.58 (3.09-4.15)	*4.42 (3.65-5.34)*
Exeter V40 / Exeter Contemporary Flanged	69,842	74 (68-79)	34%	0.40 (0.36-0.46)	0.86 (0.79-0.94)	1.22 (1.12-1.32)	1.57 (1.45-1.69)	2.27 (2.07-2.48)	*3.54 (2.94-4.25)*
Exeter V40 / Elite Plus Ogee	23,535	74 (69-80)	35%	0.34 (0.28-0.43)	0.77 (0.66-0.90)	1.11 (0.97-1.27)	1.51 (1.33-1.71)	2.15 (1.89-2.44)	2.71 (2.26-3.25)
Exeter V40 / Exeter Duration	16,726	73 (67-79)	32%	0.58 (0.48-0.71)	1.19 (1.03-1.37)	1.65 (1.46-1.87)	2.43 (2.17-2.72)	3.63 (3.26-4.05)	5.30 (4.49-6.25)
Exeter V40 / Opera	2,820	74 (68-80)	32%	0.40 (0.22-0.71)	0.81 (0.53-1.23)	1.16 (0.81-1.66)	1.56 (1.12-2.18)	3.18 (2.27-4.44)	5.24 (3.58-7.64)

Stem/cup brand	n	Median (IQR) age at primary	Percentage (%) males	Cumulative percentage probability of revision (95% CI) at:					
				1 year	3 years	5 years	7 years	10 years	13 years
Exeter V40 / Cenator Cemented Cup	2,551	75 (69-80)	32%	0.59 (0.36-0.98)	1.39 (0.99-1.94)	2.00 (1.51-2.66)	2.26 (1.72-2.97)	2.63 (2.00-3.45)	*5.54 (3.30-9.24)*
Exeter V40 / Elite Plus Cemented Cup	4,931	73 (66-78)	34%	0.31 (0.19-0.51)	0.61 (0.42-0.89)	0.81 (0.58-1.13)	1.03 (0.75-1.42)	1.53 (1.09-2.16)	*2.01 (1.38-2.92)*
Exeter V40 / Marathon	4,387	70 (63-77)	35%	0.44 (0.28-0.71)	0.95 (0.66-1.37)	1.36 (0.94-1.97)	1.66 (1.12-2.46)		
Exeter V40 / Exeter X3 Rimfit	20,960	69 (62-77)	36%	0.51 (0.42-0.62)	0.97 (0.82-1.15)	1.16 (0.96-1.40)			
Exeter V40 / Exeter Contemporary Hooded	24,433	75 (69-80)	32%	0.82 (0.71-0.94)	1.55 (1.39-1.72)	2.11 (1.91-2.32)	*2.80 (2.55-3.08)*	*4.20 (3.79-4.65)*	*6.12 (5.11-7.33)*
Exeter V40 / Charnley and Elite Plus LPW	4,422	73 (67-78)	32%	0.65 (0.45-0.94)	1.32 (1.00-1.73)	1.57 (1.22-2.03)	1.85 (1.43-2.39)	2.37 (1.79-3.14)	*2.59 (1.91-3.50)*
C-Stem AMT Cemented Stem / Elite Plus Ogee	3,153	77 (72-81)	31%	0.20 (0.09-0.45)	0.80 (0.51-1.26)	1.09 (0.71-1.67)	1.73 (1.14-2.64)	1.73 (1.14-2.64)	
C-Stem AMT Cemented Stem / Marathon	6,140	75 (69-80)	33%	0.38 (0.25-0.59)	0.90 (0.63-1.29)	1.30 (0.84-1.99)	1.30 (0.84-1.99)		
C-Stem AMT Cemented Stem / Charnley and Elite Plus LPW	2,894	75 (71-79)	32%	0.60 (0.38-0.97)	1.17 (0.83-1.67)	1.48 (1.07-2.04)	*1.83 (1.30-2.56)*	*2.57 (1.69-3.91)*	
Uncemented									
Accolade / Trident	24,868	66 (59-73)	43%	0.92 (0.81-1.05)	1.91 (1.74-2.10)	2.65 (2.44-2.88)	3.23 (2.97-3.51)	4.57 (4.05-5.16)	5.36 (3.95-7.24)
Corail / Duraloc Cementless Cup	4,044	70 (64-75)	39%	0.75 (0.52-1.06)	1.69 (1.33-2.14)	2.50 (2.05-3.04)	3.57 (3.02-4.22)	5.59 (4.81-6.49)	*9.69 (7.97-11.74)*
Corail / Pinnacle	122,635	66 (59-73)	44%	0.81 (0.76-0.86)	1.64 (1.57-1.72)	2.56 (2.45-2.66)	3.93 (3.78-4.09)	6.52 (6.20-6.87)	*8.17 (6.91-9.64)*
Corail / Trilogy	2,883	68 (62-74)	39%	0.64 (0.41-1.02)	1.17 (0.83-1.65)	1.67 (1.24-2.25)	2.28 (1.73-2.99)	3.32 (2.44-4.50)	*4.66 (2.95-7.33)*
Corail / ASR Resurfacing Cup	2,630	61 (54-67)	54%	1.07 (0.74-1.54)	7.52 (6.57-8.60)	23.31 (21.72-25.00)	35.32 (33.49-37.22)	44.07 (41.95-46.26)	
Corail / Pinnacle Gription	4,220	67 (58-75)	40%	1.11 (0.81-1.51)	1.99 (1.50-2.63)	2.36 (1.76-3.16)			
Furlong HAC Stem / CSF	16,907	69 (62-76)	40%	1.04 (0.90-1.21)	1.73 (1.54-1.94)	*2.11 (1.90-2.35)*	*2.65 (2.40-2.92)*	*3.59 (3.27-3.94)*	*4.59 (4.10-5.14)*
Furlong HAC Stem / Furlong HAC CSF Plus	20,681	66 (59-73)	44%	1.10 (0.97-1.25)	1.79 (1.61-1.99)	2.12 (1.91-2.34)	2.47 (2.22-2.75)		
Polarstem Cementless / R3 Cementless	6,137	66 (59-73)	45%	0.62 (0.45-0.87)	0.91 (0.68-1.22)	0.98 (0.72-1.32)	0.98 (0.72-1.32)		
SL-Plus Cementless Stem / EP-Fit Plus	5,218	65 (59-73)	43%	1.21 (0.94-1.55)	2.62 (2.21-3.11)	3.82 (3.31-4.42)	*4.52 (3.94-5.19)*	*5.91 (5.15-6.78)*	
Synergy Cementless Stem / R3 Cementless	2,999	65 (56-71)	50%	1.02 (0.71-1.46)	1.50 (1.09-2.07)	2.10 (1.49-2.95)	4.75 (3.02-7.44)		
Taperloc Cementless Stem / Exceed ABT	20,700	65 (58-72)	44%	1.10 (0.96-1.25)	1.52 (1.35-1.70)	1.84 (1.64-2.06)	*2.15 (1.89-2.44)*	*2.15 (1.89-2.44)*	
Anthology / R3 Cementless	3,474	63 (55-71)	42%	1.01 (0.72-1.42)	1.58 (1.17-2.12)	2.45 (1.78-3.35)	4.57 (2.90-7.15)		
Metafix Stem / Trinity	3,467	64 (56-69)	45%	0.83 (0.56-1.21)	1.50 (1.09-2.06)	1.65 (1.18-2.32)			
M/L Taper Cementless / Continuum	4,820	61 (53-68)	49%	1.15 (0.88-1.50)	1.81 (1.44-2.27)	1.96 (1.56-2.46)			
M/L Taper Cementless / Trilogy IT	2,889	63 (55-70)	52%	1.00 (0.69-1.46)	2.50 (1.84-3.39)	2.50 (1.84-3.39)			
Furlong Evolution Cementless / Furlong HAC CSF Plus	2,644	62 (52-70)	42%	1.34 (0.95-1.89)	1.97 (1.41-2.74)				
Hybrid									
CPT / Trilogy	17,437	72 (65-78)	35%	0.88 (0.75-1.04)	1.41 (1.23-1.61)	2.24 (1.98-2.54)	2.71 (2.40-3.07)	4.23 (3.65-4.90)	5.65 (4.42-7.21)
CPT / Continuum	4,627	68 (58-76)	37%	1.58 (1.24-2.00)	2.25 (1.82-2.80)	2.72 (2.15-3.45)	3.13 (2.37-4.11)		

Continued >

Stem/cup brand	n	Median (IQR) age at primary	Percentage (%) males	Cumulative percentage probability of revision (95% CI) at: 1 year	3 years	5 years	7 years	10 years	13 years
CPT / Trilogy IT	5,227	68 (61-75)	37%	1.33 (1.05-1.69)	2.20 (1.72-2.82)	2.32 (1.80-2.98)			
Exeter V40 / Pinnacle	6,437	72 (65-78)	36%	0.81 (0.61-1.07)	1.18 (0.92-1.50)	*1.61 (1.27-2.04)*	*1.84 (1.43-2.38)*	*2.17 (1.61-2.93)*	
Exeter V40 / Trident	60,984	69 (61-76)	39%	0.55 (0.50-0.62)	1.03 (0.94-1.12)	1.41 (1.29-1.52)	1.86 (1.71-2.02)	*2.61 (2.36-2.89)*	*2.89 (2.56-3.26)*
Exeter V40 / Trilogy	12,905	70 (63-76)	40%	0.59 (0.47-0.74)	0.98 (0.82-1.18)	1.35 (1.16-1.58)	1.67 (1.44-1.94)	2.40 (2.06-2.79)	*3.10 (2.48-3.86)*
Exeter V40 / ABG II Cementless Cup	2,622	65 (59-72)	35%	0.31 (0.15-0.62)	0.80 (0.52-1.24)	1.23 (0.85-1.76)	1.78 (1.30-2.44)	2.53 (1.90-3.37)	*3.66 (2.70-4.96)*
Exeter V40 / Tritanium	2,909	67 (60-74)	44%	1.13 (0.80-1.61)	1.92 (1.42-2.59)	2.34 (1.70-3.23)	2.61 (1.84-3.71)		
C-Stem AMT Cemented Stem / Pinnacle	7,821	71 (65-77)	38%	0.72 (0.55-0.94)	1.28 (1.02-1.61)	1.88 (1.48-2.39)	*2.12 (1.62-2.75)*	*3.96 (2.73-5.73)*	
Reverse hybrid									
Corail / Elite Plus Ogee	2,543	71 (65-77)	37%	0.56 (0.33-0.94)	1.34 (0.94-1.90)	1.93 (1.42-2.63)	2.21 (1.63-2.99)	2.65 (1.93-3.63)	
Corail / Marathon	9,276	70 (64-76)	38%	0.52 (0.39-0.70)	1.07 (0.85-1.34)	1.28 (1.02-1.61)	1.47 (1.15-1.88)		
Resurfacing									
Adept Resurfacing Cup	3,602	54 (48-60)	72%	1.17 (0.87-1.58)	2.52 (2.05-3.09)	4.54 (3.89-5.29)	6.30 (5.51-7.19)	8.87 (7.71-10.19)	
ASR Resurfacing Cup	3,060	55 (49-60)	68%	1.63 (1.24-2.15)	5.97 (5.18-6.87)	13.58 (12.41-14.85)	20.79 (19.38-22.28)	26.60 (24.99-28.29)	*31.30 (27.43-35.57)*
BHR Resurfacing Cup	20,974	55 (49-60)	74%	1.05 (0.92-1.20)	2.37 (2.17-2.59)	3.76 (3.50-4.03)	5.40 (5.08-5.73)	8.16 (7.74-8.60)	*10.30 (9.67-10.96)*
Cormet 2000 Resurfacing Cup	3,679	55 (48-60)	65%	1.50 (1.15-1.94)	3.68 (3.12-4.34)	7.68 (6.86-8.59)	12.21 (11.18-13.32)	17.75 (16.45-19.14)	22.11 (20.11-24.29)
Durom Resurfacing Cup	1,724	55 (49-60)	70%	1.33 (0.89-2.00)	3.60 (2.82-4.60)	5.57 (4.58-6.77)	7.61 (6.43-8.99)	8.83 (7.52-10.36)	
Recap Magnum	1,754	54 (49-60)	73%	1.83 (1.29-2.57)	3.38 (2.63-4.34)	5.56 (4.57-6.76)	8.00 (6.78-9.43)	10.29 (8.74-12.08)	
Conserve Plus Resurfacing Cup	1,345	56 (50-61)	63%	1.94 (1.32-2.83)	5.09 (4.04-6.42)	8.21 (6.85-9.82)	10.92 (9.34-12.75)	*13.56 (11.68-15.71)*	*13.56 (11.68-15.71)*

Please 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.

Table 3.9 Kaplan-Meier estimates of the cumulative percentage probability of revision (95% CI) at 1, 3, 5, 7, 10 and 13 years after the primary hip replacement for the most commonly used cup-stem brand combinations (group size >10,000) with further sub-division by main bearing surface; results are shown only for the bearing surface sub-groups with >1,000 procedures. *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	Cumulative percentage probability of revision (95% CI) at: 1 year	3 years	5 years	7 years	10 years	13 years
Cemented										
Exeter V40 / Contemporary Flanged	MoP	64,603	74 (69-80)	34%	0.39 (0.35-0.44)	0.85 (0.77-0.93)	1.21 (1.11-1.31)	1.57 (1.45-1.71)	2.28 (2.07-2.50)	3.50 (2.89-4.24)
	CoP	4,838	65 (60-70)	37%	0.52 (0.35-0.77)	0.99 (0.73-1.35)	1.31 (0.98-1.75)	1.42 (1.07-1.90)	2.10 (1.43-3.07)	*4.00 (1.85-8.53)*
Exeter V40 / Elite Plus Ogee	MoP	21,574	75 (70-80)	34%	0.35 (0.28-0.44)	0.79 (0.67-0.92)	1.11 (0.97-1.28)	1.50 (1.32-1.70)	2.14 (1.87-2.45)	2.75 (2.26-3.34)
	CoP	1,748	65 (59-71)	44%	0.30 (0.12-0.72)	0.70 (0.39-1.26)	1.08 (0.65-1.81)	1.35 (0.82-2.21)	*2.05 (1.24-3.39)*	*2.05 (1.24-3.39)*

Stem/cup brand	Bearing surface	n	Median (IQR) age at primary	Percentage (%) males	Cumulative percentage probability of revision (95% CI) at: 1 year	3 years	5 years	7 years	10 years	13 years
Exeter V40 / Exeter X3 Rimfit	MoP	14,760	72 (66-79)	34%	0.52 (0.41-0.66)	0.96 (0.79-1.17)	1.16 (0.91-1.48)			
	CoP	6,144	62 (56-67)	40%	0.47 (0.32-0.69)	0.99 (0.73-1.35)	1.16 (0.85-1.58)			
Exeter V40 / Contemporary Hooded	MoP	23,024	75 (70-80)	32%	0.82 (0.71-0.95)	1.53 (1.37-1.71)	2.09 (1.90-2.31)	2.79 (2.54-3.07)	4.12 (3.71-4.57)	*6.21 (5.10-7.55)*
	CoP	1,259	67 (61-72)	39%	0.71 (0.35-1.41)	2.03 (1.31-3.14)	2.58 (1.73-3.85)	3.14 (2.13-4.60)	*5.82 (3.82-8.82)*	*5.82 (3.82-8.82)*
Uncemented										
Accolade / Trident	MoP	11,698	71 (65-76)	41%	0.99 (0.82-1.19)	2.01 (1.77-2.30)	2.76 (2.46-3.11)	3.50 (3.10-3.94)	*5.76 (4.21-7.86)*	
	CoP	5,647	62 (56-68)	45%	0.72 (0.53-0.98)	1.52 (1.20-1.91)	1.95 (1.55-2.44)	2.20 (1.69-2.85)	*3.33 (2.28-4.85)*	
	CoC	7,335	62 (55-68)	46%	0.97 (0.77-1.22)	2.03 (1.73-2.38)	2.83 (2.46-3.25)	3.31 (2.89-3.78)	4.38 (3.73-5.14)	*5.48 (3.62-8.24)*
Corail / Pinnacle	MoP	48,744	71 (65-77)	41%	0.82 (0.74-0.91)	1.37 (1.26-1.48)	1.70 (1.57-1.84)	2.17 (1.99-2.36)	3.05 (2.71-3.43)	
	MoM	11,938	67 (60-74)	47%	0.87 (0.72-1.05)	2.44 (2.17-2.73)	5.17 (4.77-5.59)	8.78 (8.26-9.32)	13.98 (13.18-14.83)	
	CoP	21,533	64 (57-70)	45%	0.72 (0.61-0.85)	1.21 (1.05-1.39)	1.74 (1.50-2.00)	2.16 (1.83-2.55)	*2.78 (2.25-3.44)*	
	CoC	37,846	60 (53-66)	48%	0.83 (0.74-0.93)	1.79 (1.65-1.93)	2.40 (2.24-2.58)	2.93 (2.73-3.15)	3.90 (3.48-4.37)	
	CoM	1,784	63 (57-70)	41%	0.45 (0.23-0.90)	2.67 (2.02-3.54)	4.39 (3.52-5.47)	5.76 (4.72-7.03)		
Furlong HAC / Stem CSF	MoP	7,873	73 (67-78)	39%	1.29 (1.06-1.56)	2.07 (1.77-2.42)	2.43 (2.10-2.81)	3.06 (2.67-3.50)	4.41 (3.86-5.04)	*5.04 (4.31-5.89)*
	CoP	7,097	67 (61-73)	41%	0.71 (0.54-0.94)	1.26 (1.02-1.55)	1.65 (1.37-1.98)	2.07 (1.74-2.45)	2.65 (2.25-3.12)	3.62 (2.98-4.39)
	CoC	1,646	59 (53-66)	44%	1.28 (0.84-1.95)	2.08 (1.49-2.90)	2.59 (1.92-3.49)	3.19 (2.43-4.18)	4.36 (3.42-5.55)	*5.97 (4.47-7.94)*
Furlong HAC Stem / Furlong HAC CSF Plus	MoP	5,054	74 (70-79)	39%	1.55 (1.24-1.93)	2.24 (1.85-2.72)	2.91 (2.42-3.50)	3.34 (2.76-4.05)		
	CoP	2,496	67 (62-71)	47%	1.00 (0.67-1.49)	1.84 (1.35-2.51)	2.02 (1.48-2.75)	2.46 (1.77-3.40)		
	CoC	13,042	63 (56-69)	46%	0.93 (0.78-1.12)	1.59 (1.38-1.83)	1.84 (1.60-2.11)	2.15 (1.87-2.48)		
Taperloc Cementless Stem Exceed ABT	MoP	6,489	72 (66-77)	41%	1.23 (0.99-1.54)	1.75 (1.44-2.12)	2.07 (1.71-2.52)	2.52 (2.01-3.15)		
	CoP	3,795	65 (58-70)	45%	0.91 (0.65-1.27)	1.07 (0.78-1.48)	1.43 (1.01-2.02)	*2.14 (1.40-3.25)*		
	CoC	10,227	61 (54-67)	46%	1.08 (0.90-1.31)	1.52 (1.29-1.79)	1.83 (1.56-2.14)	2.02 (1.71-2.39)	*2.02 (1.71-2.39)*	
Hybrid										
CPT / Trilogy	MoP	12,415	73 (67-78)	34%	0.83 (0.68-1.00)	1.37 (1.17-1.60)	2.20 (1.92-2.52)	2.69 (2.35-3.07)	4.29 (3.67-5.00)	*5.70 (4.41-7.36)*
	CoP	4,866	68 (61-75)	35%	1.02 (0.76-1.37)	1.47 (1.13-1.93)	*2.48 (1.56-3.94)*	*2.48 (1.56-3.94)*	*2.48 (1.56-3.94)*	
Exeter V40 / Trident	MoP	33,916	73 (67-79)	37%	0.58 (0.50-0.66)	1.10 (0.98-1.23)	1.44 (1.29-1.61)	1.85 (1.65-2.08)	2.71 (2.31-3.17)	*3.18 (2.56-3.96)*
	CoP	14,200	64 (57-71)	41%	0.48 (0.38-0.62)	0.88 (0.71-1.08)	1.16 (0.92-1.45)	1.46 (1.13-1.90)	*2.52 (1.59-3.97)*	
	CoC	12,175	59 (53-65)	43%	0.57 (0.45-0.72)	1.01 (0.84-1.21)	1.50 (1.28-1.74)	1.99 (1.73-2.29)	2.59 (2.23-3.01)	*2.81 (2.38-3.31)*
Exeter V40 / Trilogy	MoP	10,418	71 (65-77)	40%	0.58 (0.45-0.74)	0.92 (0.75-1.13)	1.33 (1.11-1.59)	1.67 (1.41-1.98)	2.49 (2.09-2.96)	*3.18 (2.46-4.10)*
	CoP	2,318	63 (58-68)	40%	0.57 (0.33-0.98)	1.05 (0.70-1.58)	1.31 (0.91-1.90)	1.58 (1.11-2.23)	1.91 (1.34-2.72)	*2.71 (1.65-4.41)*

Please 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.

3.3.5 Revisions for different causes after primary hip surgery

Methodological note

The preceding sections looked at first revisions for any reason. Given that several indications may have been given for a particular revision, these will not be mutually exclusive and so cannot be regarded as 'competing risks'.

Here we have calculated incidence rates for each reason using patient-time incidence-rates (PTIRs); the total number of revisions for that reason has been divided by the total of the individual patient-years at risk. The figures shown are numbers of revisions per 1,000 years at risk.

This method is appropriate if the hazard rate (the rate at which revisions occur in the unrevised cases) remains constant. The latter is further explored by sub-dividing the time interval from the primary operation into intervals and calculating PTIRs for each interval.

Overall, 24,065 (2.7%) of the 890,681 procedures had an associated first revision. The most commonly cited indications were aseptic loosening (cited in 5,841 procedures), pain (4,298), adverse soft tissue reaction to particulate debris (4,103, a figure that is likely to be an underestimate due to changes in MDS collection), dislocation/subluxation (4,038), and infection (3,325). Pain was not usually cited alone; in 3,010 out of the 4,298 instances, it was cited together with one or more other indications. Associated PTIRs for these, and the other indications are shown in Table 3.10. 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 under-estimated because this was not solicited (i.e. not an option) on the revision report forms in the early phase of the study, i.e. was missing for MDSv1/2. Some of these cases may have been put under 'other' but we simply do not know. Adoption of the later revision report forms (MDSv3) was staggered over time and so revisions associated with a few primaries as late as 2011 had revisions reported on versions 1 and 2 of the data collection form. By restricting our analyses to primaries from 2008 onwards however, as we did in our previous three annual reports, ensures that 99.3% of revisions had been recorded on later forms. We noted, however, that only 1,814 of the 4,103 instances of adverse reactions to particulate debris would thus be included, i.e. we are thereby missing 2,289 of the earlier cases. Therefore, as we did last year, we present two sets of PTIRs, one set for all primaries, which are likely to be underestimates, and the other set for all primaries performed since the beginning of 2008, which has better ascertainment but does not include the cases with longer term follow-up.

Table 3.10 includes further breakdowns by hip fixation and bearing. Metal-on-metal (irrespective of 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.

In Table 3.11, the PTIRs for each indication are shown separately for different time periods from the primary operation, within the first year from primary operation, and between 1-3, 3-5, 5-7, 7-10 and 10+ years after surgery. (Note the maximum follow-up for any implant is now 13.75 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, peri-prosthetic fracture, and mal-alignment 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 were low.

Finally, Figures 3.11 (a) to 3.11 (f) show how PTIRs for aseptic loosening, pain, dislocation/subluxation, infection and adverse soft tissue reaction to particulate debris changed with time in an arbitrary selection of the cemented/uncemented bearing sub-groups from Table 3.10. Only sub-groups with a total overall patient-years at risk of more than $>150x10^3$ have been included. With time from operation, PTIRs for aseptic loosening and pain tended to rise in uncemented metal-on-metal replacements and resurfacings. These trends were not seen in the other groups shown (Figures 3.11 (a) and (b)). Conversely, there was a high initial rate for dislocation/subluxation in all fixation/bearing groups which later fell (Figure 3.11 (c)). Revision rates for infection were initially high and then fell in all groups apart from uncemented metal-on-metal (Figure 3.11 (d)). Revision rates due to adverse reaction to particulate debris increased with time up to five years in uncemented metal-on-metal and resurfacings (Figures 3.11 (e) and (f)). Confidence Intervals have not been shown here for simplicity, but could be quite wide; these trends require more in-depth investigation.

Table 3.10 Revision rates after primary hip replacement for each indication, expressed as numbers per 1,000 patient-years (95% CI), for all cases and by fixation and bearing surface.

Fixation/ bearing types	Patient-years at risk (x1,000)	Number of revisions per 1,000 patient-years (95% CI) for:												Patient-years at risk (x1,000) for primaries from 1.1.2008****	Revisions per 1,000 patient-years (95% CI) for adverse reaction to particulate debris for primaries from 1.1.2008****
		Aseptic loosening	Pain	Dislocation/ subluxation	Infection	Peri-prosthetic fracture	Mal-alignment	Lysis	Implant wear	Implant fracture	Head/ socket size mismatch	Other indication	Adverse reaction to particulate debris***		
All cases*	4,553.4	1.28 (1.25-1.32)	0.94 (0.92-0.97)	0.89 (0.86-0.91)	0.73 (0.71-0.76)	0.67 (0.65-0.70)	0.39 (0.37-0.41)	0.29 (0.27-0.30)	0.28 (0.27-0.30)	0.16 (0.15-0.17)	0.04 (0.03-0.05)	0.52 (0.50-0.54)	0.90 (0.87-0.93)	2,766.3	0.66 (0.63-0.69)
All cemented	1,679.1	1.00 (0.95-1.04)	0.36 (0.33-0.39)	0.83 (0.79-0.87)	0.68 (0.64-0.72)	0.43 (0.40-0.46)	0.21 (0.19-0.24)	0.19 (0.17-0.21)	0.16 (0.14-0.18)	0.08 (0.06-0.09)	0.02 (0.01-0.02)	0.16 (0.14-0.18)	0.09 (0.07-0.10)	879.8	0.07 (0.05-0.09)
Cemented by bearing surface															
MoP	1,478.5	1.01 (0.96-1.06)	0.34 (0.32-0.38)	0.85 (0.81-0.90)	0.66 (0.62-0.71)	0.44 (0.41-0.47)	0.22 (0.19-0.24)	0.19 (0.17-0.21)	0.16 (0.14-0.18)	0.07 (0.05-0.08)	0.02 (0.01-0.03)	0.15 (0.13-0.17)	0.03 (0.02-0.04)	759.6	0.03 (0.02-0.04)
MoM	9.0	3.43 (2.41-4.88)	3.32 (2.32-4.75)	1.00 (0.52-1.91)	1.11 (0.60-2.06)	1.22 (0.67-2.20)	0.22 (0.06-0.88)	1.88 (1.17-3.03)	0.22 (0.06-0.88)	0.89 (0.44-1.77)	0.11 (0.02-0.79)	2.77 (1.87-4.09)	8.74 (7.01-10.90)	2.6	10.56 (7.24-15.40)
CoP	152.8	0.72 (0.60-0.87)	0.33 (0.25-0.43)	0.66 (0.54-0.80)	0.74 (0.61-0.89)	0.29 (0.21-0.39)	0.18 (0.12-0.26)	0.11 (0.07-0.18)	0.12 (0.07-0.19)	0.08 (0.04-0.14)	0.01 (0.00-0.05)	0.13 (0.08-0.20)	0.05 (0.02-0.10)	99.4	0.06 (0.03-0.13)
Others/ unsure	38.8	1.01 (0.73-1.38)	0.44 (0.27-0.71)	0.62 (0.41-0.92)	0.93 (0.67-1.29)	0.41 (0.25-0.67)	0.18 (0.09-0.38)	0.23 (0.12-0.45)	0.13 (0.05-0.31)	0.18 (0.09-0.38)	0	0.21 (0.10-0.41)	0.41 (0.25-0.67)	18.3	0.22 (0.08-0.58)
All uncemented	1,700.8	1.61 (1.55-1.67)	1.18 (1.13-1.23)	0.98 (0.93-1.02)	0.79 (0.75-0.83)	0.74 (0.70-0.78)	0.54 (0.50-0.57)	0.31 (0.28-0.33)	0.43 (0.40-0.46)	0.24 (0.21-0.26)	0.06 (0.05-0.08)	0.70 (0.66-0.74)	1.48 (1.42-1.54)	1,198.3	1.02 (0.97-1.08)
Uncemented by bearing surface															
MoP	617.2	1.22 (1.13-1.31)	0.64 (0.58-0.71)	1.23 (1.14-1.32)	0.73 (0.66-0.80)	0.95 (0.88-1.03)	0.49 (0.44-0.55)	0.21 (0.17-0.25)	0.45 (0.40-0.51)	0.10 (0.08-0.13)	0.06 (0.04-0.08)	0.31 (0.27-0.36)	0.16 (0.13-0.20)	443.1	0.19 (0.15-0.23)
MoM	224.6	3.67 (3.43-3.93)	4.29 (4.03-4.57)	0.92 (0.80-1.06)	1.43 (1.28-1.59)	0.67 (0.57-0.79)	0.91 (0.80-1.05)	1.21 (1.08-1.36)	0.69 (0.59-0.81)	0.18 (0.13-0.24)	0.09 (0.06-0.14)	2.64 (2.44-2.87)	10.00 (9.60-10.43)	106.7	9.55 (8.98-10.15)
CoP	264.8	1.19 (1.06-1.32)	0.56 (0.47-0.65)	1.03 (0.91-1.16)	0.67 (0.58-0.77)	0.61 (0.52-0.71)	0.43 (0.36-0.52)	0.15 (0.11-0.21)	0.40 (0.33-0.48)	0.10 (0.07-0.14)	0.05 (0.03-0.08)	0.34 (0.27-0.41)	0.08 (0.05-0.13)	178.4	0.10 (0.06-0.16)
CoC	546.5	1.36 (1.26-1.46)	0.79 (0.72-0.87)	0.70 (0.63-0.77)	0.66 (0.59-0.73)	0.58 (0.52-0.65)	0.47 (0.42-0.54)	0.11 (0.09-0.15)	0.31 (0.26-0.36)	0.46 (0.41-0.53)	0.06 (0.04-0.09)	0.52 (0.46-0.58)	0.16 (0.13-0.20)	438.9	0.16 (0.13-0.21)
CoM	13.9	2.81 (2.05-3.84)	1.80 (1.22-2.66)	0.72 (0.39-1.34)	1.29 (0.82-2.06)	0.43 (0.19-0.96)	0.86 (0.49-1.52)	0.58 (0.29-1.15)	0.79 (0.44-1.43)	0.22 (0.07-0.67)	0.14 (0.04-0.58)	1.22 (0.76-1.97)	1.51 (0.99-2.32)	13.4	1.49 (0.96-2.32)
Others/ unsure	33.8	1.89 (1.48-2.42)	1.06 (0.77-1.48)	0.89 (0.62-1.27)	0.56 (0.36-0.88)	0.86 (0.60-1.23)	0.56 (0.36-0.88)	0.30 (0.16-0.55)	0.38 (0.22-0.66)	0.38 (0.22-0.66)	0.09 (0.03-0.28)	0.53 (0.34-0.85)	1.06 (0.77-1.48)	17.7	0.79 (0.47-1.33)

*Including 39 with unknown fixation/bearing.

**Based on a small group size (n=97), therefore estimates are unreliable.

***Rates likely to be underestimated: this reason not solicited in the early phase of the registry (i.e. revision report forms MDSv1/MDSv2).

****For primaries from 2008 onwards the majority of revision report forms were MDSv3/MDSv6 which explicitly stated this reason for revision.

Continued >

Table 3.10 (continued)

Fixation/ bearing types	Patient-years at risk (x1,000)	Number of revisions per 1,000 patient-years (95% CI) for:												Patient-years at risk (x1,000) for primaries from 1.1.2008****	Revisions per 1,000 patient-years (95% CI) for adverse reaction to particulate debris for primaries from 1.1.2008****
		Aseptic loosening	Pain	Dislocation/ subluxation	Infection	Peri-prosthetic fracture	Mal-alignment	Lysis	Implant wear	Implant fracture	Head/ socket size mismatch	Other indication	Adverse reaction to particulate debris***		
All hybrid	758.6	0.65 (0.59-0.71)	0.49 (0.45-0.55)	1.04 (0.97-1.12)	0.77 (0.71-0.84)	0.84 (0.78-0.91)	0.30 (0.26-0.34)	0.20 (0.17-0.23)	0.23 (0.20-0.27)	0.15 (0.13-0.18)	0.03 (0.02-0.04)	0.30 (0.26-0.34)	0.24 (0.21-0.28)	492.9	0.16 (0.13-0.20)
Hybrid by bearing surface															
MoP	481.1	0.64 (0.57-0.71)	0.38 (0.33-0.44)	1.14 (1.05-1.24)	0.79 (0.71-0.87)	0.93 (0.85-1.02)	0.30 (0.25-0.35)	0.18 (0.15-0.23)	0.25 (0.21-0.30)	0.11 (0.09-0.15)	0.02 (0.01-0.04)	0.25 (0.20-0.29)	0.06 (0.05-0.09)	310.8	0.06 (0.04-0.10)
MoM	17.8	3.59 (2.81-4.59)	3.93 (3.11-4.96)	1.46 (0.99-2.14)	1.23 (0.81-1.87)	1.57 (1.08-2.27)	0.67 (0.38-1.19)	1.57 (1.08-2.27)	0.28 (0.12-0.67)	0.28 (0.12-0.67)	0.11 (0.03-0.45)	2.52 (1.88-3.38)	7.29 (6.14-8.66)	6.6	7.13 (5.36-9.49)
CoP	111.7	0.38 (0.29-0.52)	0.31 (0.22-0.44)	1.15 (0.97-1.37)	0.87 (0.71-1.06)	0.85 (0.70-1.04)	0.20 (0.13-0.30)	0.13 (0.07-0.21)	0.19 (0.12-0.29)	0.09 (0.05-0.17)	0.04 (0.01-0.10)	0.21 (0.14-0.32)	0.04 (0.02-0.11)	88.2	0.03 (0.01-0.11)
CoC	132.7	0.52 (0.41-0.66)	0.53 (0.42-0.68)	0.53 (0.42-0.68)	0.54 (0.43-0.68)	0.47 (0.36-0.60)	0.35 (0.26-0.46)	0.10 (0.06-0.17)	0.17 (0.12-0.26)	0.32 (0.24-0.44)	0.04 (0.02-0.09)	0.26 (0.19-0.37)	0.10 (0.06-0.17)	80.5	0.10 (0.05-0.20)
Others/ unsure	15.2	0.66 (0.35-1.22)	0.92 (0.55-1.56)	0.99 (0.60-1.64)	1.05 (0.65-1.72)	0.33 (0.14-0.79)	0.13 (0.03-0.53)	0.26 (0.10-0.70)	0.26 (0.10-0.70)	0.20 (0.06-0.61)	0	0.20 (0.06-0.61)	0.20 (0.06-0.61)	6.8	0.15 (0.02-1.05)
All reverse hybrid	96.8	1.31 (1.10-1.56)	0.49 (0.36-0.65)	0.91 (0.74-1.12)	0.86 (0.69-1.06)	0.69 (0.54-0.88)	0.30 (0.21-0.43)	0.15 (0.09-0.26)	0.27 (0.18-0.39)	0.05 (0.02-0.12)	0.04 (0.02-0.11)	0.31 (0.22-0.44)	0.08 (0.04-0.17)	77.6	0.06 (0.03-0.15)
Reverse hybrid by bearing surface															
MoP	65.2	1.21 (0.97-1.51)	0.32 (0.21-0.49)	1.01 (0.80-1.29)	0.81 (0.62-1.06)	0.83 (0.63-1.08)	0.31 (0.20-0.48)	0.14 (0.07-0.27)	0.21 (0.13-0.36)	0.05 (0.01-0.14)	0.03 (0.01-0.12)	0.31 (0.20-0.48)	0.09 (0.04-0.20)	52.3	0.06 (0.02-0.18)
CoP	31.0	1.48 (1.11-1.98)	0.81 (0.54-1.19)	0.71 (0.47-1.08)	0.94 (0.65-1.35)	0.42 (0.24-0.72)	0.26 (0.13-0.52)	0.19 (0.09-0.43)	0.39 (0.22-0.68)	0.06 (0.02-0.26)	0.06 (0.02-0.26)	0.29 (0.15-0.56)	0.03 (0.00-0.23)	25.0	0.04 (0.01-0.28)
Others/ unsure**	0.6	3.25 (0.81-13.01)	1.63 (0.23-11.55)	0	1.63 (0.23-11.55)	0	1.63 (0.23-11.55)	0	0	0	0	1.63 (0.23-11.55)	1.63 (0.23-11.55)	0.4	2.72 (0.38-19.34)
All resurfacing (MoM)	317.6	2.57 (2.40-2.75)	3.99 (3.78-4.21)	0.33 (0.28-0.40)	0.54 (0.47-0.63)	1.21 (1.09-1.33)	0.75 (0.66-0.85)	0.93 (0.83-1.04)	0.30 (0.25-0.37)	0.29 (0.23-0.35)	0.08 (0.05-0.11)	2.04 (1.89-2.20)	3.95 (3.74-4.17)	117.8	3.80 (3.46-4.16)

*Including 39 with unknown fixation/bearing.

**Based on a small group size (n=97), therefore estimates are unreliable.

***Rates likely to be underestimated: this reason not solicited in the early phase of the registry (i.e. revision report forms MDSv1/MDSv2).

****For primaries from 2008 onwards the majority of revision report forms were MDSv3/MDSv6 which explicitly stated this reason for revision.

Table 3.11 Revision rates after primary hip replacement for each indication, expressed as numbers per 1,000 patient-years (95% CI), overall and by time interval from primary operation.

Time from primary operation	Patient-years at risk (x1,000)	Number of revisions per 1,000 patient-years (95% CI) for: Aseptic loosening	Pain	Dislocation/ subluxation	Infection	Peri-prosthetic fracture	Mal-alignment	Lysis	Implant wear	Implant fracture	Head/ socket size mismatch	Other indication	Adverse reaction to particulate debris***	Patient-years at risk (x1,000) for primaries from 1.1.2008***	Revisions per 1,000 patient-years (95% CI) for adverse reaction to particulate debris for primaries from 1.1.2008***
All cases	4,553.4	1.28 (1.25-1.32)	0.94 (0.92-0.97)	0.89 (0.86-0.91)	0.73 (0.71-0.76)	0.67 (0.65-0.70)	0.39 (0.37-0.41)	0.29 (0.27-0.30)	0.28 (0.27-0.30)	0.16 (0.15-0.17)	0.04 (0.03-0.05)	0.52 (0.50-0.54)	0.90 (0.87-0.93)	2,766.3	0.66 (0.63-0.69)
Years															
<1 year	836.2	1.13 (1.06-1.20)	0.66 (0.61-0.72)	2.37 (2.27-2.48)	1.54 (1.46-1.63)	1.67 (1.59-1.76)	0.77 (0.71-0.83)	0.08 (0.06-0.10)	0.35 (0.31-0.39)	0.23 (0.20-0.27)	0.11 (0.09-0.13)	0.72 (0.67-0.78)	0.09 (0.07-0.11)	646.4	0.11 (0.09-0.14)
1 - 3 years	1,374.4	1.13 (1.08-1.19)	0.91 (0.86-0.96)	0.64 (0.60-0.68)	0.75 (0.70-0.79)	0.34 (0.31-0.37)	0.35 (0.32-0.38)	0.16 (0.14-0.19)	0.16 (0.14-0.18)	0.13 (0.11-0.15)	0.03 (0.03-0.05)	0.42 (0.39-0.46)	0.29 (0.26-0.32)	1,006.2	0.36 (0.33-0.40)
3 - 5 years	1,003.3	1.14 (1.08-1.21)	1.09 (1.03-1.16)	0.47 (0.43-0.51)	0.48 (0.44-0.52)	0.41 (0.37-0.45)	0.27 (0.24-0.30)	0.27 (0.24-0.30)	0.24 (0.21-0.27)	0.13 (0.11-0.15)	0.02 (0.01-0.03)	0.50 (0.46-0.55)	1.02 (0.96-1.08)	653.7	0.95 (0.88-1.03)
5 - 7 years	679.5	1.40 (1.32-1.49)	1.20 (1.12-1.28)	0.46 (0.41-0.51)	0.40 (0.36-0.45)	0.52 (0.47-0.58)	0.28 (0.25-0.33)	0.44 (0.39-0.49)	0.32 (0.28-0.37)	0.16 (0.13-0.20)	0.02 (0.01-0.04)	0.54 (0.49-0.60)	1.97 (1.87-2.08)	353.0	1.54 (1.41-1.67)
7 - 10 years†	524.7	1.80 (1.69-1.92)	0.98 (0.90-1.07)	0.61 (0.54-0.68)	0.40 (0.35-0.46)	0.61 (0.55-0.68)	0.28 (0.23-0.33)	0.66 (0.59-0.73)	0.42 (0.36-0.47)	0.17 (0.14-0.21)	0.02 (0.01-0.03)	0.53 (0.47-0.60)	2.10 (1.98-2.23)	107.0	1.98 (1.73-2.27)
10+ years*	135.3	2.19 (1.96-2.46)	0.48 (0.38-0.61)	0.60 (0.48-0.74)	0.38 (0.29-0.50)	0.84 (0.69-1.00)	0.24 (0.17-0.33)	0.76 (0.63-0.92)	0.78 (0.65-0.95)	0.26 (0.19-0.36)	0.01 (0.00-0.06)	0.24 (0.17-0.33)	1.29 (1.12-1.50)		

*Current maximum observed follow up is 13.75 years.

**Rates likely to be underestimated: this reason not solicited in the early phase of the registry (i.e. revision report forms MDSv1/MDSv2).

***For primaries from 2008 onwards the majority of revision report forms were MDSv3/MDSv6 which explicitly stated this reason for revision.

† 7 - 9 years for adverse reaction to particulate debris.

Figure 3.11 (a)

Change in PTIR with time from primary hip replacement, for **aseptic loosening** for selected fixation/bearing sub-groups.

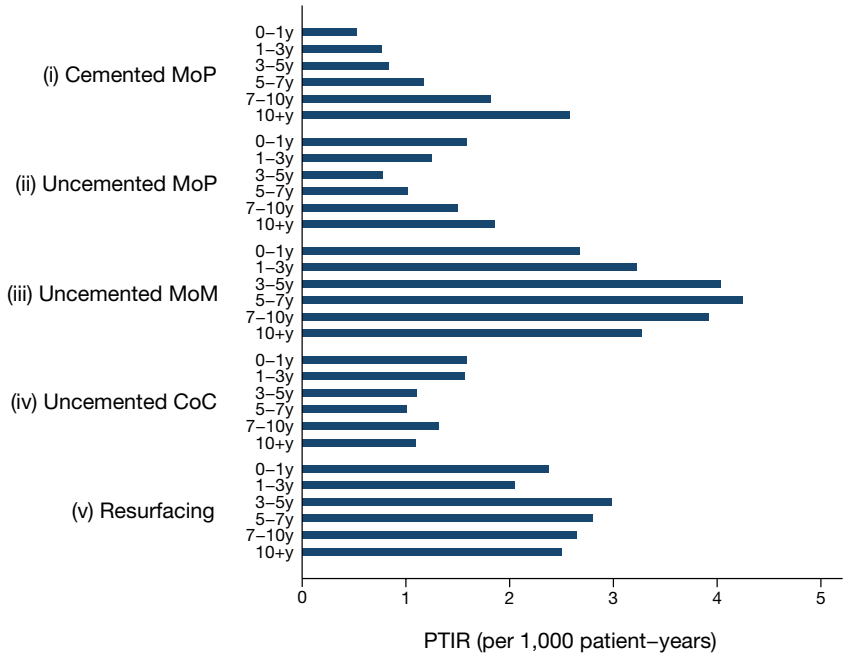


Figure 3.11 (b)

Change in PTIR with time from primary hip replacement, for **pain** for selected fixation/bearing sub-groups.

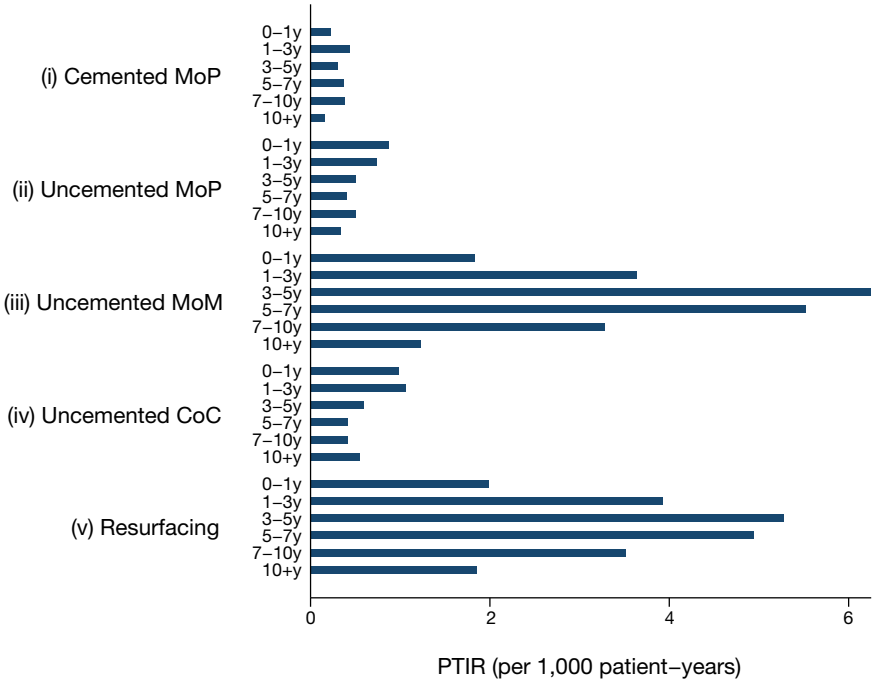


Figure 3.11 (c)

Change in PTIR with time from primary hip replacement, for **dislocation/subluxation** for selected fixation/bearing sub-groups.

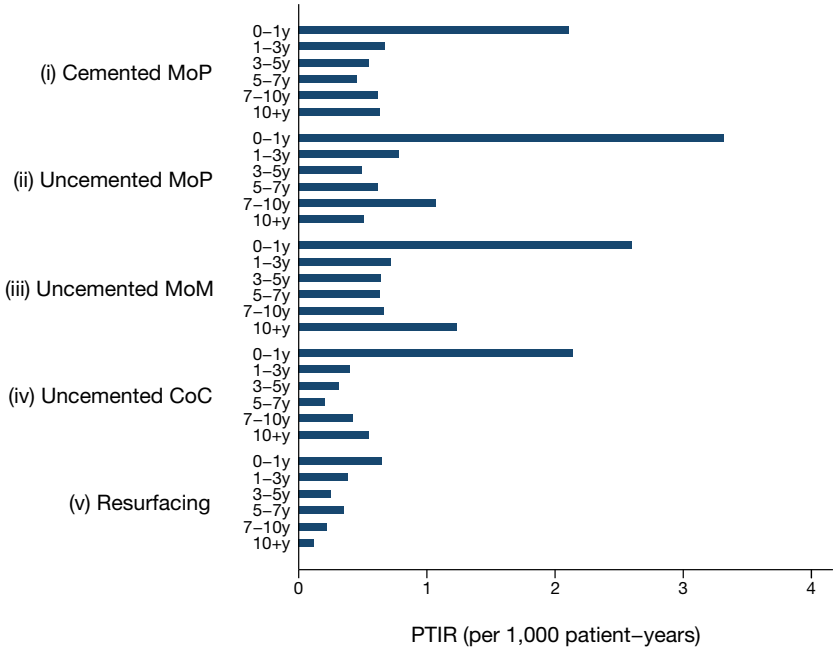


Figure 3.11 (d)

Change in PTIR with time from primary hip replacement, for **infection** for selected fixation/bearing sub-groups.

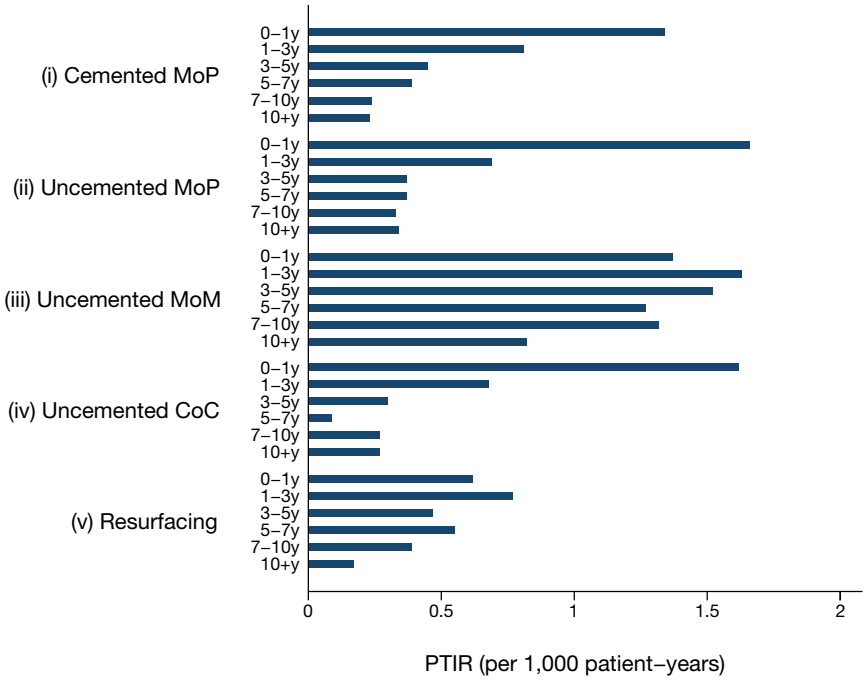


Figure 3.11 (e)

Change in PTIR with time from primary hip replacement, for **adverse soft tissue reaction to particulate debris** for selected fixation/bearing sub-groups.

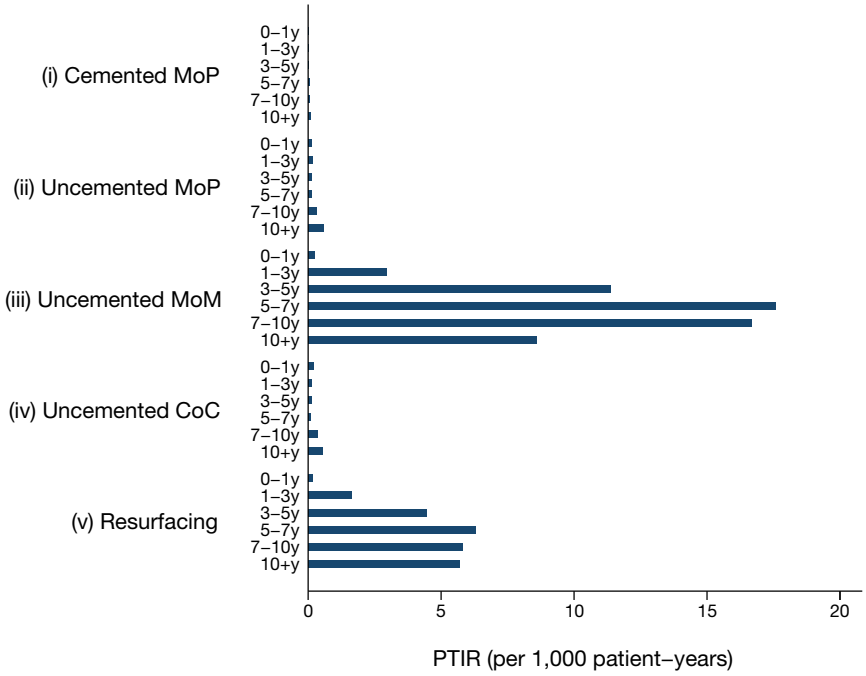
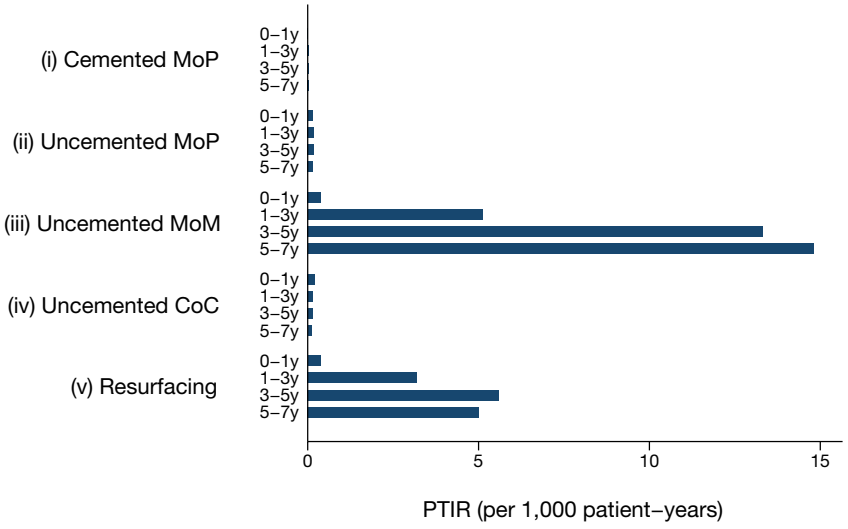


Figure 3.11 (f)

Change in PTIR with time from primary hip replacement, for **adverse soft tissue reaction to particulate debris** for selected fixation/bearing sub-groups including primaries since 2008 only.



3.3.6 Mortality after primary hip surgery

This section describes the mortality of the cohort up to 13 years from primary operation, according to gender and age group. Deaths were updated on 28 February 2017 using data from the NHS Personal Demographic Service. A total of 207 cases were excluded because the NHS number was not traceable and, therefore, the ages could not be verified. One additional record was excluded as age was missing and one further record was excluded because of uncertainty in gender, leaving 890,472. Amongst these, were 4,304 bilateral operations, with the left and right side operated on the same day; here the second of the two has been excluded, leaving 886,168 procedures, of whom 113,030 had died before the end of 2016.

Table 3.12 shows Kaplan-Meier estimates of cumulative percentage mortality at 30 days, 90 days and at 1, 3, 5, 7, 10, 11 and 13 years from the primary operation, 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 section.

Table 3.12 Kaplan-Meier estimates of the cumulative percentage mortality (95% CI), at different time points after primary hip replacement, for all cases and by age/gender.

		Cumulative percentage probability of death (95% CI) at:								
	n	30 days	90 days	1 year	3 years	5 years	7 years	10 years	11 years	13 years
All cases	886,168*	0.23 (0.22-0.24)	0.48 (0.47-0.50)	1.48 (1.46-1.51)	4.91 (4.86-4.95)	9.53 (9.45-9.60)	15.11 (15.01-15.21)	24.94 (24.78-25.09)	28.45 (28.27-28.64)	35.64 (35.33-35.96)
Males										
<55 years	53,052	0.08 (0.06-0.11)	0.16 (0.13-0.20)	0.51 (0.45-0.57)	1.36 (1.26-1.47)	2.21 (2.07-2.36)	3.30 (3.11-3.50)	4.93 (4.64-5.22)	5.63 (5.28-5.99)	6.88 (6.31-7.50)
55-59 years	36,410	0.06 (0.04-0.09)	0.19 (0.15-0.25)	0.63 (0.55-0.71)	1.86 (1.71-2.02)	3.28 (3.07-3.50)	5.05 (4.77-5.35)	8.36 (7.92-8.83)	9.96 (9.41-10.55)	13.30 (12.29-14.39)
60-64 years	52,092	0.13 (0.10-0.16)	0.25 (0.21-0.30)	0.86 (0.78-0.94)	2.64 (2.50-2.79)	4.81 (4.61-5.03)	7.30 (7.02-7.59)	12.56 (12.09-13.04)	14.45 (13.89-15.03)	18.60 (17.65-19.60)
65-69 years	61,922	0.17 (0.14-0.21)	0.37 (0.32-0.42)	1.14 (1.06-1.23)	3.61 (3.45-3.78)	6.92 (6.68-7.16)	11.07 (10.74-11.40)	18.78 (18.26-19.32)	21.67 (21.04-22.31)	29.51 (28.36-30.70)
70-74 years	61,168	0.22 (0.18-0.26)	0.47 (0.42-0.53)	1.67 (1.57-1.78)	5.60 (5.41-5.81)	10.67 (10.39-10.97)	16.92 (16.54-17.32)	29.39 (28.77-30.02)	34.23 (33.49-35.00)	44.83 (43.51-46.18)
75-79 years	50,628	0.42 (0.37-0.48)	0.78 (0.70-0.86)	2.51 (2.38-2.66)	8.63 (8.37-8.90)	16.96 (16.57-17.36)	27.75 (27.22-28.30)	46.23 (45.41-47.06)	52.96 (51.98-53.95)	*66.38 (64.66-68.09)*
80-84 years	28,564	0.82 (0.72-0.93)	1.53 (1.39-1.68)	4.27 (4.03-4.51)	13.57 (13.13-14.02)	27.08 (26.44-27.73)	42.76 (41.93-43.60)	66.42 (65.30-67.54)	72.78 (71.53-74.02)	*83.81 (81.84-85.67)*
85+ years	11,987	1.73 (1.51-1.98)	3.09 (2.80-3.42)	7.85 (7.37-8.36)	23.82 (22.98-24.69)	44.00 (42.90-45.13)	63.34 (62.08-64.60)	*85.77 (84.42-87.05)*	*90.30 (88.91-91.58)*	*95.72 (94.05-97.03)*
Females										
<55 years	53,208	0.06 (0.04-0.09)	0.21 (0.18-0.26)	0.67 (0.60-0.74)	1.63 (1.52-1.75)	2.49 (2.34-2.65)	3.45 (3.26-3.66)	4.93 (4.65-5.22)	5.39 (5.06-5.73)	6.37 (5.85-6.93)
55-59 years	42,208	0.07 (0.05-0.10)	0.19 (0.15-0.24)	0.59 (0.52-0.67)	1.71 (1.58-1.84)	3.03 (2.84-3.23)	4.47 (4.22-4.73)	6.96 (6.58-7.35)	7.90 (7.46-8.37)	9.71 (9.02-10.45)
60-64 years	65,199	0.07 (0.05-0.10)	0.17 (0.14-0.20)	0.60 (0.54-0.66)	2.02 (1.90-2.14)	3.76 (3.59-3.94)	5.68 (5.46-5.91)	9.44 (9.08-9.82)	11.06 (10.60-11.53)	14.87 (14.02-15.76)
65-69 years	90,303	0.08 (0.07-0.11)	0.23 (0.20-0.27)	0.76 (0.71-0.82)	2.55 (2.44-2.67)	4.82 (4.66-4.99)	7.70 (7.47-7.94)	13.66 (13.28-14.06)	15.98 (15.51-16.46)	21.48 (20.60-22.38)
70-74 years	98,606	0.12 (0.10-0.14)	0.29 (0.26-0.32)	0.96 (0.90-1.03)	3.53 (3.41-3.66)	7.19 (7.00-7.38)	11.79 (11.53-12.07)	21.63 (21.18-22.09)	25.58 (25.03-26.14)	34.74 (33.71-35.79)
75-79 years	90,065	0.24 (0.21-0.27)	0.47 (0.43-0.52)	1.53 (1.45-1.62)	5.61 (5.45-5.78)	11.68 (11.43-11.94)	19.34 (18.99-19.69)	34.85 (34.29-35.42)	40.73 (40.05-41.41)	52.70 (51.51-53.90)
80-84 years	59,862	0.37 (0.32-0.42)	0.84 (0.77-0.91)	2.58 (2.45-2.71)	9.07 (8.82-9.32)	18.69 (18.31-19.07)	31.48 (30.97-32.00)	53.57 (52.82-54.32)	61.47 (60.60-62.33)	*74.63 (73.24-75.99)*
85+ years	30,894	0.82 (0.72-0.92)	1.81 (1.66-1.96)	4.89 (4.65-5.15)	16.24 (15.79-16.70)	32.12 (31.48-32.76)	50.33 (49.55-51.12)	74.08 (73.12-75.04)	80.36 (79.29-81.41)	*90.19 (88.63-91.61)*

* Excludes 208 cases where the age could not be verified (because NHS number was not traceable or age was missing) plus one further case with uncertain gender; amongst the remainder, the second of 4,304 pairs of simultaneous bilateral operations were also excluded.

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

As total hip replacement is becoming an increasingly popular treatment option for fractured neck of femur; this section updates results from last year's annual report (13th Annual Report 2016) on revision and mortality rates for primary hip replacements performed as a result of fractured neck of femur compared to cases implanted for other reasons. A total of 24,609 (2.8%) of the primary total hip replacements were performed for fracture of the neck of femur (#NOF)[2].

Table 3.13 below shows that the proportion of primary hip replacements due to fractured neck of femur has continued to increase with time to a maximum of 4.9% in 2016.

Table 3.13 Proportions of primary total hip replacements for fracture of the neck of femur by year of primary operation.

Year of primary	n	Number (%) with fractured neck of femur
2003	14,452	142 (1.0%)
2004	28,057	292 (1.0%)
2005	40,573	390 (1.0%)
2006	48,470	529 (1.1%)
2007	60,751	773 (1.3%)
2008	67,124	863 (1.3%)
2009	68,101	1,074 (1.6%)
2010	70,618	1,361 (1.9%)
2011	73,631	1,706 (2.3%)
2012	77,775	2,433 (3.1%)
2013	79,885	3,115 (3.9%)
2014	86,977	3,716 (4.3%)
2015	86,496	3,955 (4.6%)
2016	87,733	4,260 (4.9%)
All years	890,643*	24,609 (2.8%)

*Excludes 38 with no data.

Table 3.14 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 (72.9% versus 59.4%: P<0.001, Chi-squared test). The #NOF cases were significantly older (median age 73 years versus 69 years at operation: P<0.001 by Mann-Whitney U-test). Cemented and hybrid hips were used more commonly in #NOF than in the other group.

Figure 3.12 shows that the overall failure rate (cumulative revision) was higher in the #NOF group compared with the remainder (P<0.001, logrank test). This effect appeared not to be 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).

Finally Figure 3.13 shows a marked 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 above, 208 cases with untraced NHS numbers or missing age have been excluded, together with 4,304 cases that were the second of simultaneous bilateral procedures. 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.

[2] These comprised 2,224 cases with reasons for primary including fractured neck of femur in the early phase of the registry (i.e. 200,900 implants entered using MDSv1 and v2) and 22,385 cases with reasons including acute trauma neck of femur in the later phase (i.e. 689,743 entered using MDSv3 and v6). 39 cases were omitted as no reasons were given.

Table 3.14 Comparison between primary hip replacements for fractured neck of femur and the remainder of cases with respect to gender, age and type of primary hip received.

	Reason for primary hip replacement		
	Fractured neck of femur (n=24,609)	Other reasons (n=866,034)	Comparison
% Females*	72.9%	59.4%	P<0.001 (Chi-squared test)
Median age (IQR)**			
Both genders	73 (IQR 66-79)	69 (IQR 61-76)	P<0.001 (Mann-Whitney U-test)
Males only	72 (IQR 65-79)	67 (IQR 59-75)	P<0.001 (Mann-Whitney U-test)
Females only	73 (IQR 66-79)	70 (IQR 62-77)	P<0.001 (Mann-Whitney U-test)
% Hip type***			
Cemented	44.2%	34.6%	
Uncemented	23.2%	39.5%	
Hybrid	29.9%	18.8%	Overall P<0.001 (Chi-squared test)
Reverse hybrid	2.5%	2.5%	
Resurfacing	0.1%	4.5%	

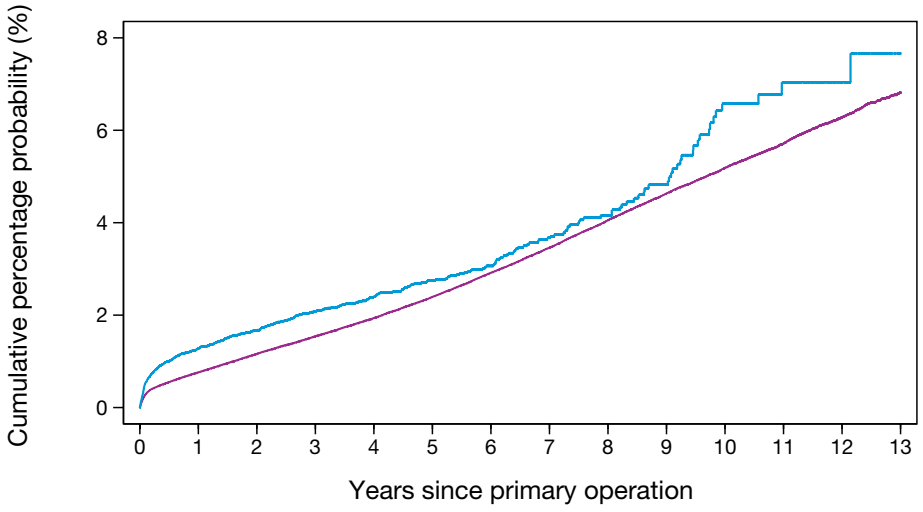
*Excludes one with uncertain gender.

**Excludes 208 whose NHS number was untraced whose ages, therefore, could not be verified.

***Excludes 39 with uncertain hip type.

Figure 3.12

Cumulative percentage revision rates (Kaplan-Meier) for hip primaries implanted for fractured neck of femur compared with all other cases.

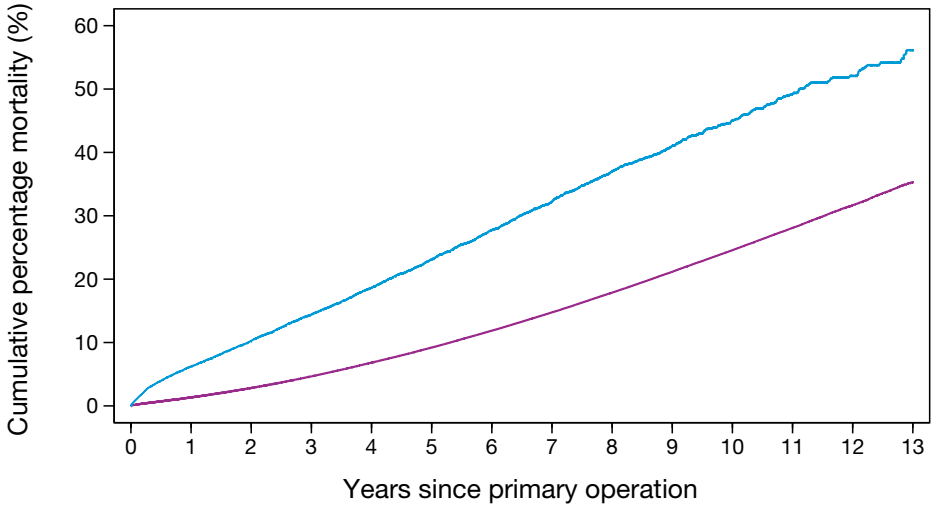


Number at risk

Other	866,034	766,088	672,197	578,674	492,753	410,757	334,522	264,433	200,374	141,864	92,582	55,552	27,004	8,627
Fract. neck of femur	24,609	18,804	14,389	10,490	7,461	5,174	3,677	2,538	1,696	1,110	632	350	174	49

Figure 3.13

Cumulative percentage mortality (Kaplan-Meier) for hip primaries implanted for fractured neck of femur compared with all other cases.



Number at risk

Other	861,564	767,783	676,257	584,371	499,643	418,634	343,165	273,302	208,555	148,254	97,011	58,247	28,328	9,033
Fract. neck of femur	24,568	19,023	14,608	10,709	7,641	5,313	3,787	2,646	1,774	1,174	681	377	188	55

3.3.8 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, aseptic lymphocyte-dominated vasculitis-associated lesion (ALVAL) 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. Interestingly, the breakdowns by age and gender show that cemented fixation has the lowest implant revision rate at ten years in all age bands and both genders.

Overall the number of primary hip replacements recorded annually in the NJR continues to increase and in 2016 over 87,000 were performed in England, Wales, Northern Ireland and the Isle of Man.

Previous trends of implant usage have become more pronounced with time. Since 2010 the use of ceramic-on-polyethylene bearings has steadily increased with a corresponding decline in the use of ceramic-on-ceramic bearings. This is possibly in response to the growing body of evidence from the NJR showing the very low failure rates associated with ceramic-on-polyethylene bearings.

The proportion of implants with uncemented fixation increased from 17% in 2003 to 46% in 2010 and thereafter declined to 39% in 2016. Meanwhile the proportion of implants with hybrid fixation is steadily increasing from 12% in 2003 to 28% in 2016.

This year, for the first time, we have presented data by age and gender comparing combinations of fixation and bearing. This will assist clinicians and patients in choosing classes of prostheses that are effective for their particular age and gender and makes interesting reading. For example, in males under 55 years of age, cemented ceramic-on-polyethylene constructs have nearly half the revision rate of cementless metal-on-polyethylene constructs at all time points. Hybrid ceramic-on-polyethylene and hybrid ceramic-on-

ceramic implants have similar outcomes to cemented ceramic-on-polyethylene. Uncemented hips with metal-on-polyethylene, uncemented metal-on-metal bearings, hybrid metal-on-polyethylene, and resurfacings all have statistically significantly worse survivorship at ten years.

In women under 55 years of age, cemented ceramic-on-polyethylene gives excellent results with 3.79% (95% CI 2.26-5.35) 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 to those achieved by cemented ceramic-on-polyethylene. In contrast 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.

Considering these ten-year implant survival rates alongside ten-year mortality rates in our patient population shows that in older patients the vast majority of treatment strategies will last the rest of the patients' lives. We now have mortality data out to 13 years post-surgery and this shows that the majority of patients aged over 75 years have died by 13 years regardless of gender. Even in those aged 65 to 69 years at the time of surgery, only 70% of males and 79% of females are still alive 13 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[3].

With regard to specific branded stem-cup combinations some of the best implant survivorship 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. For a more detailed analysis of this question please see Tucker et al. published open access in Acta Orthopaedica[4].

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.

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 brands of resurfacing have failure rates greater than 8% at ten years. 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. 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 arthroplasty 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.

[3] 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

[4] Tucker K, Pickford M, Newell C, Howard P, Hunt LP, Blom AW. Mixing of components from different manufacturers in total hip arthroplasty: prevalence and comparative outcomes. Acta Orthop. 2015;86(6):671-7

Part 3

3.4 Revisions of a total hip replacement

3.4.1 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 2016, for all patients with valid patient identifiers (i.e. whose data could therefore be linked).

In total there were 97,341 revisions on 85,200 individual patient-sides[5] (80,462 actual patients). In addition to revisions on the 24,103 revised primaries described in section 3.3 of this report, there were revisions associated with 61,097 unrecorded primaries.

Revisions are classified as single stage and stage one and stage two of two-stage revisions. Information on stage one and stage two are entered into the database separately, whereas stage one and stage two revisions in practice have to be linked. In some cases, stage one revisions have been entered without 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 3.15 below gives an overview of all revision procedures carried out each year since April 2003[5]. There were up to a maximum of nine documented revision procedures associated with any individual patient-side (discussed later in this section). The temporal increase reflects the increasing number of at-risk implants prevailing in the database.

Table 3.15 Numbers of all hip revision procedures, by type of procedure, carried out each year.

Year of revision surgery	Type of revision procedure			All procedures
	Single stage	Stage one of two-stage	Stage two of two-stage	
2003*	1,430 (100.0%)	- - - -	- - - -	1,430
2004	2,434 (90.0%)	117 (4.3%)	154 (5.7%)	2,705
2005	3,406 (87.0%)	206 (5.3%)	303 (7.7%)	3,915
2006	4,166 (86.6%)	267 (5.6%)	375 (7.8%)	4,808
2007	5,515 (87.2%)	347 (5.5%)	461 (7.3%)	6,323
2008	5,995 (86.0%)	424 (6.1%)	551 (7.9%)	6,970
2009	6,283 (84.2%)	523 (7.0%)	654 (8.8%)	7,460
2010	7,068 (86.6%)	500 (6.1%)	591 (7.2%)	8,159
2011	7,989 (87.6%)	529 (5.8%)	606 (6.6%)	9,124
2012	9,218 (88.1%)	602 (5.8%)	648 (6.2%)	10,468
2013	8,516 (87.8%)	564 (5.8%)	619 (6.4%)	9,699
2014	8,315 (87.0%)	658 (6.9%)	581 (6.1%)	9,554
2015	7,582 (86.2%)	645 (7.3%)	566 (6.4%)	8,793
2016	6,966 (87.8%)	483 (6.1%)	484 (6.1%)	7,933
All years	84,883 (87.2%)	5,865 (6.0%)	6,593 (6.8%)	97,341

*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.

Table 3.16 shows the stated reasons for the revision surgery. Please note that, as several reasons can be stated, the reasons are not mutually exclusive and therefore column percentages do not add up to 100%.

[5] For 233 patient-sides, multiple procedures had been entered on the same operation date; 232 had two on the same date and one had three. Details of the components that had been entered for these cases were reviewed. As a result of this, 237 of the 466 revision procedures have been dropped and 21 have been reclassified.

Table 3.16 Reasons for the hip revision procedures: percentages indicating each reason, calculated separately for single and two-stage revisions.

Reason	Type of revision procedure		
	Single stage (n=84,883)	Stage one of two-stage (n= 5,865)	Stage two of two-stage (n=6,593)
Aseptic loosening	50.1%	13.2%	12.3%
Pain	20.5%	13.5%	9.3%
Lysis	15.4%	9.6%	6.1%
Dislocation/subluxation	15.2%	4.1%	3.4%
Implant wear	14.1%	4.5%	3.1%
Periprosthetic fracture	10.1%	3.7%	4.0%
Other indication	7.6%	3.4%	8.3%
Malalignment	5.6%	1.5%	0.9%
Implant fracture	3.6%	1.1%	1.3%
Infection	3.5%	80.3%	72.5%
Head-socket size mismatch	0.8%	0.3%	0.2%
Adverse reaction to particulate debris*	11.0% n=66,920	3.1% n=4,847	2.3% n=5,231

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

3.4.2 Rates of hip re-revision

For a given patient-side, we have looked at the survival following the first documented revision procedure in the NJR (n=85,200). In most instances (91.3%), the first revision procedure was a single stage revision, however in the remaining 8.7% it was part of a two-stage procedure. 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 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 eight).

Kaplan-Meier estimates were calculated to estimate the cumulative probability of a subsequent revision (re-revision). These rates are plotted in Figure 3.14 (a) and tabulated in Table 3.17 (a). There were 7,522 re-revisions and in 16,330 cases the patient died without having been revised; the censoring date for the remainder was the end of 2016.

In Figure 3.14 (b) we sub-divided the first revisions into those for whom a primary had been recorded in the NJR (n=24,103) and the remainder. The survival of the former appeared much worse. This is interesting as primaries not in the NJR are likely to have been performed prior to 2003 and thus represent late failure. In contrast, revisions linked to primaries in the NJR are more likely to represent early failure. It thus appears that revision after late failure is less likely to need re-revision than revision after early failure. Figure 3.14 (c) and Table 3.17 (b) further exemplify this; cumulative re-revision rates up to three years are shown separately for those with primaries in the NJR according to their time intervals to first revision, less than 1 year, 1 to 3, 3 to 5 and more than 5 years.

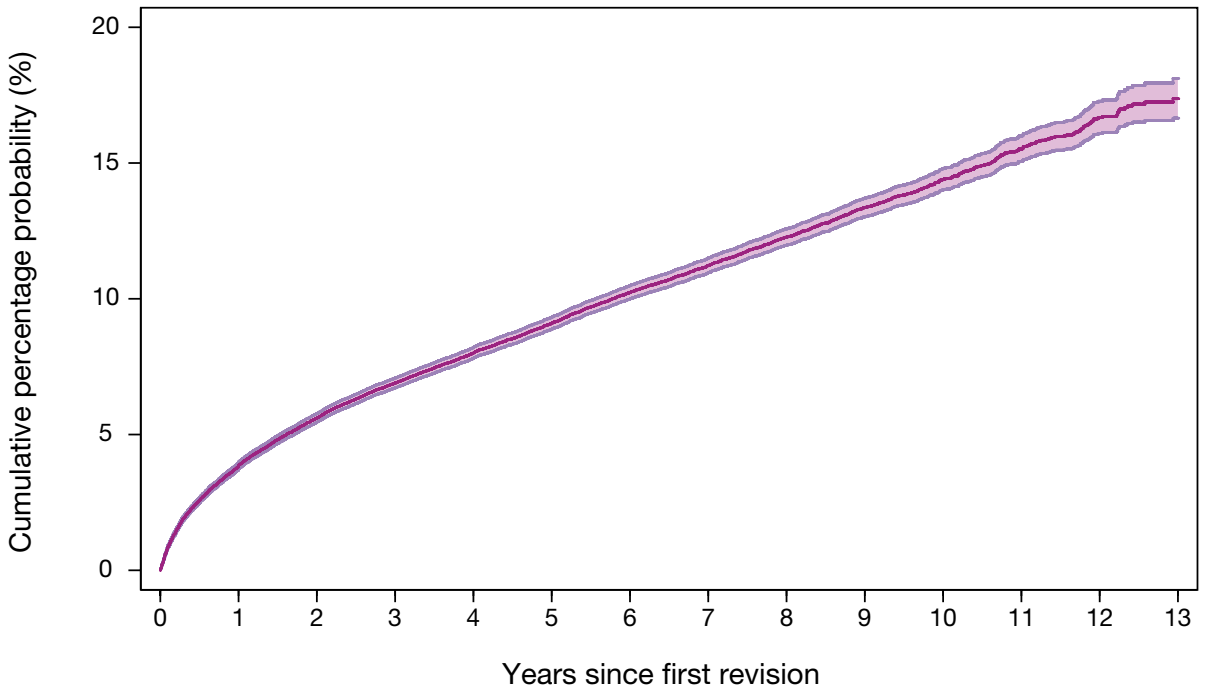
There is a relationship between the indication for first revision and time to first revision; earlier in this report (section 3.3.5) we showed, for example, that revisions for dislocation/subluxation and pain were more prevalent in the early period after the primary and aseptic loosening and pain later 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.

For those with documented primaries within the NJR, Figures 3.15 (a) to (e) show cumulative re-revision rates up to five years from the first revision, 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 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, 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. However, for reverse hybrid hip replacements, the worst re-revision rates were experienced by those who had their first revision within 3 to 5 years of the initial primary hip replacement; though the numbers were small and therefore the results should be interpreted with caution.

Table 3.17 (c) shows cumulative re-revision rates at 1, 3, and 5 years following the first revision for those with documented primaries within the NJR, broken down by fixation types and bearing surfaces. Overall, the worst re-revision rates were demonstrated in those where the initial primary had been uncemented, with metal-on-metal bearings faring worse than other bearings within the group. The failure rates for resurfacings were comparatively low.

Figure 3.14 (a)

Kaplan-Meier estimate of the cumulative probability of a hip re-revision (shaded area indicate point-wise 95% CI).

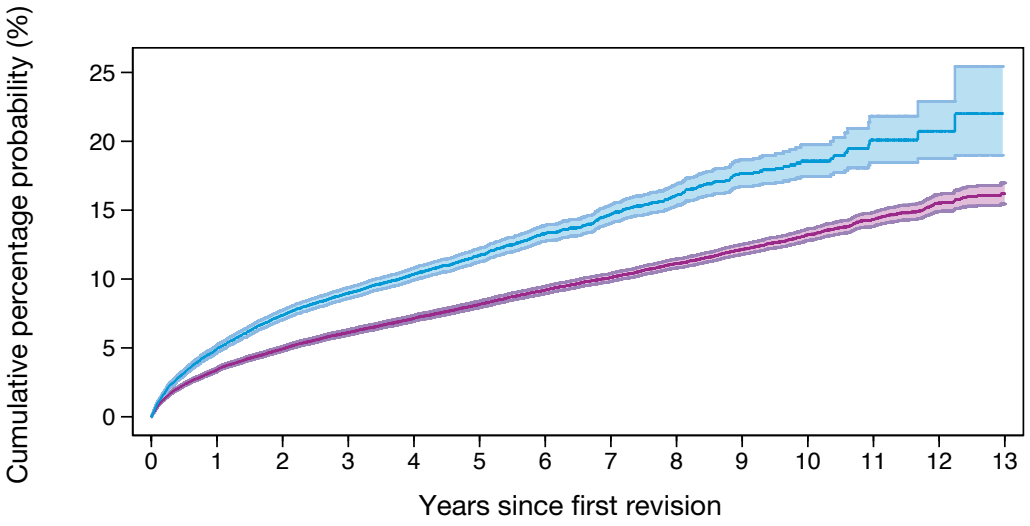


Number at risk

85,199	72,938	63,204	53,592	44,368	35,045	27,245	20,862	15,431	10,700	6,697	3,931	1,921	602

Figure 3.14 (b)

Kaplan-Meier estimates of the cumulative probability of a hip re-revision, shown separately for those with documented primaries in the NJR* and the remainder (shaded area indicate point-wise 95% CIs).



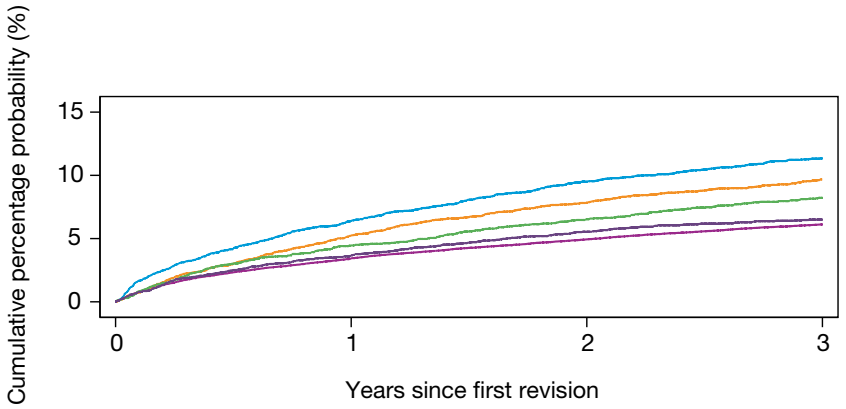
Number at risk

Primary not in the NJR	61,096	53,207	47,015	40,608	34,374	28,124	22,673	17,854	13,583	9,652	6,187	3,691	1,839	586
Primary in the NJR	24,103	19,731	16,189	12,984	9,994	6,921	4,572	3,008	1,848	1,048	510	240	82	16

*First documented revision in the NJR.

Figure 3.14 (c)

Kaplan-Meier estimates of the cumulative probability of a hip re-revision up to three years from the first revision. Those with documented primaries in the NJR* are shown separately from the remainder and have been sub-divided into those that had their first revision within <1, 1-3, 3-5 and >5 years from the initial primary.



Numbers at risk

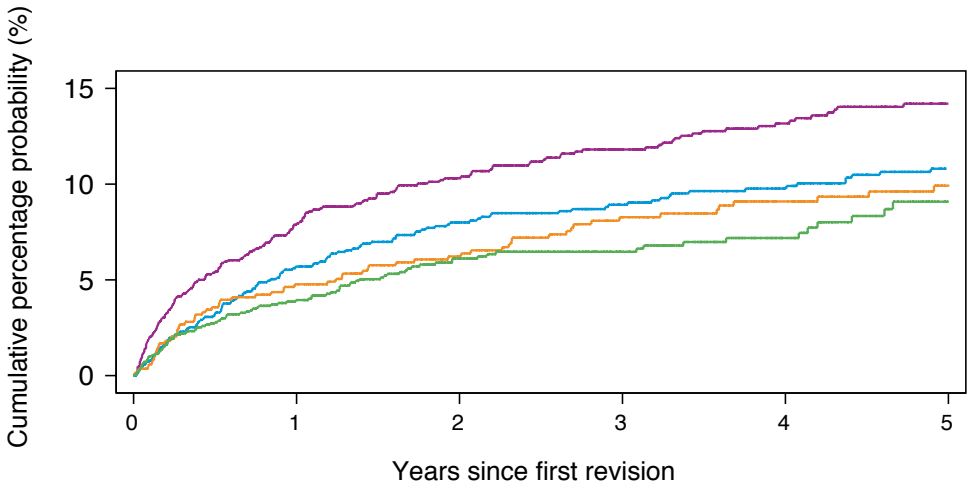
Primary not in the NJR	61,096	53,207	47,015	40,608
First rev. <1y	6,674	5,490	4,545	3,751
First rev. 1–3y	5,438	4,674	4,038	3,481
First rev. 3–5y	4,313	3,785	3,341	2,871
First rev. 5+y	7,678	5,782	4,265	2,881

*First documented revision in the NJR.

Figure 3.15 (a)

Kaplan-Meier estimates of the cumulative probability of a hip re-revision up to five years from the first revision, shown separately for type of fixation used in the primary, with further sub-division by length of time from the primary to the first revision (<1, 1-3, 3-5 and >5).

(a) **Cemented**



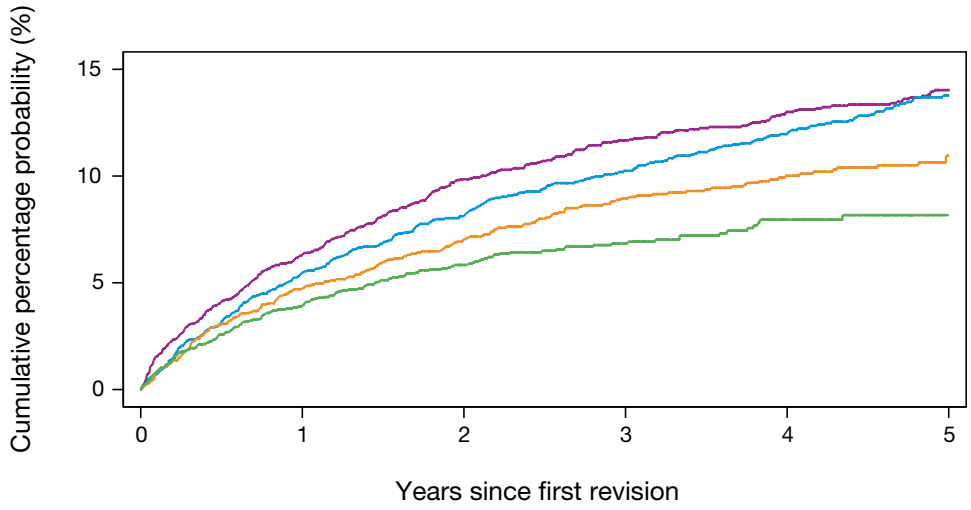
Numbers at risk

First rev. <1y	1,478	1,173	967	781	630	490
First rev. 1–3y	1,378	1,141	961	802	665	515
First rev. 3–5y	841	695	592	493	397	284
First rev. 5+y	1,699	1,225	857	581	370	187

Figure 3.15 (b)

Kaplan-Meier estimates of the cumulative probability of a hip re-revision up to five years from the first revision, shown separately for type of fixation used in the primary, with further sub-division by length of time from the primary to the first revision (<1, 1-3, 3-5 and >5).

(b) **Uncemented**



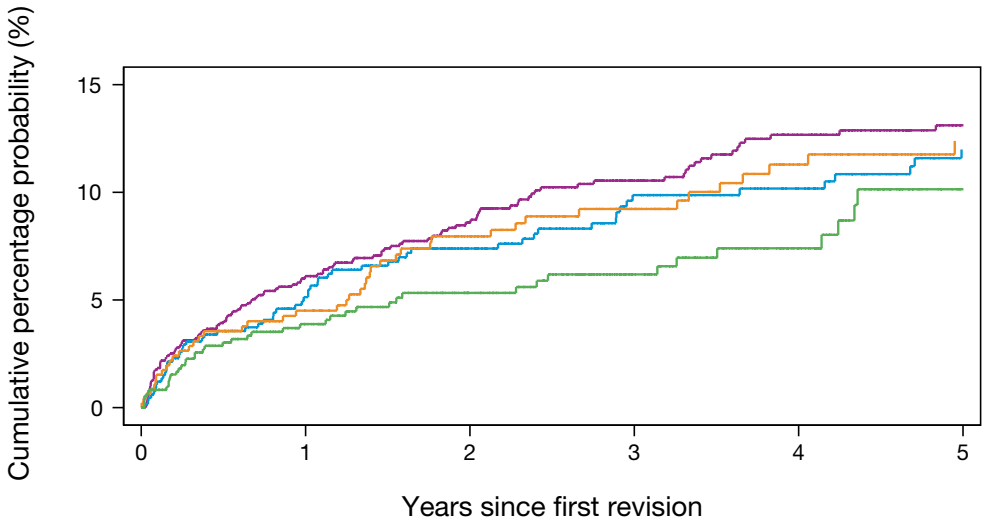
Numbers at risk

First rev. <1y	3,337	2,791	2,321	1,914	1,564	1,196
First rev. 1–3y	2,584	2,252	1,955	1,685	1,398	1,077
First rev. 3–5y	2,081	1,841	1,614	1,371	1,029	572
First rev. 5+y	3,401	2,538	1,810	1,156	603	203

Figure 3.15 (c)

Kaplan-Meier estimates of the cumulative probability of a hip re-revision up to five years from the first revision, shown separately for type of fixation used in the primary, with further sub-division by length of time from the primary to the first revision (<1, 1-3, 3-5 and >5).

(c) **Hybrid**



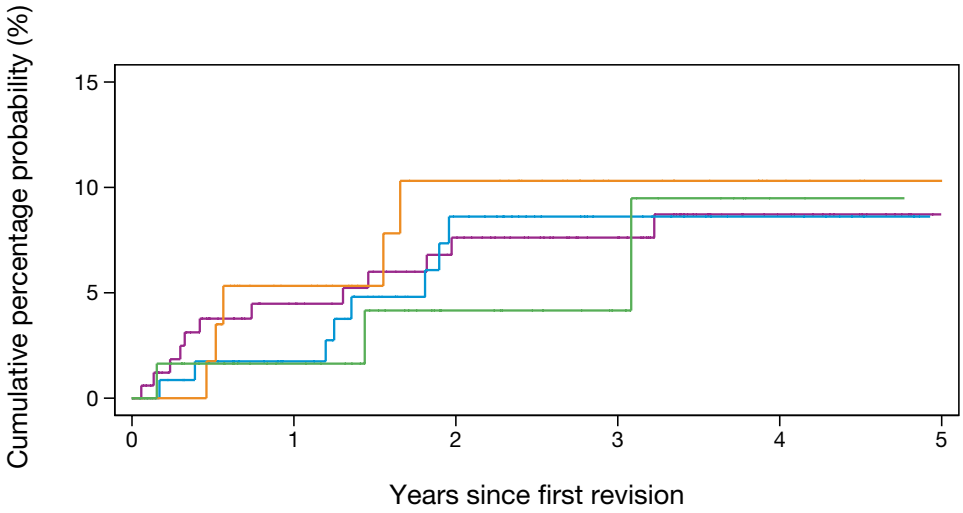
Numbers at risk

First rev. <1y	1,206	933	709	550	442	360
First rev. 1–3y	666	527	428	340	282	219
First rev. 3–5y	462	389	314	247	192	140
First rev. 5+y	733	514	375	258	166	76

Figure 3.15 (d)

Kaplan-Meier estimates of the cumulative probability of a hip re-revision up to five years from the first revision, shown separately for type of fixation used in the primary, with further sub-division by length of time from the primary to the first revision (<1, 1-3, 3-5 and >5).

(d) **Reverse hybrid**



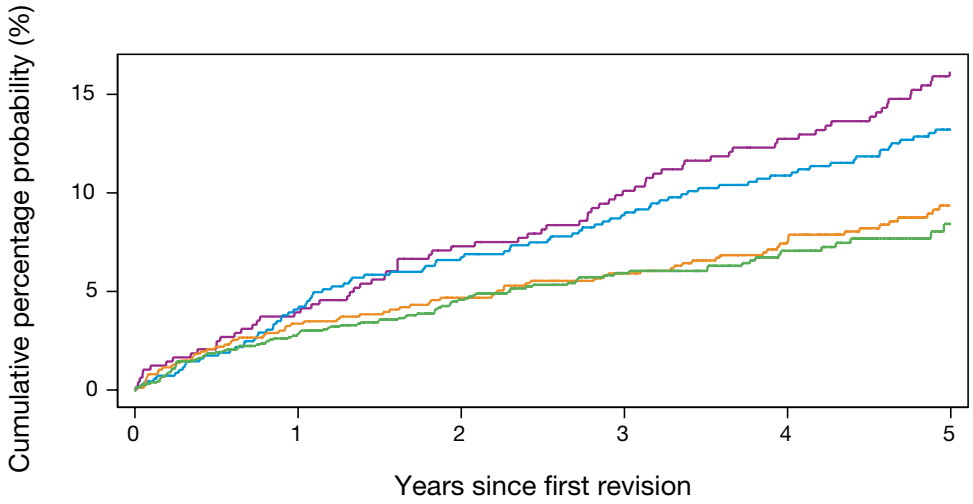
Numbers at risk

First rev. <1y	169	131	113	93	66	50
First rev. 1–3y	120	99	71	57	49	39
First rev. 3–5y	58	45	35	21	13	8
First rev. 5+y	67	45	28	20	10	8

Figure 3.15 (e)

Kaplan-Meier estimates of the cumulative probability of a hip re-revision up to five years from the first revision, shown separately for type of fixation used in the primary, with further sub-division by length of time from the primary to the first revision (<1, 1-3, 3-5 and >5).

(e) **Resurfacing**



Numbers at risk

First rev. <1y	484	462	435	413	392	359
First rev. 1–3y	690	655	623	597	556	488
First rev. 3–5y	871	815	786	739	620	425
First rev. 5+y	1,778	1,460	1,195	866	550	225

Table 3.17 (a) Kaplan-Meier estimates of cumulative percentage probability of a hip re-revision following the first revision.

Time point from which time was measured:	Sub-group	n	Cumulative re-revision rate (95% CI) at:					
			1 year	3 years	5 years	7 years	10 years	13 years
First revision*	All	85,200	3.86 (3.73-3.99)	6.90 (6.72-7.08)	9.09 (8.87-9.32)	11.23 (10.96-11.51)	14.40 (14.01-14.80)	17.37 (16.65-18.12)
First revision	Primary not recorded in the NJR	61,097	3.44 (3.29-3.59)	6.12 (5.92-6.32)	8.15 (7.91-8.40)	10.13 (9.84-10.43)	13.21 (12.80-13.64)	16.19 (15.45-16.97)
	Primary recorded in the NJR	24,103	4.95 (4.67-5.24)	8.98 (8.59-9.39)	11.74 (11.25-12.24)	14.72 (14.07-15.40)	18.56 (17.44-19.75)	*22.01 (18.99-25.43)*

*First documented revision in the NJR.

Table 3.17 (b) Kaplan-Meier estimates of cumulative percentage probability of a hip re-revision following the first revision, sub-divided by time since primary.

	n	Cumulative re-revision rate (95% CI) at:	
		1 year	3 years
Primary not in the NJR	61,097	3.44 (3.29-3.59)	6.12 (5.92-6.32)
Primary in the NJR where the first revision took place:			
<1 year after primary	6,674	6.41 (5.83-7.04)	11.34 (10.54-12.19)
1-3 years from primary	5,438	5.24 (4.67-5.89)	9.68 (8.87-10.55)
3-5 years from primary	4,313	4.46 (3.87-5.13)	8.22 (7.40-9.13)
5+ years from primary*	7,678	3.67 (3.26-4.14)	6.50 (5.89-7.17)

*Note: maximum interval was 12.9 years.

Table 3.17 (c) Kaplan-Meier estimates of the cumulative percentage probability of a hip re-revision (95% CI) at 1, 3, and 5 years following the first revision in those with documented primaries in the NJR, by fixation and bearing surface (group size >1,000 in the case of the bearing surfaces).

Fixation	Bearing surface	n	Cumulative percentage probability of re-revision (95% CI) following first revision at:		
			1 year	3 years	5 years
All types	All	24,103	4.95 (4.67-5.24)	8.98 (8.59-9.39)	11.74 (11.25-12.24)
Cemented	All	5,396	5.65 (5.05-6.33)	8.96 (8.15-9.83)	11.07 (10.10-12.12)
	MoP	4,676	5.55 (4.91-6.27)	8.66 (7.81-9.59)	10.62 (9.60-11.74)
Uncemented	All	11,403	5.16 (4.76-5.59)	9.57 (9.00-10.18)	12.12 (11.42-12.87)
	MoP	3,046	5.31 (4.55-6.20)	9.31 (8.23-10.52)	11.56 (10.25-13.02)
	MoM	4,268	4.87 (4.25-5.57)	9.36 (8.46-10.34)	12.34 (11.21-13.57)
	CoP	1,144	6.00 (4.73-7.61)	11.99 (9.99-14.35)	13.57 (11.32-16.23)
	CoC	2,612	4.90 (4.12-5.83)	9.01 (7.88-10.30)	11.29 (9.91-12.85)
Hybrid	All	3,067	5.13 (4.38-6.01)	9.26 (8.16-10.50)	12.02 (10.64-13.56)
	MoP	1,883	5.60 (4.62-6.79)	9.37 (8.00-10.96)	12.04 (10.31-14.02)
Resurfacing	(MoM)	3,823	3.36 (2.83-4.00)	7.11 (6.29-8.03)	11.09 (9.98-12.31)

*Note: maximum interval was 12.2 years.

3.4.3 Reasons for the hip re-revision

Table 3.18 shows a breakdown of the stated indications for the first revision and for any subsequent revision (note the indications are not mutually exclusive). Column (i) shows indications for the first revision in the NJR, (ii)/(iii) for the first revision but depending on whether or not the implants were subsequently re-revised, and (iv) for the re-revisions themselves.

Table 3.18 Reasons for the hip first revision and subsequent re-revision.

		Reasons for the first recorded revision for those who were:		
	(i) Reasons for first (recorded) revision	(ii) Not subsequently re-revised	(iii) Subsequently re-revised	(iv) Reasons for the re-revision
Number of cases	**85,199**	**77,677**	**7,522**	**7,522**
Aseptic loosening	41,077	37,677	3,400	2,416
Pain	17,231	15,726	1,505	1,131
Lysis	13,194	12,158	1,036	566
Implant wear	11,808	10,902	906	505
Dislocation/subluxation	11,172	10,134	1,038	1,793
Infection	7,832	6,873	959	1,532
Periprosthetic fracture	8,079	7,372	707	751
Malalignment	4,448	4,074	374	367
Implant fracture	2,862	2,610	252	282
Head-socket (size) mismatch	628	565	63	50
Other indication	6,399	5,784	615	503
Adverse reaction to particulate debris	7,095 n=66,157	6,592 n=61,029	503 n=5,128	453 n=6,752

Finally, Tables 3.19 (a) and 3.19 (b) provide additional evidence that the 61,097 revised joints with no associated primary in the NJR tended to be later revisions than the 24,103 joints that did have an associated primary. The results also show that the numbers of revisions with an associated primary in the NJR increased with time.

3.4.4 90-day mortality after hip revision

The overall cumulative percentage mortality at 90 days after hip revision was lower in the cases with their primaries documented in the NJR compared with the remainder (Kaplan-Meier estimates 1.01 (95% CI 0.89-1.14) versus 1.64 (1.54-1.74)), which may reflect the fact that this patient group were 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 73 (IQR 65-80) years. The percentage of males was similar in both groups (43.6% versus 42.1% respectively).

Table 3.19 Temporal changes in first hip revisions reported in the NJR and associated indications.

(a) Number of first hip revisions by year and proportions with an associated primary in the NJR.

Year of first revision in the NJR*	Number of (first) revisions*	Number (%) with the associated primary in the NJR
2003	1,404	43 (3.1%)
2004	2,620	141 (5.4%)
2005	3,707	301 (8.1%)
2006	4,466	450 (10.1%)
2007	5,835	803 (13.8%)
2008	6,300	1,132 (18.0%)
2009	6,560	1,492 (22.7%)
2010	7,121	1,934 (27.2%)
2011	7,978	2,627 (32.9%)
2012	9,032	3,305 (36.6%)
2013	8,228	3,001 (36.5%)
2014	8,017	3,028 (37.8%)
2015	7,304	3,008 (41.2%)
2016	6,627	2,838 (42.8%)
Total	85,199	24,103 (28.3%)

*First documented revision in the NJR.

(b) Numbers of first recorded hip revisions by stage and whether or not primary was 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	1,361	43	0	0
2004	2,270	120	209	21
2005	3,073	244	333	57
2006	3,633	363	383	87
2007	4,580	669	452	134
2008	4,686	929	482	203
2009	4,581	1,226	487	266
2010	4,771	1,703	416	231
2011	4,958	2,357	393	270
2012	5,343	2,976	384	329
2013	4,909	2,697	318	304
2014	4,643	2,732	346	296
2015	3,996	2,696	300	312
2016	3,570	2,590	219	248
All years	56,374	21,345	4,722	2,758

*First documented revision in the NJR.

Part 3

3.5 Outcomes after primary knee replacement

This section reviews the outcome of primary knee replacement surgery in terms of two key events that could happen post-operatively to a patient who has undergone a knee replacement or to the knee joint; the 'first revision' of a knee implant and/or patient death or mortality.

Core to the analysis approach for both outcomes is modelling the time until the event is observed to happen and giving due consideration to the time the patient or joint is at risk of the event happening. Further details of the statistical methods are given in statistical methodology notes I to III overleaf.

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

The patient cohort described in this section is any patient whose recorded primary knee replacement surgery date fell on or after 1 April 2003 and up to 31 December 2016 (inclusive). The maximum follow-up time a patient could have for either outcome is 13.75 years, corresponding to a patient operated on at the start of the registry.

Tables 3.1 and 3.2 provide an overview of the primary knee replacement patient cohort. Over the period of 2003 to 2016, a total of 975,739 knee joints were replaced for the first time (primary joint replacement). There were a total of 800,477 patients with a NJR record of primary knee replacement on one or both sides. Approximately four fifths of the patient cohort had just one record of a primary knee joint replacement since the establishment of the NJR. The remaining fifth of patients were those who had records of both left and right knees being replaced for the first time. The majority of this patient sub-group had primary knee surgery at different times for each side (164,665 patients), but 10,597 patients had surgery for both knees on the same date (1.3% of all patients in the cohort).

The predominant clinical reason recorded for primary surgery was osteoarthritis (OA); it was the sole stated reason in 938,349 (96%) of primary knee surgeries and one of the reasons recorded in a further 1.1% of primaries performed when multiple clinical reasons for surgery were given on the data collection form.

Terminology note:

The knee is made up of three compartments: medial, lateral and patellofemoral compartments. When a total knee replacement (TKR) is implanted, two out of the three compartments are always replaced (medial and lateral) and the patella is resurfaced if the surgeon considers this to be of benefit to the patient. 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.

There is variation in the constraint of the tibial insert 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. The tibial element may be modular with a metallic tibial tray and a polyethylene insert or non-modular consisting of an all-polyethylene tibial component (monobloc polyethylene tibia). In recent years monobloc all-polyethylene tibial components have increased in popularity.

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.

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 phrase constraint here, for brevity, total knee replacements are termed unconstrained (instead of posterior cruciate-retaining) or posterior-stabilised (instead of posterior cruciate-stabilised).

Methodological note I: Survival analysis, time at risk and censoring

Survival analyses have been employed to provide estimates of the two main outcomes of interest after primary knee replacement surgery; namely the cumulative probability that an implant is revised for the first time at different times after primary operation (revision outcome) and the cumulative probability that a patient dies at different lengths of time after primary knee surgery (mortality outcome).

Key to these methods is correctly specifying the period of time after primary surgery each replaced joint is at risk of the event of being revised or the patient is at risk of dying. In addition, not all replaced joints will be revised (or all patients will die) over the observation period, i.e. the event of interest will not happen to all joints/patients. When this is the case, the time observations are censored. Censored observations occur for a number of reasons; they can be those cases which have not experienced the outcome of interest by the end of the observation period or those which are no longer available to be observed until the end date of the observation period, termed observations lost to follow-up. As a consequence of censoring, the total number of patients at risk of the event at different points in time will vary over the whole observation period.

For mortality, the period of time at risk contributed by a patient in the cohort is the length of time until they died post primary surgery or, if they do not die, the time from primary surgery until the last day in December 2016, the last date of the period of observation for this report.

Turning to the revision outcome, the time a joint is at risk of being revised for the first time is either the time until the joint is revised post primary surgery (and before the end of 2016), the time until they die after surgery without being revised (and before the end of 2016) or the period of time they are not revised after primary surgery up until the last date of observation in 2016.

Methodological note II: Use of Kaplan-Meier estimation for describing mortality and revision

The main tables and figures shown in the text are based on Kaplan-Meier estimates of the cumulative probability of the joint being revised or the patient dying at different times after the primary surgery. The calculated probabilities have been multiplied by 100 in all results presented here and so represent the cumulative percentage probability of having a first revision or of dying at different times after surgery.

This is a change to previous NJR annual reports (prior to 2014) where a mixture of Kaplan-Meier estimation of the cumulative probability of having a first revision (or of dying) and Nelson-Aalen estimation of cumulative hazard (the expected total number of revisions or deaths up to a point in time) were reported. Clearly, the two methods find different quantities – one is a probability and the other is not – but, under certain conditions, both methods provided similar estimates in terms of actual numerical values (see the glossary for further technical details). This is no longer the case and we now solely use Kaplan-Meier estimation throughout Part Three.

The Confidence Intervals (CI) found for the cumulative percentage probability estimates of revision or death, based on the Kaplan-Meier method, become less reliable when the number at risk of revision or death falls below 250. Several methods have been proposed to calculate Confidence Intervals. These proposed methods produce confidence intervals which are all in agreement with one another when there are high numbers at risk. However, they begin to give very different upper and lower limits once the numbers at risk falls below 250. To date, there has been no clear consensus on which method is to be preferred when numbers at risk are small. For this reason, we highlight the point estimate of the cumulative chance of revision/death and the confidence interval throughout in *blue italics* once the number at risk drops below 250 cases.

Methodological note III: Competing risks considerations

One assumption which underpins the use of the Kaplan-Meier method to estimate the cumulative chance of death or first revision is that the patients/joints whose times are censored, have the same chance of having the event of interest happen to them after censoring as those cases still at risk in the study.

This assumption could be compromised if the reason they are censored is as a result of other events happening to the patient or joint after primary knee surgery, but not the main one of interest, which potentially change the likelihood of the main outcome (first revision or death) occurring afterwards. An event like this is known as a competing risk.

For example, if a patient dies before having a first revision, their observation will be treated as censored but the chance of the outcome revision happening after death is impossible. Death, here, is the competing risk. The true effect of the event death on the Kaplan-Meier estimates for revision as the main outcome can only be assessed if it is accounted for in the modelling process. One commonly proposed method is the use of the Cumulative Incidence Function (CIF) adjusting for the competing risk of death (see section 3.3.2.6 of the NJR Annual Report 2014 where the impact of CIF on the probability estimates obtained was considered).

In the main analyses presented here, we have not made adjustments for competing risks in the modelling of first revision and death as outcomes.

So, in the case of the revision outcome, no adjustment for the competing risk of death has been made in the main survival table and figure presentations. However, a simple assessment of the impact of the competing risk of death on the revision outcome estimates using the cumulative incidence function is presented in the text.

For mortality, we have not accounted for the impact that having a first or further revision after primary surgery may have on the likelihood of a patient dying subsequently, compared to the likelihood of death for those who have not had a first or further revision surgery.

3.5.1 Overview of primary knee surgery

3.5.1.1 Main types of primary knee surgery and changes in type of operation over time

Table 3.20 shows the proportion of all main kinds of primary knee operations carried out between 2003 and 2016, broken down by the method of fixation, constraint and bearing used for the implant in surgery. A breakdown within each method of fixation of the percentage of constraint and bearing types used in surgery is shown in a separate column. The vast majority of replacements performed were total knee replacements (TKRs) with an all cemented implant being the most common technique of fixation used (84.9% of all primary knee operations). A further 5.1% were either all uncemented or hybrid total knee replacements (where at least one component utilises cemented fixation and at least one component utilises uncemented fixation). Most partial knee replacements (UKRs) were unicondylar (8.7% of the total) with the remainder being patellofemoral knee replacements (1.2%).

More than half of all operations (56.6%) were total knee replacements which were all cemented, unconstrained and fixed, followed by 20.7% which were all cemented, posterior stabilised and fixed. Within each method of fixation, it can be seen that uncemented/hybrid prostheses are mostly unconstrained (cruciate retaining) but almost equally likely to have a mobile or fixed bearing. Two-thirds (66.6%) of cemented implants are unconstrained (cruciate retaining) and have a fixed bearing. Unicondylar knee surgery typically involves the use of a mobile type of bearing/constraint. A number of primary knee joint operations could not be classified according to their bearing/constraint (approximately 1.1% of the total cohort).

Table 3.21 shows the annual change in the usage of primary knee replacements. Overall, more than 80% of all primaries utilised an all cemented fixation method and since 2003, the share of all implant replacements of this type has increased by about 6%. The main decline in the type of primary knee surgery carried out has been in the use of all uncemented and hybrid total knee replacements over time (now 2.4% of all knee replacements). Each implant of this type now used has decreased proportionally to less than a third of those figures reported for 2003 (when they were 9.5% of all knee replacements).

Table 3.20 Numbers and percentages of primary knee replacements by fixation method, constraint and bearing type.

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			
Total knee replacement				
All cemented		**828,573**		**84.9**
Cemented and				
	unconstrained, fixed	551,832	66.6	56.6
	unconstrained, mobile	34,507	4.2	3.5
	posterior-stabilised, fixed	202,284	24.4	20.7
	posterior-stabilised, mobile	11,526	1.4	1.2
	constrained, condylar	6,428	0.8	0.7
	monobloc polyethylene tibia	12,765	1.5	1.3
	bearing type unknown	9,231	1.1	0.9
All uncemented		**40,720**		**4.2**
All hybrid		**8,898**		**0.9**
Uncemented/hybrid and				
	unconstrained, fixed	21,625	43.6	2.2
	unconstrained, mobile	23,395	47.2	2.4
	posterior-stabilised, fixed	3,376	6.8	0.3
	other constraint	632	1.3	0.1
	bearing type unknown	590	1.2	0.1
Unicompartmental knee replacement				
All unicondylar		**85,312**		**8.7**
Unicondylar and				
	fixed	27,901	32.7	2.9
	mobile	56,523	66.3	5.8
	bearing type unknown	888	1	0.1
All patellofemoral		**12,191**	**n/a**	**1.2**
Fixation unknown	**Bearing type unknown**	**45**	**n/a**	**<0.01**
All types		**975,739**	**n/a**	**100.0**

Table 3.21 Percentage of all primary knee replacements performed each year by total and partial knee replacement types by fixation method[1].

	Percentage of primary knee replacements performed in each year by fixation method and percentage breakdown by constraint/bearing type[2]													
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total knee replacement														
All cemented	**81.5**	**80.8**	**81.7**	**81.3**	**81.9**	**81.8**	**82.6**	**84.0**	**85.4**	**86.7**	**87.7**	**87.4**	**87.4**	**87.3**
Cemented and														
unconstrained fixed	53.2	52.8	52.8	50.4	50.3	51.2	52.8	54.2	56.3	59.0	59.8	60.7	61.7	62.2
unconstrained mobile	4.0	4.2	5.4	6.5	6.4	5.7	4.8	4.1	3.0	2.4	2.2	2.0	1.7	1.8
posterior-stabilised fixed	20.7	20.6	19.6	20.1	20.4	20.9	21.4	21.8	21.6	21.0	21.1	20.5	20.2	19.8
posterior-stabilised mobile	0.9	1.1	1.6	1.9	1.6	1.4	1.4	1.4	1.2	1.1	1.2	1.0	0.8	0.5
constrained condylar	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.4	0.4	0.6	0.8	1.0	1.2	1.3
monobloc polyethlene tibia	0.3	0.2	0.4	0.6	0.9	0.8	0.7	1.0	1.6	2.0	2.1	1.9	1.5	1.5
bearing/ constraint unknown	1.9	1.3	1.5	1.6	2.0	1.5	1.2	1.2	1.2	0.6	0.5	0.4	0.3	0.3
All uncemented	**6.7**	**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**
Uncemented and														
unconstrained fixed	2.6	2.4	2.4	2.7	3.0	2.8	2.6	1.8	1.4	1.0	0.7	0.6	0.7	0.7
unconstrained mobile	3.2	3.3	3.2	3.1	3.0	2.9	2.6	2.6	2.4	2.0	1.6	1.6	1.4	1.1
posterior-stabilised fixed	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.2	0.2	0.2	0.2	0.3	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
constraint unknown	0.2	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
All hybrid	**2.8**	**2.8**	**2.4**	**1.7**	**1.4**	**1.4**	**1.2**	**0.9**	**0.5**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**
Hybrid and														
unconstrained fixed	2.3	2.3	1.9	1.2	1.0	1.1	1.0	0.7	0.3	0.2	0.2	0.1	0.1	0.1
unconstrained mobile	0.3	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
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
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
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

Table 3.21 (continued)

	Percentage of primary knee replacements performed in each year by fixation method and percentage breakdown by constraint/bearing type[2]													
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Unicompartmental knee replacement														
All unicondylar	8.0	8.7	8.6	9.3	8.9	9.1	9.0	9.0	8.5	8.2	8.1	8.5	8.8	9.2
Unicondylar and														
fixed	1.4	1.8	2.0	2.3	2.0	2.1	2.2	2.7	2.6	3.0	3.3	3.5	3.7	4.1
mobile	6.5	6.7	6.5	6.9	6.7	6.8	6.6	6.2	5.8	5.2	4.7	5.0	5.1	5.1
constraint unknown	0.2	0.2	0.1	0.2	0.1	0.2	0.2	0.1	0.1	<0.1	0.1	<0.1	<0.1	<0.1
All patellofemoral	1.0	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
All unknown		0.2	0.01											
All types (n)	13,546	27,762	42,301	50,360	66,878	74,277	76,259	78,908	82,501	86,299	85,935	95,740	96,826	98,147

Note: 1 Percentage of all primary operations in a particular year which used one of the five fixation methods: cemented, uncemented, hybrid, patellofemoral or unicondylar. 2 Percentages shown represent percentage of total procedures.

3.5.1.2 Reasons for primary knee replacement surgery

The diagnostic reason(s) for a patient undergoing primary knee replacement surgery form part of the clinical pre-assessment process and are recorded by the clinician on the MDS form. Of all reasons for primary surgery, the dominant diagnosis recorded in the registry is knee osteoarthritis; the number of joints with a sole diagnosis of knee osteoarthritis as the indication for knee replacement is 938,349 (96%) of all 975,595 knee replacements with a reason for primary surgery recorded in the NJR. Other possible diagnoses include avascular necrosis, trauma, inflammatory arthritis and infection (see Table 3.22 footnotes for primary diagnoses details).

Table 3.22 shows the main reasons cited by clinicians for primary surgery, as selected from the listed diagnoses available on the particular version of the data collection form filled out by the clinician. The total number of indications, the percentage this forms of the total number of knee operations and a breakdown of these by gender are shown separately for each reason. Reasons shown are all indications given for a primary surgery and in some cases multiple reasons have been given for a primary operation. Therefore, reasons are not mutually exclusive of each other. In addition, 144 knee procedures had no recorded reason for undergoing primary surgery.

After osteoarthritis, the most frequently given indication for surgery was inflammatory arthritis (forming about 2% of reasons). There is some indication of gender differences in the primary reason given for carrying out knee replacement, although for some diagnoses, the numbers of cases are small.

Table 3.22 Reasons for primary knee replacement surgery; number and percentage of all NJR recorded primary knee replacement surgeries carried out for each clinical reason broken down by gender.

Reason for Knee Primary	Number (%) of knee joints with specified primary diagnosis[1] (n= 975,595)		All joints with this reason[1] (% of all joints)
	Male	Female	
Osteoarthritis	413,516 (96.9)	535,727 (95.6)	949,243 (96.1)
Avascular necrosis	1,381 (0.3)	2,190 (0.4)	3,571 (0.4)
Previous infection	402 (0.1)	265 (<0.1)	667 (0.1)
Previous trauma	3,126 (0.7)	2,472 (0.4)	5,598 (0.6)
Inflammatory arthritis[2]	5,178 (1.2)	15,516 (2.8)	20,694 (2.1)
Trauma	16 (<0.1)	24 (<0.1)	40 (<0.1)
Other indication[3]	3,191 (0.7)	4,295 (0.8)	7,486 (0.8)

Note: 1 More than one diagnosis could be indicated by the clinician and results represent all reasons given by the surgeon. 2 Inflammatory arthritis for knees combines diagnoses of rheumatoid arthritis, seronegative and seropositive rheumatoid arthritis, and other inflammatory arthropathy. 3 Other indication includes failed internal fixation, previous arthrodesis, and other indicated reasons for primary knee replacement.

3.5.1.3 Summary of the types of primary knee surgery performed by consultant surgeons and units

Within the whole registry, the 975,739 primary knee joint replacement procedures contributing to our analyses were carried out by a total of 3,124 consultant surgeons working across 460 units. Over the last three years (1st January 2014 to 31st December 2016), 290,713 primary knee procedures were performed by 2,007 consultant surgeons working across 403 units. Looking at caseload over this three-year period, the median number of primary procedures per consultant surgeon was 104 (IQR 26-214) and the median number of procedures per unit was 633 (IQR 318-1,006).

Over this three-year period, there have been 261,842 primary total knee replacements performed by 1,999 surgeons (median=95; IQR 25-194) in 403 separate units (median=565 cases per unit; IQR 277-939). In the same time period, there have been 25,718 primary unicondylar knee procedures performed by 820 consultant surgeons (median=12; IQR 3-35) in 364 units (median=37 cases per unit; IQR 13.5-81.5). The number of procedures per consultant over this period may be lower for newly qualified consultants and those who may have retired during this period. Table 3.23 shows how the caseload of TKR, unicondylar and patellofemoral procedures for units and consultants has changed over the last three years.

Table 3.23 Descriptive statistics of total knee replacement, unicondylar and patellofemoral procedures performed by consultant and unit by year of surgery in the last three years.

	Year of surgery:	2014	2015	2016
	Number of procedures in year:	95,740	96,826	98,147
Consultant: Total knee replacements (TKR)	Number of consultants providing primary replacement each year	1,723	1,722	1,694
	Mean number of primary replacements per consultant	50	51	52
	Median (IQR) number of any primary replacement per consultant	40 (14-74)	40 (16-74)	41 (17-71)
	Number of consultants who entered >50 procedures each year	707	706	710
	Number of consultants who entered >100 procedures each year	223	213	210
Consultant: Unicondylar replacements	Number of consultants providing primary replacement each year	646	647	637
	Mean number of primary replacements per consultant	13	13	14
	Median (IQR) number of any primary replacement per consultant	6 (3-14)	6 (2-15)	7 (2-17)
	Number of consultants who entered >10 procedures each year	212	234	242
	Number of consultants who entered >50 procedures each year	33	32	34
Consultant: Patellofemoral replacements	Number of consultants providing primary replacement each year	317	295	282
	Mean number of primary replacements per consultant	3.3	3.6	3.7
	Median (IQR) number of any primary replacement per consultant	2 (1-4)	2 (1-5)	2 (1-4)
	Number of consultants who entered >10 procedures each year	14	12	14
	Number of consultants who entered >20 procedures each year	2	3	2
Units: Total knee replacements	Number of units providing primary replacement each year	391	386	394
	Mean number of primary replacements per unit	221	226	224
	Median (IQR) number of any primary replacement per unit	195 (97-315)	197 (99-317)	195 (97-312)
	Number of units who entered >300 procedures each year	102	110	112
	Number of units who entered >500 procedures each year	17	21	17
Units: Unicondylar replacements	Number of units providing primary replacement each year	342	328	329
	Mean number of primary replacements per unit	24	26	27
	Median (IQR) number of any primary replacement per unit	13 (5-29)	14 (6-29)	14 (6-32)
	Number of units who entered >10 procedures each year	196	202	195
	Number of units who entered >50 procedures each year	42	41	51
Units: Patellofemoral replacements	Number of units providing primary replacement each year	220	229	222
	Mean number of primary replacements per unit	4.8	4.7	4.7
	Median (IQR) number of any primary replacement per unit	3 (2-6)	3 (1-6)	3 (1-6)
	Number of units who entered >10 procedures each year	23	25	26
	Number of units who entered >20 procedures each year	6	3	3

Looking at recent annual unit caseload, in 2016, 8% of units performing primary total knee replacements (Figure 3.16 (a)) performed less than 25 total knee replacements during the year. This compares to unicondylar knee replacements (Figure 3.16 (b)) where 62% of units performed 20 or less unicondylar knee replacements in the year. Figure 3.16 (c) shows that 99% of units performing patellofemoral replacements performed 20 or less patellofemoral replacements in the year.

Looking at recent annual consultant caseload (Figure 3.16 (a)), in 2016, 34% of primary total knee replacement consultants were performing 25 or less total knee replacements a year. This accounts for approximately 7% of primary total knee replacements. For unicondylar knee replacements (Figure 3.16 (b)), 25% of consultants were performing one or two cases a year accounting for only 2.4% of total unicondylar replacements. A further 37% of unicondylar consultants were performing between three and ten cases a year. In total these 62% of unicondylar consultants were performing 17.3% of all unicondylar procedures. For patellofemoral replacements (Figure 3.16 (c)), 54% of patellofemoral consultants were performing only one or two in the year which accounts for 21.2% of all patellofemoral replacements in the year. A further 41% were performing between three and ten cases a year. This means that 5% of patellofemoral consultants are doing 23.3% of all patellofemoral replacements. In total, 99% of patellofemoral consultants are performing 20 or less patellofemoral replacements in the year.

Figure 3.16 (a)

Exploring unit and consultant frequency of TKR, unicondylar and patellofemoral knee surgery, and total caseload in the NJR between 2014 and 2016.

(a) **TKR**

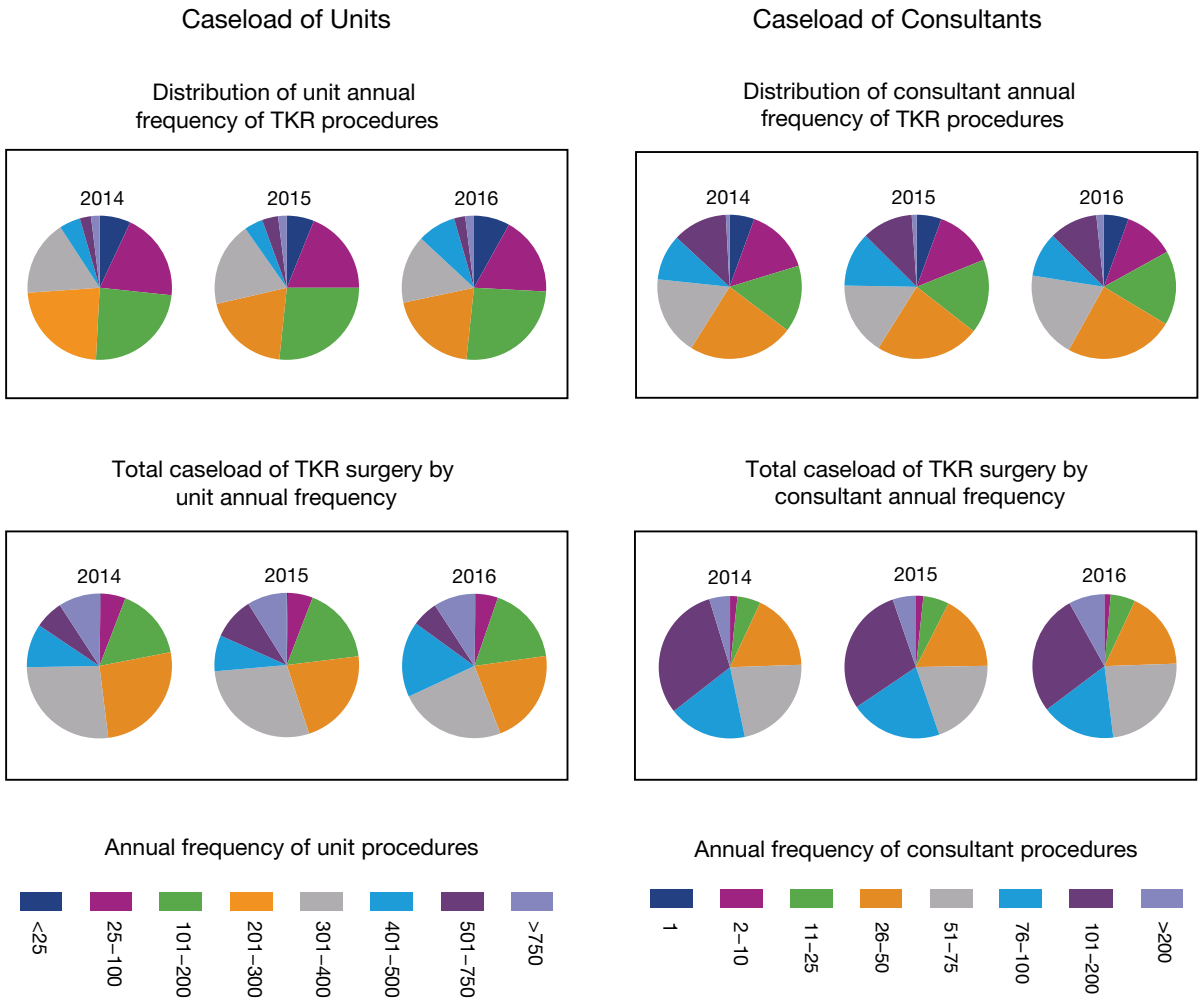


Figure 3.16 (b)

Exploring unit and consultant frequency of TKR, unicondylar and patellofemoral knee surgery, and total caseload in the NJR between 2014 and 2016.

(b) **Unicondylar**

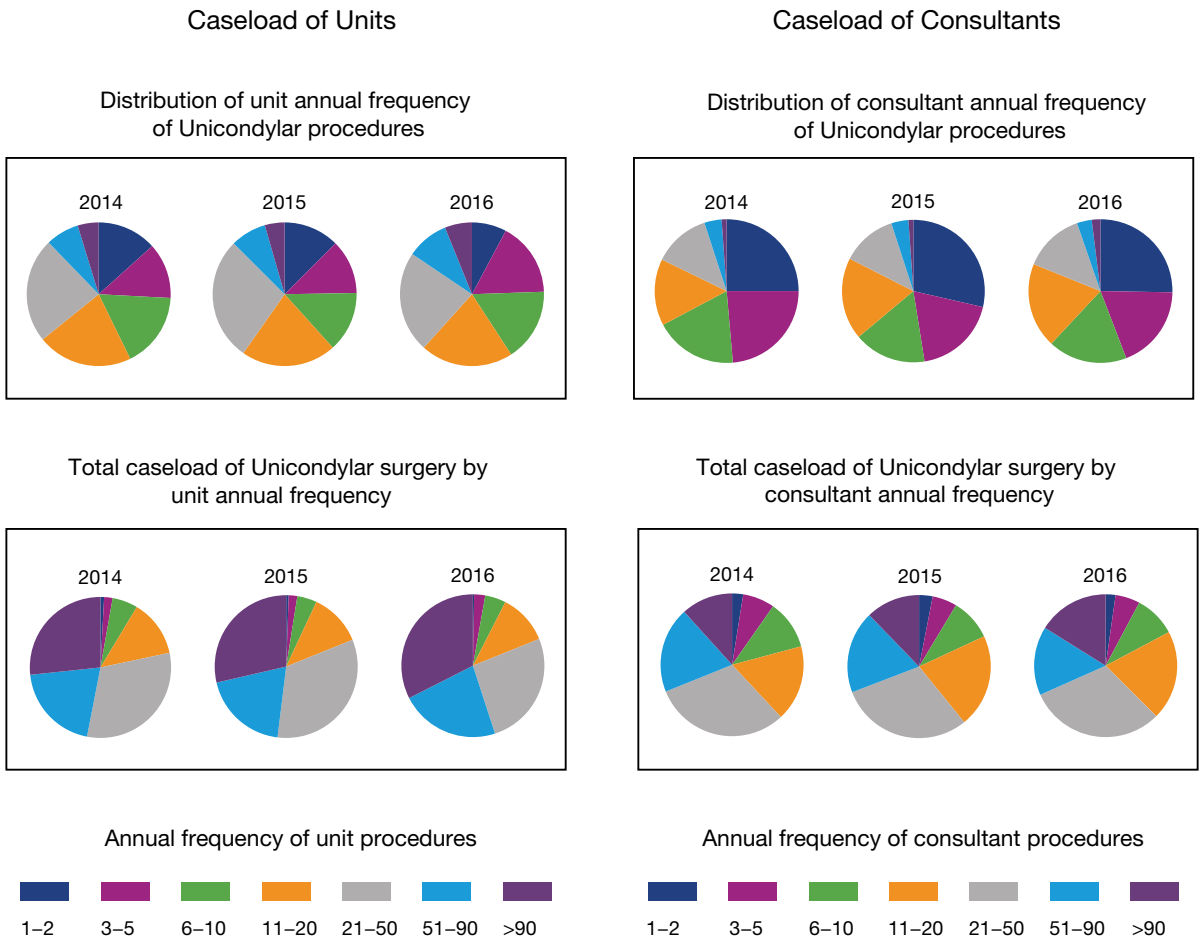
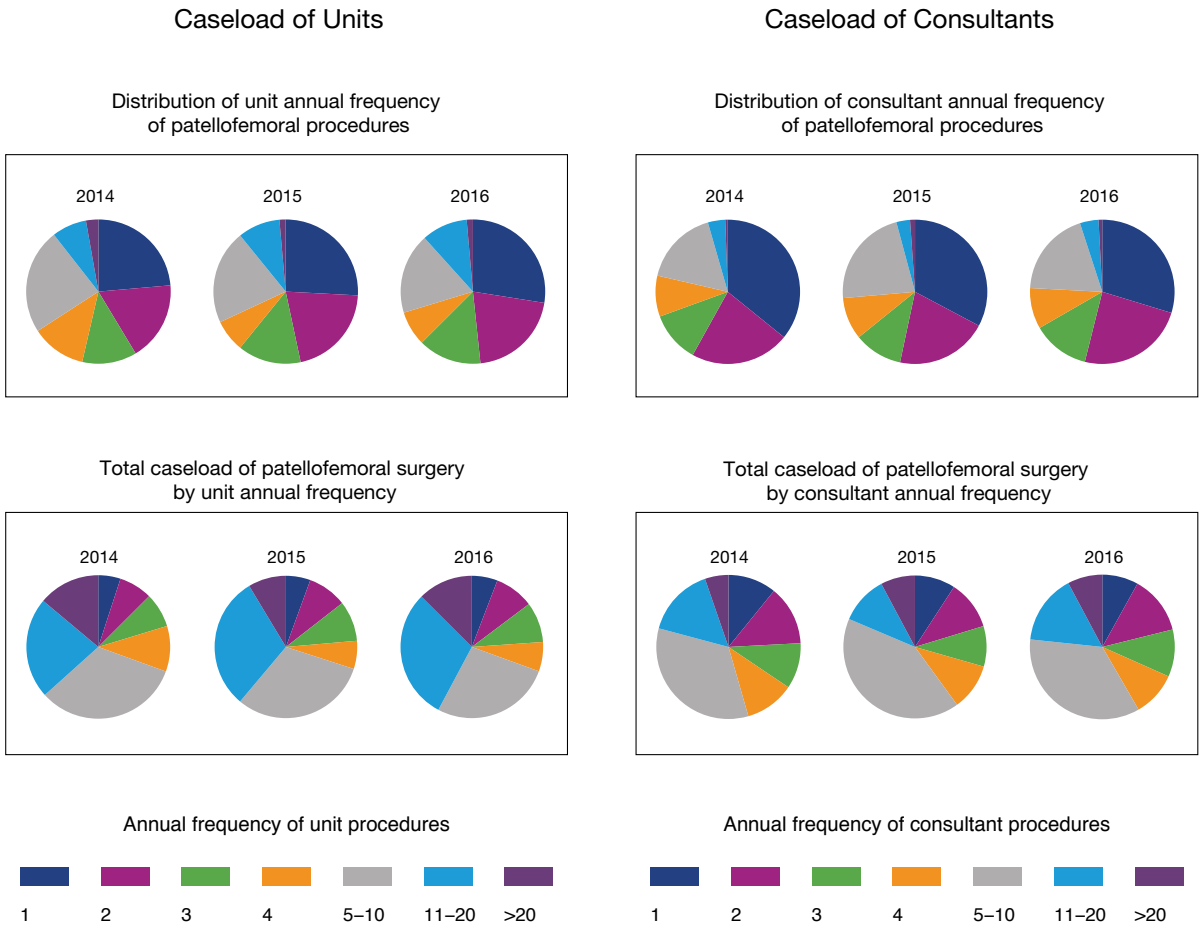


Figure 3.16 (c)

Exploring unit and consultant frequency of TKR, unicondylar and patellofemoral knee surgery, and total caseload in the NJR between 2014 and 2016.

(c) **Patellofemoral**



3.5.1.4 Age and gender characterisation of the primary knee patient cohort

Table 3.24 shows the age and gender distribution of patients undergoing a first replacement of their knee joint. The median age of a person receiving a cemented total knee replacement was 70 years (IQR 64-76 years). However, for unicompartmental primary knee surgery, patients were typically six (unicondylar; median age 64 years; IQR 57-70) and twelve years younger (patellofemoral; median age 58 years; IQR 51-67). The 99th percentile of patient age for all types of surgery ranged between 85 and 88 years, indicating that surgery was rarely undertaken in a person aged 90 years or older, although the maximum age of a patient who underwent primary knee surgery as recorded on the NJR was aged 102 years.

Over all operation types, a higher percentage of females (56.8%) than males have had a knee joint replaced. Women are also more likely to have a primary total knee replacement; 57.3%, 52.0% and 55.6% 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%). Patellofemoral surgery is predominantly carried out on females (77.6% of patients) who are typically younger than a TKR or unicondylar patient with a median age at operation of 58.

Table 3.24 Age (in years) and percentage (%) male at primary operation[1, 2] for different types of knee replacement and by fixation, constraint and bearing type.

Fixation method	Constraint and bearing type	Percentage (%) male[1]	Age of patient (years)		
			Median (IQR)[2]	Minimum age	Maximum age
All cemented		**42.3**	**70 (64-76)**	**7**	**102**
Cemented and	unconstrained, fixed	42.7	70 (64-76)	13	102
	unconstrained, mobile	42.7	69 (62-76)	22	98
	posterior-stabilised, fixed	41.0	70 (64-77)	15	102
	posterior-stabilised, mobile	44.9	66 (60-73)	22	95
	constrained, condylar	36.0	71 (63-78)	18	97
	bearing type unknown	42.1	70 (63-77)	7	99
	monobloc polyethylene tibia	40.7	74 (69-79)	25	96
All uncemented		**48.0**	**69 (62-75)**	**20**	**101**
All hybrid		**44.4**	**69 (62-76)**	**23**	**96**
Uncemented/ hybrid and	unconstrained, fixed	48.0	69 (62-76)	24	99
	unconstrained, mobile	45.6	69 (62-75)	25	101
	posterior-stabilised, fixed	51.7	66 (59-74)	20	94
	other type	64.5	66 (60-74)	33	93
	bearing type unknown	48.6	68 (61-76)	23	93
All unicondylar		**53.0**	**64 (57-70)**	**18**	**97**
Unicondylar and	fixed	53.9	63 (56-70)	18	97
	mobile	52.6	64 (57-71)	23	95
	bearing type unknown	50.9	63 (56-70)	31	91
All patellofemoral		**22.4**	**58 (51-67)**	**21**	**93**
Fixation unknown	bearing type unknown	**46.7**	**69 (59-77)**	**43**	**85**
All types		**43.2**	**69 (63-76)**	**7**	**102**

Note: 1 The percentage male figures are based on a total number of 975,737 primary knee replacements after omitting two cases where gender was not specified. 2 Age distribution based on age at primary operation excluding 181 with age registered as less than or equal to zero or unverifiable age or gender. Figures are thus based on a total of 975,558 replace primary knee joints. The interquartile range (IQR) shows the age range of the middle 50% of patients arranged in order of their age at time of primary knee operation.

3.5.2 First revision after primary knee surgery

A total of 24,399 first revisions of a knee prosthesis have been linked to NJR primary knee replacement surgery records of operations undertaken between 2003 and 2016.

This section explores how different surgical, clinical and patient factors affect the estimated cumulative probability of a knee prosthesis being revised for the first time at increasing time points after the primary surgery.

In brief, the main factors we consider, with references to the main results associated with these, are:

- **Year of primary operation (section 3.5.2.1)**: Formal submission of records of joint replacement surgery taking place in England and Wales to a national database was not a mandatory requirement in the initial years of the NJR. Figures 3.17 (a) and (b) review the chance of knee implant first revision by year of operation given the shift from optional to mandatory record keeping.
- **Age and gender (section 3.5.2.2):** Figures 3.18 (a) and (b) show age and age-gender stratified Kaplan-Meier estimates of the cumulative percentage chance of revision after primary surgery.
- **Fixation method and constraint (section 3.5.2.3):** Implant survivorship up to 13 years after the primary operation date are presented in Tables 3.25 (a) and 3.25 (b) broken down by fixation method and then by constraint and bearing within fixation method. The latter table also gives age group and gender sub-divisions of survivorship, when numbers are sufficient for these sub-groups. Figures 3.19 (a), (b) and (c) compare the implant survivorship of different bearing/constraints when the method of fixation used for the knee joint was each of cemented, uncemented/hybrid or a unicompartmental replacement, respectively.
- **Clinical reasons for revision (section 3.5.2.4):** Revision rates for different reasons, broken down by fixation method and by fixation/constraint and bearing, are shown in Tables 3.26 and 3.27. Table 3.28 considers whether revision rates for different reasons change over various periods of time after the date of primary surgery.
- **Type of brand (section 3.5.2.5):** The cumulative percentage chance of revision for different implant brands at different points in time after primary surgery is looked at in Tables 3.29 to 3.31. These tables have additional columns detailing brand specific summaries of patient age at primary operation (median and IQR) and the proportion of males receiving the particular implant brand at primary surgery.

3.5.2.1 Temporal trends in the cumulative probability of a first revision by year of primary knee replacement

Figures 3.17 (a) and (b) illustrate temporal changes in the overall revision rates using Kaplan-Meier; procedures have been grouped by the year of the primary operation. Figure 3.17 (a) plots each Kaplan-Meier survival curve with a common origin, i.e. time zero is equal to the year of operation. Figure 3.17 (b) shows the same curves plotted against calendar time, where the origin of each curve is the year of operation. Figure 3.17 (b) separates each year allowing changes in failure rates to be clearly identified.

In addition, the revision rate at 1, 3 and 5 years has 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 3 and 5 years reduced for operations performed between 2009 and 2016. 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 is: 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.

Figure 3.17 (a)

Changes in cumulative percentage chance of knee replacement failure by year of primary operation. Kaplan-Meier estimates of cumulative percentage probability of a first revision grouped by year in which primary surgery took place.

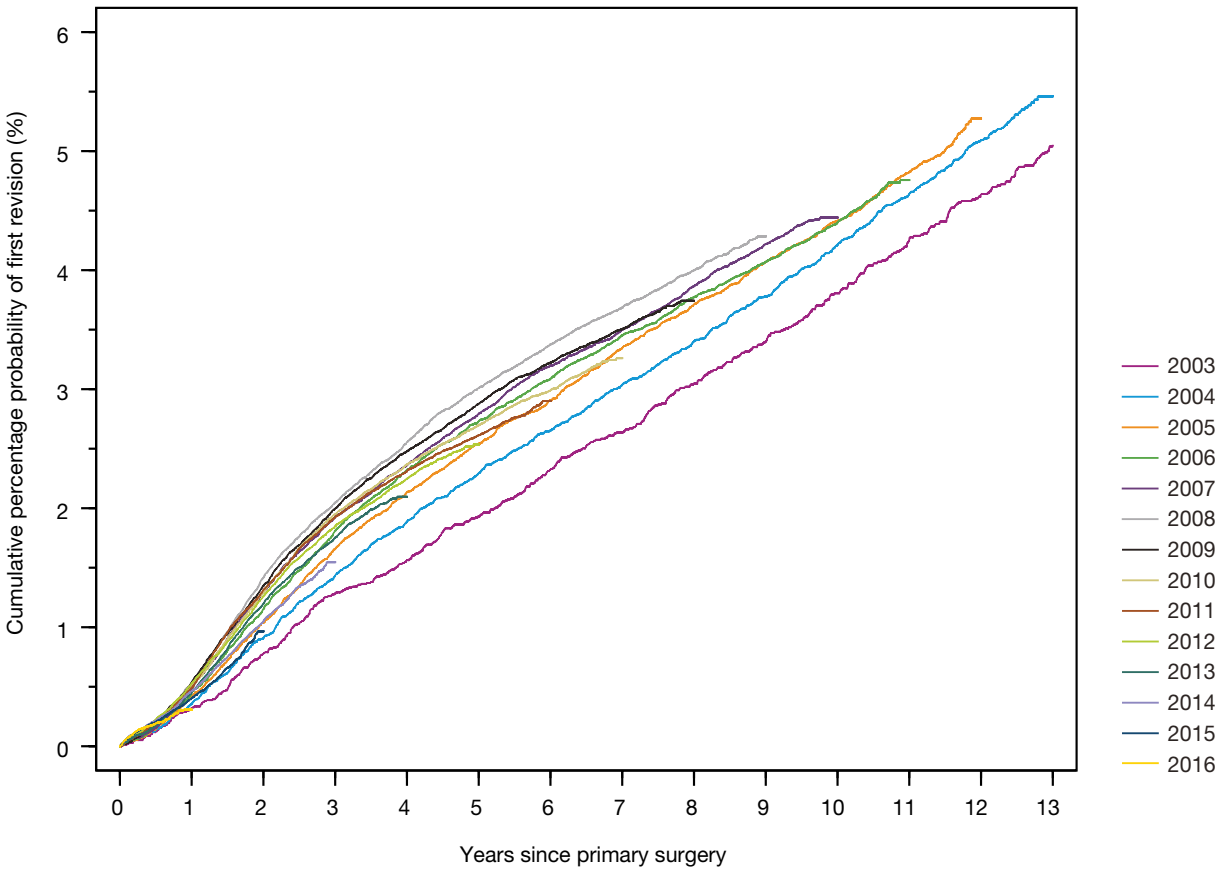
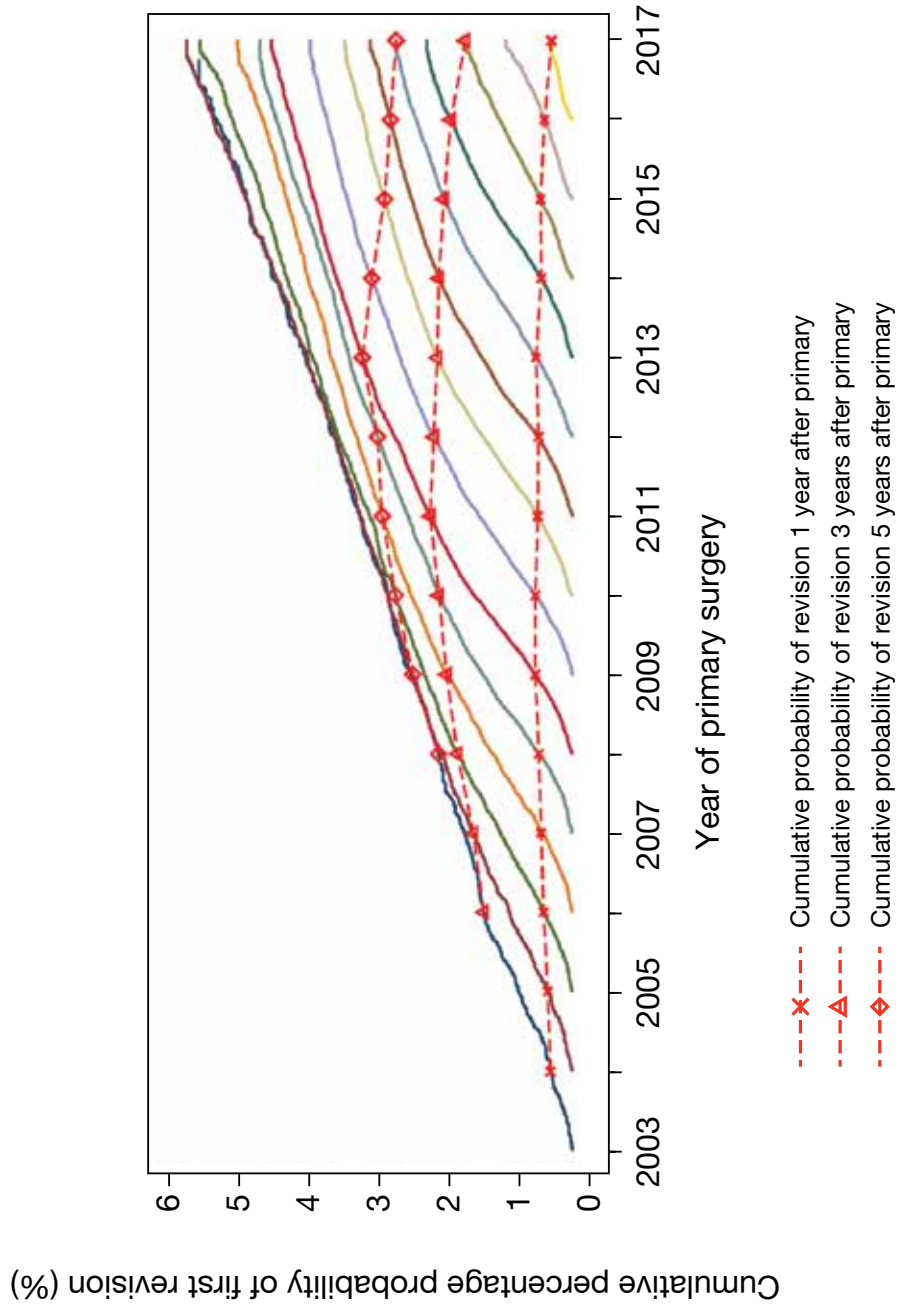


Figure 3.17 (b)

Temporal changes in revision rates after primary knee replacement: Kaplan-Meier estimates of cumulative percentage probability of revision for each year of primary operation with failure rates at 1, 3, and 5 years indicated.



3.5.2.2 Revisions after primary knee surgery by grouped age at primary and gender

Figures 3.18 (a) shows that the chance of revision after primary cemented total knee replacement 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 75 when they underwent primary surgery.

Figure 3.18 (a)

Kaplan-Meier estimates of the cumulative percentage probability of a first revision of primary **cemented** knee replacement broken down by age group (age at primary in years) at increasing years after the primary surgery.

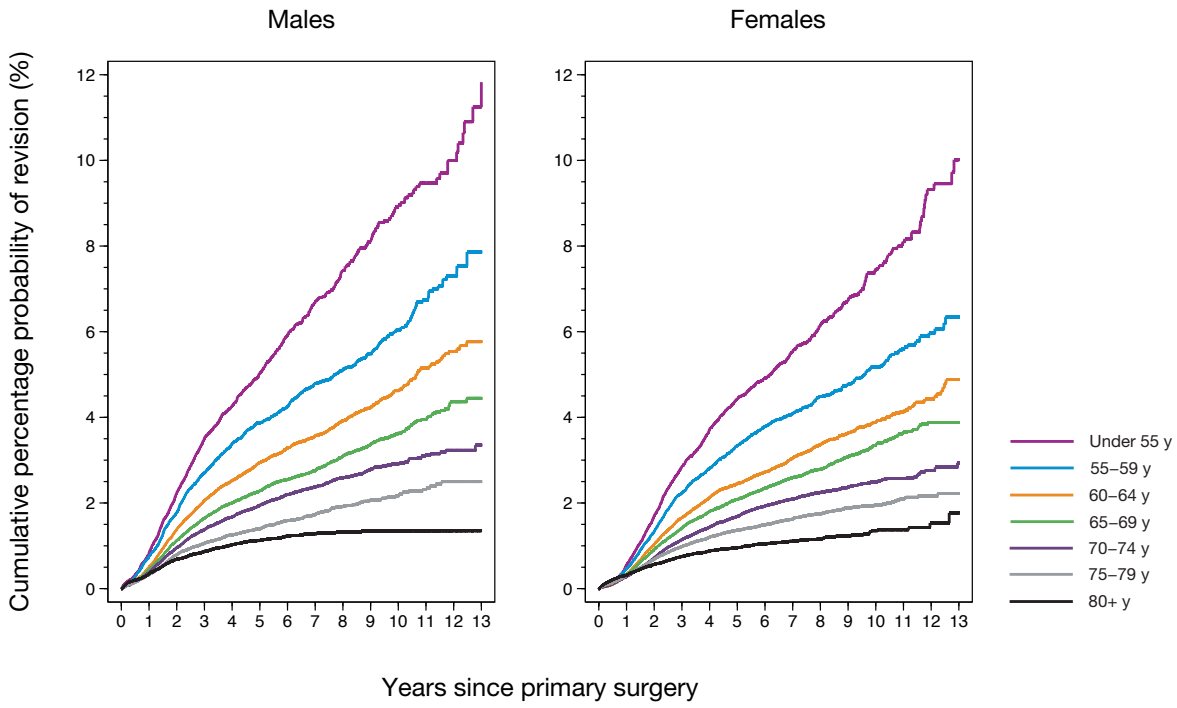
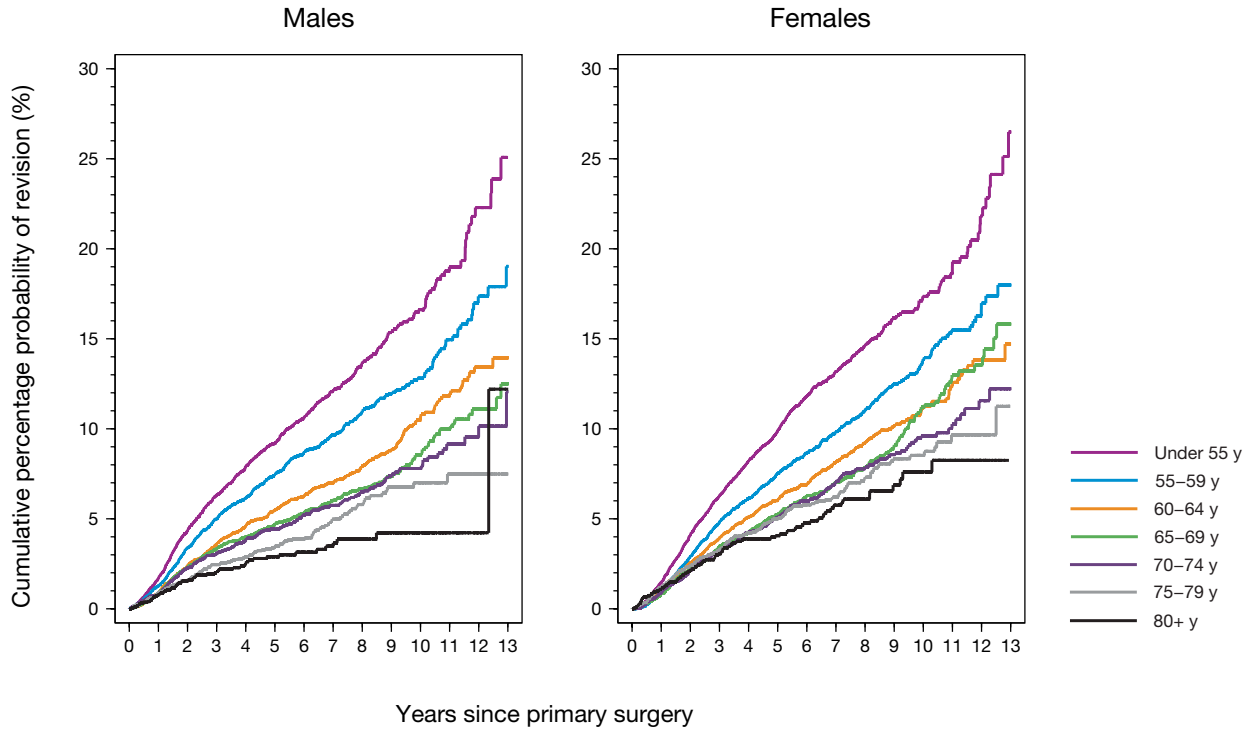


Figure 3.18 (b) shows that the risk of revision of primary unicondylar knee replacement is, again, substantially higher for younger patient cohorts but that there are less marked differences in younger patients in the risk of revision according to gender. The risk of revision appears to be higher in females over the age of 75 compared to males.

Figure 3.18 (b)

Kaplan-Meier estimates of the cumulative percentage probability of a first revision of primary **unicondylar** knee replacement broken down by age group (age at primary in years) and gender at increasing years after the primary surgery.



3.5.2.3 Revisions after primary knee surgery by fixation method and constraint

Table 3.25 (a) 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 and sub-divided further within each fixation type by bearing/constraint type and for UKR, by bearing/constraint type. Estimates are shown, together with 95% Confidence Intervals (95% CI), at each year after primary surgery.

Table 3.25 (b) shows gender and age stratified Kaplan-Meier estimates of the cumulative percentage probability of first revision, for any revision cause, firstly for all cases combined, then by knee fixation/ constraint sub-divisions. Estimates are shown, along with 95% CI, at 1, 3, 5, 7, 10 and 13 years after the primary operation.

Estimates in *blue italics* indicate that the cumulative percentage probability of a first revision of a knee joint replacement estimate is less reliable as these are based on fewer than 250 at risk at that point in time. In addition, for a group at risk size of fewer than 250, the upper 95% CI limit tends to be underestimated by the estimation method used here. Other methods have been proposed which take into account the impact that censoring has on estimation of CIs when numbers at risk are small. However, the upper limit values found differ considerably and as yet there is no clear consensus as to which method provides the most accurate upper limit. Estimates (and CIs) are not given when the number at risk falls below ten.

Unicompartmental knee replacements seem to fare worse compared to total knee replacements with the chance of revision at each estimated time point being more than double that of a TKR. The revision rate for unicondylar (medial or lateral UKR) is 2.8 times higher than the observed rate for all types of knee replacement at 13 years and the revision rate for patellofemoral replacement is over four times higher at 12 and 13 years although less than 250 remain at risk at 13 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 compared to their male, age equivalent, counterpart. The reverse pattern is seen in patellofemoral implant survivorship. It is clear that partial knee replacement surgery is used generally in younger patients. Younger patients may also be more active which may put more strain on their implants and increase the risk of revision. However, for the first time in this report, we have reported revision by age group and the pattern is consistent across age groups.

Figures 3.19 (a) and (b) explore the chance of knee joint revision for different bearings and constraints within a particular knee fixation type; that of cemented, uncemented/hybrid. Figure 3.19 (c) looks at the chance of revision for the most commonly used constraints in a unicondylar knee replacement and patellofemoral implants. It should be noted that unknown constraint/ fixation combinations are not shown.

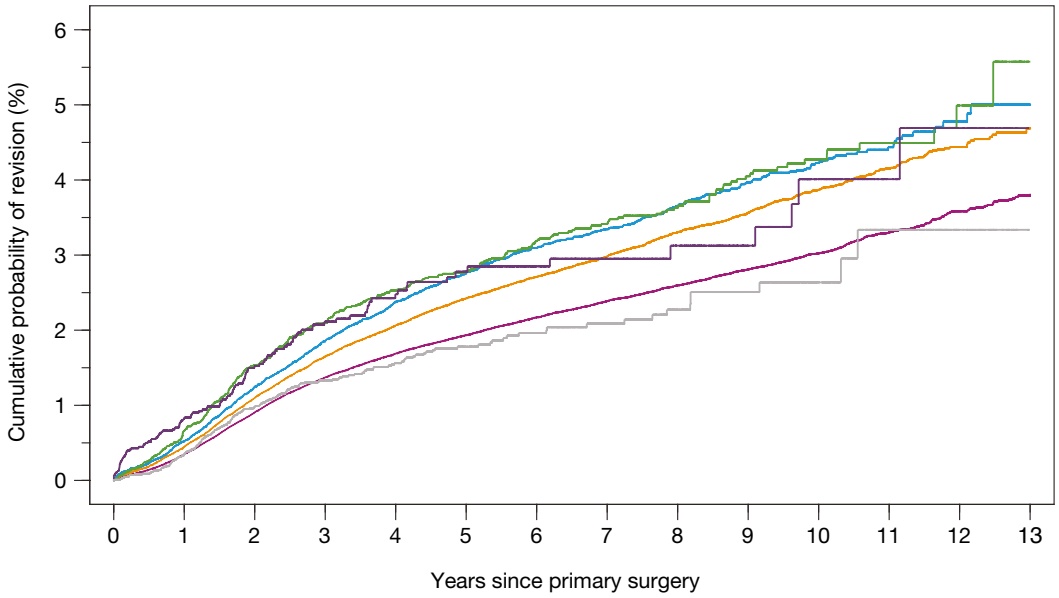
Overall, little difference is seen in implant survivorship by constraint within a fixation type apart from:

- Cemented unconstrained, fixed bearing total knee replacement results in lower chances of revision overall compared to other combinations of constraint and bearing used in a cemented fixation of the joint with modular tibial components (Figure 3.19 (a))
- Uncemented/hybrid total knee replacements (Figure 3.19 (b)) with posterior stabilised constraint and fixed bearings fare worse than their unconstrained bearing equivalents

Figure 3.19 (a)

Comparison of the Kaplan-Meier cumulative percentage probability estimates of a knee prosthesis first revision for different constraint and bearing types at increasing years after the primary surgery when the primary arthroplasty method of fixation is cemented only.

(a) **Cemented**



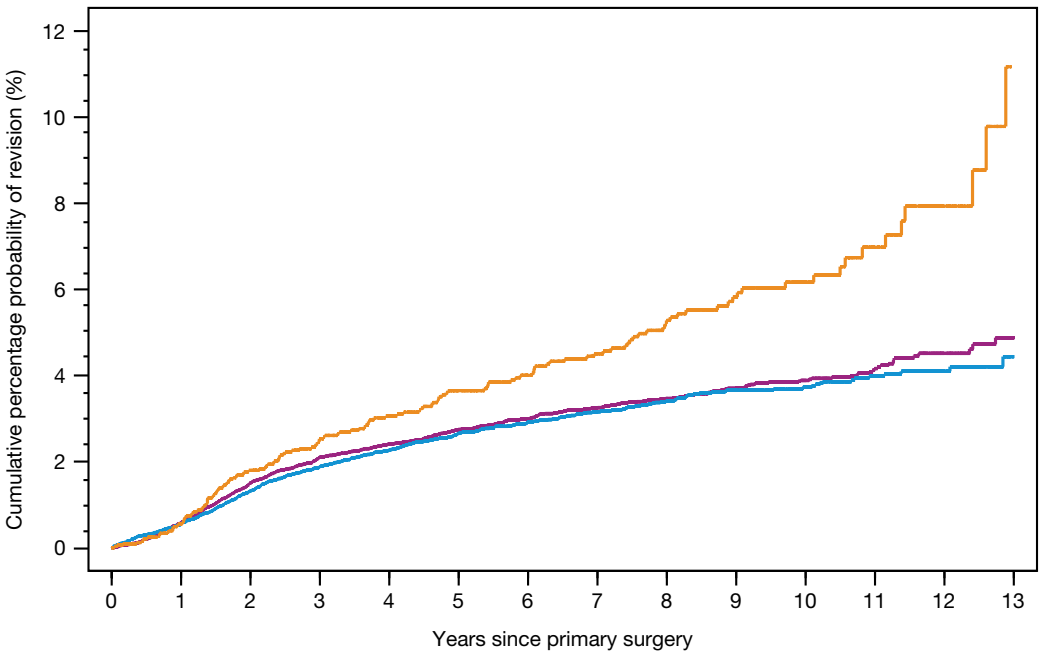
Number at risk

Unconstrained, fixed	551,832	483,984	416,668	351,961	295,334	240,847	192,174	149,207	110,352	76,222	48,250	28,724	13,171	3,982
Unconstrained, mobile	34,507	32,293	30,015	27,525	25,073	22,512	19,655	16,279	12,687	8,770	5,203	2,649	1,003	296
Posterior–stabilised, fixed	202,284	179,843	157,107	134,678	114,208	94,398	75,749	58,502	42,969	29,360	18,289	10,700	5,073	1,547
Posterior–stabilised, mobile	11,526	10,891	9,940	8,845	7,703	6,678	5,609	4,484	3,452	2,510	1,541	821	298	88
Constrained, condylar	6,428	4,945	3,696	2,617	1,853	1,348	1,018	748	544	395	234	147	69	19
Monobloc polyethylene tibia	12,765	11,100	9,447	7,486	5,590	3,883	2,618	1,881	1,353	832	398	185	74	30

Figure 3.19 (b)

Comparison of the Kaplan-Meier cumulative percentage probability estimates of a knee prosthesis first revision for different constraint and bearing types at increasing years after the primary surgery when the primary arthroplasty method of fixation is uncemented or hybrid.

(b) **Uncemented/hybrid**



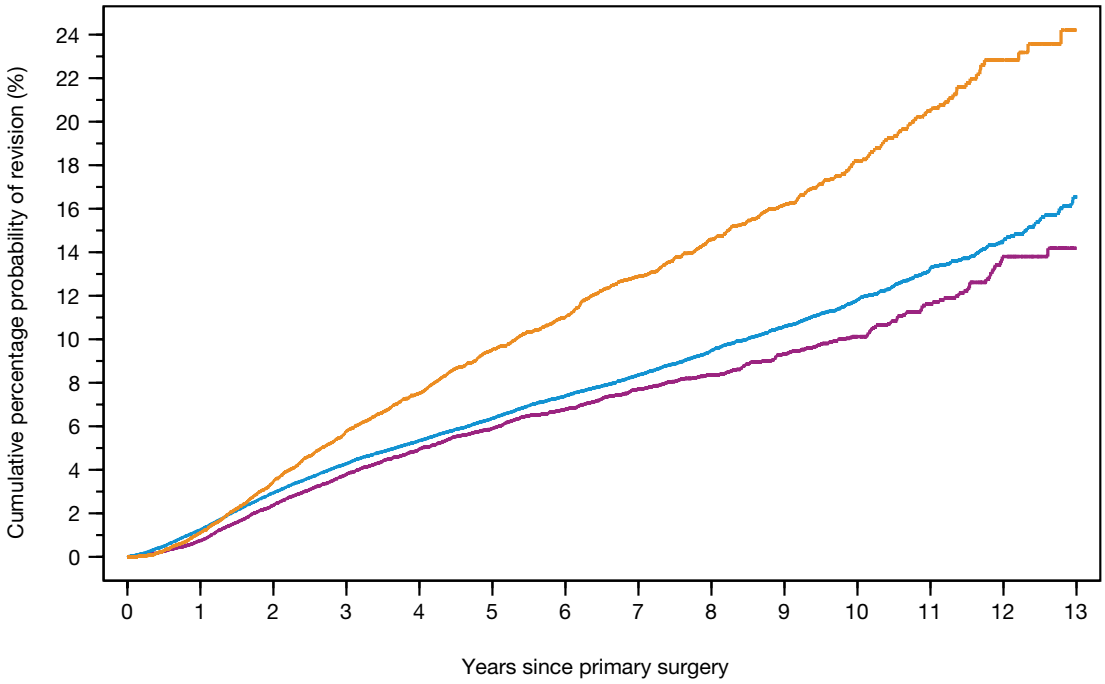
Number at risk

Unconstrained, fixed	21,625	20,438	19,323	18,187	17,005	15,594	13,897	11,734	9,120	6,525	4,182	2,600	1,236	373
Unconstrained, mobile	23,395	21,711	19,700	17,582	15,772	13,636	11,361	9,207	7,177	5,084	3,309	1,967	948	285
Posterior–stabilised, fixed	3,376	3,156	2,866	2,519	2,262	2,027	1,807	1,546	1,211	904	602	347	162	56

Figure 3.19 (c)

Comparison of the Kaplan-Meier cumulative percentage probability estimates of a knee prosthesis first revision for different constraint and bearing types at increasing years after the primary surgery when the primary is a unicondylar or patellofemoral partial knee replacement.

(c) **Unicondylar and patellofemoral partial knee replacements**



Number at risk

Unicondylar, fixed	27,901	23,627	19,608	15,942	12,963	10,293	8,097	6,080	4,511	3,127	1,994	1,080	443	116
Unicondylar, mobile	56,523	50,628	44,641	39,084	34,471	29,588	24,580	19,659	14,819	10,303	6,530	3,795	1,795	538
Patellofemoral	12,191	10,981	9,614	8,355	7,203	5,924	4,752	3,653	2,670	1,750	1,018	588	267	83

Table 3.25 (a) Kaplan-Meier estimates of the cumulative percentage probability of first revision (95% CI) at specified times after primary knee replacement, by fixation, constraint and bearing type[1,2].

Fixation/constraint/bearing type	n	Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is: 1 year	3 years	5 years	7 years	10 years	13 years
All types	**975,739**	**0.47 (0.46-0.49)**	**1.81 (1.78-1.84)**	**2.63 (2.59-2.67)**	**3.31 (3.26-3.36)**	**4.34 (4.27-4.40)**	**5.62 (5.47-5.77)**
Others/unknown	**45**		*0*	*0*	*2.63 (0.37-17.25)*	*2.63 (0.37-17.25)*	
All cemented	**828,573**	**0.39 (0.38-0.41)**	**1.49 (1.46-1.52)**	**2.13 (2.10-2.17)**	**2.63 (2.59-2.67)**	**3.35 (3.29-3.42)**	**4.16 (4.03-4.29)**
unconstrained, fixed	551,832	0.35 (0.33-0.37)	1.37 (1.34-1.41)	1.93 (1.89-1.98)	2.39 (2.34-2.44)	3.02 (2.95-3.10)	3.82 (3.66-3.98)
unconstrained, mobile	34,507	0.52 (0.45-0.61)	1.85 (1.71-2.01)	2.76 (2.58-2.95)	3.35 (3.14-3.57)	4.23 (3.96-4.51)	5.00 (4.52-5.54)
posterior-stabilised, fixed	202,284	0.45 (0.42-0.48)	1.65 (1.59-1.71)	2.43 (2.35-2.51)	2.99 (2.90-3.08)	3.87 (3.74-4.01)	4.69 (4.43-4.96)
posterior-stabilised, mobile	11,526	0.67 (0.53-0.84)	2.10 (1.84-2.39)	2.78 (2.47-3.12)	3.41 (3.05-3.82)	4.28 (3.80-4.81)	*5.58 (4.30-7.22)*
constrained, condylar	6,428	0.82 (0.62-1.09)	2.11 (1.72-2.59)	2.78 (2.27-3.40)	2.95 (2.40-3.63)	*4.01 (2.96-5.43)*	*4.69 (3.19-6.87)*
monobloc polyethylene tibia	12,765	0.35 (0.26-0.47)	1.33 (1.13-1.57)	1.78 (1.52-2.08)	2.09 (1.77-2.46)	2.64 (2.14-3.24)	*3.34 (2.39-4.65)*
bearing type unknown	9,231	0.80 (0.63-1.01)	2.41 (2.11-2.76)	3.43 (3.05-3.85)	4.20 (3.76-4.68)	5.00 (4.45-5.60)	*5.88 (4.84-7.15)*
All uncemented	**40,720**	**0.58 (0.51-0.66)**	**2.09 (1.95-2.24)**	**2.86 (2.69-3.04)**	**3.39 (3.19-3.59)**	**4.12 (3.87-4.37)**	**5.37 (4.78-6.03)**
unconstrained, fixed	15,540	0.65 (0.53-0.79)	2.32 (2.08-2.58)	2.98 (2.71-3.28)	3.50 (3.19-3.83)	4.20 (3.82-4.61)	*5.30 (4.49-6.26)*
unconstrained, mobile	21,608	0.53 (0.44-0.64)	1.88 (1.69-2.08)	2.67 (2.44-2.91)	3.17 (2.91-3.45)	3.73 (3.42-4.07)	4.43 (3.80-5.16)
posterior-stabilised, fixed	2,860	0.62 (0.38-0.99)	2.49 (1.95-3.18)	3.59 (2.90-4.44)	4.44 (3.63-5.41)	6.35 (5.22-7.70)	*12.07 (8.06-17.87)*
other constraint	246	*0*	*2.03 (0.77-5.34)*	*2.60 (1.09-6.15)*	*2.60 (1.09-6.15)*	*2.60 (1.09-6.15)*	
bearing type unknown	466	0.65 (0.21-2.00)	1.62 (0.77-3.37)	3.38 (2.01-5.65)	3.95 (2.43-6.38)	*4.92 (3.06-7.85)*	*5.50 (3.44-8.75)*
All hybrid	**8,898**	**0.57 (0.43-0.75)**	**1.84 (1.57-2.16)**	**2.44 (2.12-2.81)**	**3.03 (2.66-3.45)**	**3.56 (3.12-4.05)**	*4.41 (3.73-5.21)*
unconstrained, fixed	6,085	0.47 (0.32-0.68)	1.60 (1.31-1.96)	2.17 (1.82-2.59)	2.67 (2.28-3.14)	3.18 (2.72-3.72)	*4.04 (3.30-4.95)*
unconstrained, mobile	1,787	1.03 (0.64-1.65)	1.90 (1.31-2.75)	2.40 (1.68-3.43)	2.91 (2.04-4.15)	*3.64 (2.41-5.47)*	*4.45 (2.73-7.21)*

Note: 1 Estimates in *blue italics* indicate that fewer than 250 cases remain at risk at the time shown. 2 Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Table 3.25 (a) (continued)

Fixation/constraint/bearing type	n	Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is:					
		1 year	3 years	5 years	7 years	10 years	13 years
posterior-stabilised, fixed	516	0.20 (0.03-1.41)	2.73 (1.60-4.66)	3.93 (2.49-6.17)	4.85 (3.17-7.38)	*5.33 (3.49-8.09)*	*6.99 (3.97-12.14)*
other constraint	386	0.28 (0.04-1.97)	2.35 (1.18-4.65)	*3.01 (1.63-5.53)*	*4.31 (2.50-7.37)*	*4.89 (2.88-8.26)*	
bearing type unknown	124	*1.61 (0.41-6.29)*	*6.89 (3.50-13.34)*	*6.89 (3.50-13.34)*	*9.57 (5.17-17.34)*	*9.57 (5.17-17.34)*	
All unicondylar	**85,312**	**1.09 (1.02-1.16)**	**4.13 (3.98-4.28)**	**6.20 (6.01-6.40)**	**8.16 (7.93-8.40)**	**11.38 (11.04-11.74)**	**15.96 (15.10-16.87)**
fixed	27,901	0.75 (0.65-0.86)	3.81 (3.56-4.08)	5.92 (5.58-6.28)	7.73 (7.30-8.19)	10.13 (9.49-10.80)	*14.18 (12.70-15.82)*
mobile	56,523	1.26 (1.17-1.36)	4.29 (4.11-4.47)	6.37 (6.14-6.60)	8.36 (8.09-8.65)	11.82 (11.41-12.25)	16.54 (15.53-17.61)
bearing type unknown	888	0.68 (0.31-1.51)	3.75 (2.67-5.26)	4.92 (3.65-6.63)	7.34 (5.67-9.46)	*11.01 (8.50-14.20)*	*12.99 (9.58-17.49)*
All patellofemoral	**12,191**	**1.11 (0.93-1.32)**	**5.78 (5.35-6.26)**	**9.54 (8.95-10.17)**	**12.89 (12.15-13.68)**	**18.18 (17.05-19.38)**	*24.21 (21.84-26.79)*

Note: 1 Estimates in *blue italics* indicate that fewer than 250 cases remain at risk at the time shown. 2 Blank cells indicate the number at risk is below ten and thus estimates have been omitted as they are highly unreliable.

Table 3.25 (b) Kaplan-Meier estimates of the cumulative percentage probability of first revision (95% CI) at specified times after primary knee replacement, by age and gender[1], for each fixation, constraint and bearing group. *Blue italics signify that fewer than 250 cases remained at risk at these time points.*

		Males							Females						
			Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is:							Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is:					
Fixation group	Age at primary (years)	n	1 year	3 years	5 years	7 years	10 years	13 years	n	1 year	3 years	5 years	7 years	10 years	13 years
All types	<55	30,095	1.08 (0.96-1.20)	4.41 (4.16-4.68)	6.40 (6.08-6.73)	8.41 (8.01-8.83)	11.14 (10.57-11.75)	*15.93 (14.33-17.69)*	42,413	0.81 (0.73-0.90)	3.89 (3.69-4.11)	6.14 (5.88-6.42)	7.97 (7.63-8.31)	10.59 (10.11-11.09)	14.16 (13.02-15.39)
All cemented	<55	19,966	0.82 (0.70-0.96)	3.51 (3.24-3.81)	5.04 (4.69-5.42)	6.70 (6.25-7.17)	8.96 (8.31-9.66)	*11.83 (10.13-13.78)*	28,336	0.57 (0.49-0.67)	2.85 (2.64-3.08)	4.44 (4.16-4.74)	5.55 (5.21-5.92)	7.47 (6.96-8.02)	*10.02 (8.87-11.30)*
unconstrained, fixed	<55	12,630	0.73 (0.59-0.90)	3.11 (2.79-3.48)	4.53 (4.11-5.00)	6.17 (5.62-6.77)	8.42 (7.60-9.32)	*11.83 (9.41-14.82)*	18,187	0.50 (0.41-0.62)	2.44 (2.20-2.71)	3.87 (3.54-4.23)	4.92 (4.51-5.37)	6.60 (6.00-7.27)	*9.51 (7.92-11.40)*
unconstrained, mobile	<55	1,220	1.09 (0.64-1.88)	4.27 (3.23-5.63)	5.84 (4.59-7.43)	7.38 (5.89-9.22)	*9.96 (7.76-12.75)*	*13.84 (8.45-22.21)*	1,491	0.70 (0.38-1.29)	3.27 (2.44-4.37)	5.41 (4.28-6.82)	6.82 (5.49-8.46)	*8.57 (6.76-10.84)*	*10.39 (7.48-14.34)*
posterior-stabilised, fixed	<55	4,810	0.69 (0.49-0.98)	3.92 (3.35-4.59)	5.78 (5.04-6.64)	7.42 (6.49-8.47)	10.23 (8.80-11.87)	*12.58 (10.00-15.76)*	6,986	0.52 (0.37-0.73)	3.37 (2.92-3.88)	5.15 (4.55-5.82)	6.39 (5.67-7.20)	8.82 (7.70-10.10)	*11.64 (9.53-14.17)*
posterior-stabilised, mobile	<55	650	1.40 (0.73-2.68)	4.06 (2.76-5.95)	4.82 (3.37-6.87)	6.16 (4.40-8.59)	*7.23 (5.09-10.23)*		726	1.39 (0.75-2.57)	4.64 (3.30-6.50)	5.96 (4.40-8.04)	6.40 (4.75-8.58)	*9.19 (6.68-12.58)*	
constrained, condylar	<55	225	*3.67 (1.85-7.21)*	*5.83 (3.22-10.45)*	*6.85 (3.83-12.07)*	*6.85 (3.83-12.07)*	*6.85 (3.83-12.07)*		315	*0.73 (0.18-2.90)*	*1.69 (0.63-4.47)*	*1.69 (0.63-4.47)*	*1.69 (0.63-4.47)*	*5.47 (1.38-20.38)*	
monobloc polyethylene tibia	<55	124	*0.87 (0.12-6.01)*	*5.70 (2.59-12.30)*	*5.70 (2.59-12.30)*	*7.38 (3.49-15.25)*	*7.38 (3.49-15.25)*		177	*1.19 (0.30-4.69)*	*3.86 (1.75-8.41)*	*4.98 (2.35-10.39)*	*4.98 (2.35-10.39)*	*4.98 (2.35-10.39)*	
bearing type unknown	<55	307	2.00 (0.90-4.39)	*5.54 (3.43-8.89)*	*8.70 (5.84-12.86)*	*12.70 (8.95-17.86)*	*13.68 (9.63-19.25)*		454	1.81 (0.91-3.59)	5.86 (4.00-8.56)	9.15 (6.70-12.43)	*11.09 (8.25-14.81)*	*12.68 (9.27-17.23)*	*12.68 (9.27-17.23)*
All uncemented	<55	1,562	0.66 (0.36-1.23)	4.14 (3.21-5.34)	5.53 (4.40-6.93)	6.84 (5.52-8.45)	*8.15 (6.58-10.08)*	*15.22 (9.46-24.01)*	1,658	0.86 (0.51-1.45)	4.36 (3.44-5.52)	6.36 (5.20-7.76)	7.06 (5.81-8.56)	8.38 (6.91-10.15)	*8.38 (6.91-10.15)*
unconstrained, fixed	<55	638	0.81 (0.34-1.94)	4.43 (3.01-6.49)	5.94 (4.23-8.32)	7.28 (5.30-9.97)	*8.49 (6.20-11.57)*		617	1.17 (0.56-2.44)	3.51 (2.28-5.39)	4.99 (3.44-7.21)	5.76 (4.04-8.16)	*7.29 (5.14-10.29)*	*7.29 (5.14-10.29)*
unconstrained, mobile	<55	709	0.73 (0.30-1.74)	4.34 (2.99-6.27)	5.60 (4.00-7.81)	7.27 (5.31-9.93)	*8.27 (6.00-11.34)*	*8.27 (6.00-11.34)*	854	0.71 (0.32-1.58)	4.26 (3.04-5.94)	6.48 (4.90-8.56)	7.09 (5.40-9.28)	*8.28 (6.32-10.81)*	
posterior-stabilised, fixed	<55	183	*0*	*1.78 (0.58-5.43)*	*2.62 (0.98-6.93)*	*2.62 (0.98-6.93)*	*6.13 (2.53-14.49)*		163	*0.63 (0.09-4.38)*	*8.05 (4.65-13.76)*	*11.25 (7.02-17.76)*	*12.32 (7.78-19.20)*	*13.61 (8.67-21.01)*	
other constraint	<55	18	*0*	*7.14 (1.04-40.92)*					4						
bearing type unknown	<55	14	*0*	*8.33 (1.22-46.10)*	*8.33 (1.22-46.10)*	*8.33 (1.22-46.10)*			20		*5.00 (0.72-30.53)*	*5.00 (0.72-30.53)*	*5.00 (0.72-30.53)*		
All hybrid	<55	338	0.90 (0.29-2.76)	3.41 (1.90-6.07)	6.17 (3.97-9.51)	*7.76 (5.21-11.48)*	*8.71 (5.77-13.04)*		417	0.51 (0.13-2.01)	3.05 (1.70-5.44)	4.87 (3.05-7.73)	*7.04 (4.72-10.45)*	*7.46 (5.04-10.98)*	*8.93 (5.65-13.96)*
unconstrained, fixed	<55	198	*1.01 (0.25-3.98)*	*3.09 (1.40-6.74)*	*5.85 (3.28-10.32)*	*7.10 (4.18-11.94)*	*7.10 (4.18-11.94)*		255	*0.80 (0.20-3.17)*	*3.78 (1.98-7.14)*	*5.54 (3.25-9.36)*	*7.00 (4.34-11.19)*	*7.00 (4.34-11.19)*	8.94 (5.09-15.44)
unconstrained, mobile	<55	61	*0*	*1.92 (0.27-12.88)*	*4.65 (1.16-17.70)*	*7.72 (2.50-22.53)*			87	*0*	*0*	*0*	*0*		

Note: 1 Excludes 181 cases where either gender was not specified and/or ages were invalid and NHS trace not complete. Total sample on which results are based is 975,558 primary knee replacements.

Fixation group	Age at primary (years)	Males							Females						
		n	Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is:						n	Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is:					
			1 year	3 years	5 years	7 years	10 years	13 years		1 year	3 years	5 years	7 years	10 years	13 years
posterior-stabilised, fixed	<55	36	*0*	*0*	*3.23 (0.46-20.77)*	*7.43 (1.88-26.93)*			42		*2.44 (0.35-16.08)*	*5.08 (1.29-18.83)*	*8.14 (2.68-23.30)*		
other constraint	<55	34		*8.82 (2.93-24.91)*	*11.86 (4.62-28.60)*	*11.86 (4.62-28.60)*	*11.86 (4.62-28.60)*		24	*0*	*0*	*4.35 (0.62-27.07)*	*13.46 (4.55-36.18)*	*13.46 (4.55-36.18)*	
bearing type unknown	<55	9							9						
All unicondylar	**<55**	**7,350**	**1.70 (1.42-2.03)**	**6.33 (5.74-6.97)**	**9.21 (8.46-10.02)**	**12.16 (11.22-13.18)**	**16.62 (15.19-18.16)**	*25.07 (21.13-29.60)*	**8,285**	**1.49 (1.24-1.79)**	**6.29 (5.73-6.89)**	**9.93 (9.19-10.73)**	**13.18 (12.26-14.17)**	**17.35 (16.03-18.77)**	*26.49 (22.21-31.41)*
fixed	<55	3,019	1.31 (0.94-1.81)	5.42 (4.56-6.43)	8.32 (7.15-9.67)	10.69 (9.18-12.42)	*13.43 (11.24-16.01)*		3,084	1.10 (0.78-1.57)	6.24 (5.32-7.30)	9.33 (8.11-10.71)	12.51 (10.93-14.29)	*16.37 (14.09-18.97)*	*21.82 (16.79-28.09)*
mobile	<55	4,242	1.96 (1.57-2.44)	6.86 (6.08-7.73)	9.74 (8.77-10.80)	12.89 (11.69-14.20)	17.94 (16.17-19.88)	*25.97 (21.26-31.49)*	5,106	1.73 (1.40-2.14)	6.33 (5.65-7.10)	10.24 (9.31-11.25)	13.60 (12.47-14.83)	17.80 (16.20-19.53)	*28.20 (22.78-34.60)*
bearing type unknown	<55	89	*2.27 (0.57-8.78)*	*9.37 (4.80-17.87)*	*11.94 (6.60-21.08)*	*16.87 (10.05-27.53)*	*22.06 (12.16-38.07)*		95	*1.05 (0.15-7.24)*	*6.47 (2.96-13.84)*	*9.92 (5.28-18.22)*	*9.92 (5.28-18.22)*	*17.64 (8.64-34.10)*	
All patellofemoral	**<55**	**876**	**2.46 (1.59-3.79)**	**9.56 (7.63-11.95)**	**14.85 (12.29-17.87)**	*18.67 (15.61-22.24)*	*23.40 (19.12-28.45)*		**3,715**	**1.09 (0.80-1.50)**	**6.25 (5.44-7.18)**	**10.33 (9.21-11.57)**	**14.53 (13.09-16.11)**	**20.49 (18.25-22.97)**	*24.76 (20.45-29.80)*
All types	**55-64**	**105,622**	**0.68 (0.63-0.73)**	**2.60 (2.50-2.71)**	**3.78 (3.65-3.92)**	**4.71 (4.56-4.87)**	**6.24 (6.02-6.47)**	**8.30 (7.85-8.78)**	**127,295**	**0.48 (0.44-0.52)**	**2.27 (2.18-2.36)**	**3.43 (3.31-3.55)**	**4.36 (4.22-4.50)**	**5.71 (5.51-5.91)**	**7.27 (6.87-7.69)**
All cemented	**55-64**	**82,071**	**0.60 (0.55-0.65)**	**2.28 (2.17-2.40)**	**3.26 (3.12-3.40)**	**3.99 (3.82-4.16)**	**5.10 (4.88-5.34)**	**6.49 (6.07-6.95)**	**103,933**	**0.39 (0.35-0.43)**	**1.88 (1.79-1.98)**	**2.78 (2.67-2.90)**	**3.44 (3.30-3.58)**	**4.37 (4.18-4.56)**	**5.43 (5.05-5.83)**
unconstrained, fixed	55-64	54,985	0.51 (0.45-0.57)	2.09 (1.97-2.23)	2.96 (2.79-3.13)	3.64 (3.44-3.84)	4.60 (4.33-4.88)	6.17 (5.61-6.78)	69,362	0.36 (0.31-0.41)	1.74 (1.64-1.85)	2.49 (2.35-2.63)	3.06 (2.90-3.23)	3.93 (3.71-4.17)	4.83 (4.43-5.26)
unconstrained, mobile	55-64	4,126	0.74 (0.52-1.06)	2.57 (2.11-3.12)	3.78 (3.21-4.45)	4.62 (3.97-5.37)	5.67 (4.87-6.60)	*5.97 (5.01-7.10)*	4,874	0.49 (0.32-0.73)	2.16 (1.77-2.63)	3.28 (2.78-3.86)	3.91 (3.35-4.56)	4.89 (4.19-5.70)	*6.38 (4.86-8.33)*
posterior-stabilised, fixed	55-64	19,132	0.74 (0.62-0.87)	2.63 (2.40-2.89)	3.90 (3.59-4.23)	4.77 (4.41-5.17)	6.19 (5.68-6.75)	*7.53 (6.74-8.42)*	25,054	0.44 (0.37-0.54)	2.16 (1.97-2.37)	3.37 (3.11-3.64)	4.17 (3.87-4.49)	5.19 (4.78-5.63)	*6.47 (5.59-7.49)*
posterior-stabilised, mobile	55-64	1,731	0.76 (0.44-1.31)	2.26 (1.64-3.11)	2.70 (2.01-3.63)	3.31 (2.50-4.39)	4.91 (3.64-6.61)	*5.31 (3.88-7.24)*	1,944	0.37 (0.17-0.77)	1.62 (1.12-2.32)	2.84 (2.14-3.77)	3.81 (2.94-4.93)	4.84 (3.74-6.25)	*7.72 (3.66-15.90)*
constrained, condylar	55-64	589	0.96 (0.40-2.31)	2.79 (1.52-5.10)	*4.13 (2.25-7.52)*	*4.13 (2.25-7.52)*	*4.13 (2.25-7.52)*		764	0.43 (0.14-1.34)	1.95 (1.04-3.67)	*1.95 (1.04-3.67)*	*1.95 (1.04-3.67)*	*5.22 (2.08-12.80)*	
monobloc polyethylene tibia	55-64	582	0.77 (0.29-2.03)	2.12 (1.14-3.91)	*3.15 (1.81-5.46)*	*3.75 (2.14-6.53)*	*4.64 (2.59-8.27)*		779	0.27 (0.07-1.09)	1.98 (1.13-3.47)	2.77 (1.65-4.62)	*2.77 (1.65-4.62)*	*4.83 (2.74-8.45)*	
bearing type unknown	55-64	926	1.53 (0.91-2.57)	4.44 (3.26-6.03)	5.58 (4.23-7.34)	5.89 (4.49-7.70)	*7.98 (5.97-10.63)*	*9.30 (6.78-12.68)*	1,156	0.80 (0.42-1.52)	3.01 (2.15-4.21)	4.37 (3.29-5.79)	5.84 (4.52-7.54)	*6.37 (4.94-8.18)*	*6.37 (4.94-8.18)*
All uncemented	**55-64**	**5,389**	**0.59 (0.42-0.84)**	**2.30 (1.91-2.76)**	**3.27 (2.80-3.83)**	**4.02 (3.47-4.65)**	**5.16 (4.44-5.98)**	*7.03 (5.51-8.96)*	**5,311**	**0.60 (0.42-0.85)**	**2.34 (1.95-2.80)**	**3.51 (3.02-4.09)**	**4.36 (3.79-5.02)**	**5.43 (4.71-6.24)**	*6.79 (5.48-8.41)*

Note: 1 Excludes 181 cases where either gender was not specified and/or ages were invalid and NHS trace not complete. Total sample on which results are based is 975,558 primary knee replacements.

Continued >

Table 3.25 (b) (continued)

Fixation group	Age at primary (years)	Males n	Males: Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is: 1 year	3 years	5 years	7 years	10 years	13 years	Females n	Females: Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is: 1 year	3 years	5 years	7 years	10 years	13 years
unconstrained, fixed	55-64	2,085	0.45 (0.23-0.86)	2.42 (1.82-3.22)	3.39 (2.65-4.33)	4.19 (3.34-5.25)	5.43 (4.31-6.82)	*6.23 (4.74-8.16)*	1,994	0.72 (0.43-1.22)	2.63 (2.00-3.47)	3.42 (2.68-4.37)	4.49 (3.60-5.60)	5.41 (4.32-6.78)	*6.55 (5.00-8.56)*
unconstrained, mobile	55-64	2,647	0.58 (0.35-0.97)	2.22 (1.71-2.90)	3.23 (2.58-4.04)	3.90 (3.15-4.83)	4.41 (3.56-5.46)	*5.98 (4.27-8.33)*	2,853	0.50 (0.30-0.85)	2.05 (1.57-2.68)	3.45 (2.79-4.27)	4.03 (3.28-4.94)	4.97 (4.06-6.07)	*5.50 (4.38-6.89)*
posterior-stabilised, fixed	55-64	536	0.96 (0.40-2.28)	1.80 (0.94-3.43)	2.32 (1.28-4.16)	*3.44 (2.01-5.88)*	*7.43 (4.65-11.78)*		377	0.82 (0.27-2.53)	3.45 (1.97-6.01)	5.18 (3.24-8.22)	*6.80 (4.46-10.29)*	*9.81 (6.62-14.43)*	
other constraint	55-64	46	*0*	*2.86 (0.41-18.60)*	*2.86 (0.41-18.60)*				24	*0*	*0*	*0*			
bearing type unknown	55-64	75	*2.68 (0.68-10.31)*	*4.18 (1.37-12.43)*	*7.27 (3.08-16.64)*	*7.27 (3.08-16.64)*	*7.27 (3.08-16.64)*		63	*0*	*0*	*1.72 (0.24-11.62)*	*1.72 (0.24-11.62)*	*1.72 (0.24-11.62)*	
All hybrid	**55-64**	**1,013**	**0.51 (0.21-1.22)**	**1.89 (1.20-2.99)**	**2.62 (1.76-3.89)**	**3.65 (2.57-5.18)**	**4.49 (3.15-6.39)**	*7.81 (5.27-11.50)*	**1,193**	**0.53 (0.24-1.17)**	**2.16 (1.44-3.24)**	**3.14 (2.23-4.41)**	**3.76 (2.73-5.16)**	**4.13 (3.01-5.66)**	*4.13 (3.01-5.66)*
unconstrained, fixed	55-64	651	0.31 (0.08-1.23)	1.25 (0.63-2.49)	2.28 (1.35-3.82)	3.06 (1.94-4.83)	*3.76 (2.39-5.89)*	*6.57 (4.02-10.64)*	769	0.79 (0.36-1.75)	2.42 (1.53-3.82)	3.29 (2.22-4.87)	3.91 (2.72-5.62)	4.39 (3.07-6.27)	*4.39 (3.07-6.27)*
unconstrained, mobile	55-64	195	*1.08 (0.27-4.27)*	*1.80 (0.58-5.54)*	*1.80 (0.58-5.54)*	*1.80 (0.58-5.54)*	*1.80 (0.58-5.54)*		283	*0*	*1.01 (0.25-3.98)*	*1.79 (0.57-5.62)*	*1.79 (0.57-5.62)*	*1.79 (0.57-5.62)*	
posterior-stabilised, fixed	55-64	73	*0*	*3.01 (0.76-11.51)*	*3.01 (0.76-11.51)*	*3.01 (0.76-11.51)*	*3.01 (0.76-11.51)*		76		*2.67 (0.67-10.24)*	*5.57 (2.13-14.19)*	*7.77 (3.24-18.04)*	*7.77 (3.24-18.04)*	
other constraint	55-64	75	*1.47 (0.21-9.98)*	*6.05 (2.31-15.32)*	*6.05 (2.31-15.32)*	*8.58 (3.56-19.93)*	*12.74 (5.41-28.41)*		54	*0*	*2.33 (0.33-15.38)*	*2.33 (0.33-15.38)*	*2.33 (0.33-15.38)*	*2.33 (0.33-15.38)*	
bearing type unknown	55-64	19		*5.26 (0.76-31.88)*	*5.26 (0.76-31.88)*	*19.62 (6.60-50.26)*			11	*0*					
All unicondylar	**55-64**	**16,273**	**1.06 (0.91-1.24)**	**4.20 (3.88-4.55)**	**6.33 (5.91-6.78)**	**8.12 (7.61-8.66)**	**11.53 (10.77-12.34)**	*16.15 (14.42-18.07)*	**13,927**	**1.03 (0.87-1.22)**	**4.36 (4.00-4.74)**	**6.74 (6.27-7.24)**	**8.96 (8.38-9.57)**	**12.47 (11.64-13.36)**	*16.32 (14.66-18.14)*
fixed	55-64	5,442	0.58 (0.40-0.83)	3.26 (2.76-3.85)	5.83 (5.09-6.67)	7.47 (6.55-8.50)	10.61 (9.20-12.22)	*15.44 (12.27-19.34)*	4,464	0.78 (0.56-1.11)	4.31 (3.68-5.04)	6.46 (5.63-7.40)	8.81 (7.73-10.03)	11.06 (9.58-12.75)	*14.13 (11.53-17.25)*
mobile	55-64	10,652	1.30 (1.10-1.54)	4.66 (4.25-5.11)	6.64 (6.13-7.20)	8.44 (7.83-9.09)	11.98 (11.08-12.95)	*16.63 (14.63-18.87)*	9,311	1.17 (0.96-1.41)	4.40 (3.97-4.87)	6.92 (6.36-7.52)	9.14 (8.46-9.87)	13.06 (12.07-14.13)	*17.09 (15.17-19.23)*
bearing type unknown	55-64	179	*1.13 (0.28-4.44)*	*3.46 (1.57-7.53)*	*4.09 (1.97-8.39)*	*7.62 (4.38-13.09)*	*8.59 (5.03-14.47)*		152	*0*	*3.55 (1.49-8.32)*	*3.55 (1.49-8.32)*	*3.55 (1.49-8.32)*	*5.90 (2.32-14.57)*	
All patellofemoral	**55-64**	**871**	**1.60 (0.93-2.74)**	**5.73 (4.26-7.69)**	**9.87 (7.80-12.47)**	*13.53 (10.85-16.82)*	*20.28 (15.85-25.74)*		**2,926**	**0.76 (0.49-1.16)**	**5.53 (4.70-6.51)**	**9.40 (8.26-10.70)**	**13.06 (11.61-14.68)**	**17.88 (15.83-20.16)**	*25.00 (19.63-31.53)*

Note: 1 Excludes 181 cases where either gender was not specified and/or ages were invalid and NHS trace not complete. Total sample on which results are based is 975,558 primary knee replacements.

Table 3.25 (b) (continued)

Fixation group	Age at primary (years)	Males							Females						
		n	Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is:						n	Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is:					
			1 year	3 years	5 years	7 years	10 years	13 years		1 year	3 years	5 years	7 years	10 years	13 years
All types	**65-74**	**167,309**	**0.48 (0.45-0.52)**	**1.71 (1.65-1.78)**	**2.39 (2.31-2.48)**	**2.93 (2.83-3.03)**	**3.79 (3.65-3.94)**	**4.74 (4.44-5.07)**	**206,258**	**0.35 (0.33-0.38)**	**1.48 (1.43-1.54)**	**2.18 (2.11-2.26)**	**2.74 (2.65-2.83)**	**3.56 (3.43-3.69)**	**4.31 (4.09-4.54)**
All cemented	**65-74**	**142,221**	**0.42 (0.39-0.46)**	**1.52 (1.45-1.59)**	**2.12 (2.03-2.21)**	**2.57 (2.47-2.68)**	**3.26 (3.12-3.41)**	**3.90 (3.65-4.17)**	**182,765**	**0.31 (0.28-0.34)**	**1.28 (1.22-1.34)**	**1.88 (1.80-1.95)**	**2.33 (2.24-2.42)**	**2.90 (2.79-3.02)**	**3.39 (3.19-3.60)**
unconstrained, fixed	65-74	97,003	0.40 (0.36-0.44)	1.39 (1.31-1.47)	1.96 (1.86-2.06)	2.38 (2.26-2.50)	2.92 (2.76-3.09)	3.69 (3.35-4.05)	122,031	0.25 (0.22-0.28)	1.18 (1.11-1.25)	1.70 (1.62-1.79)	2.13 (2.02-2.23)	2.64 (2.50-2.78)	3.00 (2.80-3.22)
unconstrained, mobile	65-74	5,702	0.53 (0.37-0.75)	1.87 (1.54-2.28)	2.71 (2.30-3.21)	3.16 (2.70-3.71)	4.24 (3.61-4.99)	*4.68 (3.85-5.69)*	7,200	0.44 (0.31-0.62)	1.59 (1.31-1.93)	2.29 (1.95-2.70)	2.94 (2.53-3.42)	3.66 (3.14-4.26)	*4.39 (3.57-5.39)*
posterior-stabilised, fixed	65-74	33,423	0.47 (0.40-0.56)	1.72 (1.57-1.88)	2.34 (2.16-2.54)	2.91 (2.69-3.15)	3.92 (3.60-4.26)	4.25 (3.86-4.68)	45,345	0.41 (0.36-0.48)	1.41 (1.30-1.54)	2.15 (2.00-2.31)	2.61 (2.43-2.80)	3.34 (3.09-3.60)	4.01 (3.51-4.58)
posterior-stabilised, mobile	65-74	1,797	0.52 (0.27-0.99)	1.93 (1.36-2.74)	2.58 (1.89-3.53)	3.04 (2.24-4.11)	*3.53 (2.55-4.87)*	*4.68 (3.07-7.10)*	2,125	0.58 (0.33-1.02)	1.97 (1.44-2.70)	2.52 (1.89-3.36)	3.16 (2.41-4.15)	3.31 (2.51-*4.35*)	*4.20 (2.63-6.69)*
constrained, condylar	65-74	815	0.42 (0.13-1.30)	2.65 (1.56-4.49)	*4.56 (2.83-7.32)*	*4.56 (2.83-7.32)*	*5.89 (3.32-10.34)*		1,410	0.76 (0.41-1.41)	2.17 (1.42-3.32)	2.86 (1.87-4.36)	*3.22 (2.09-4.96)*	*3.22 (2.09-4.96)*	
monobloc polyethylene tibia	65-74	1,950	0.11 (0.03-0.44)	1.41 (0.92-2.17)	1.91 (1.27-2.85)	*2.19 (1.42-3.37)*	*2.19 (1.42-3.37)*		2,901	0.38 (0.20-0.71)	1.44 (1.03-2.01)	2.03 (1.48-2.78)	2.31 (1.67-3.18)	*2.82 (1.96-4.06)*	
bearing type unknown	65-74	1,531	0.73 (0.41-1.32)	2.51 (1.82-3.46)	3.07 (2.28-4.12)	3.35 (2.51-4.45)	3.91 (2.91-5.23)	*3.91 (2.91-5.23)*	1,753	0.52 (0.27-1.00)	1.52 (1.03-2.24)	2.62 (1.94-3.55)	3.31 (2.51-4.37)	3.90 (2.89-5.24)	*4.75 (3.10-7.24)*
All uncemented	**65-74**	**7,684**	**0.58 (0.43-0.78)**	**1.78 (1.49-2.12)**	**2.36 (2.02-2.76)**	**2.82 (2.43-3.27)**	**3.47 (2.96-4.05)**	*4.35 (2.99-6.29)*	**7,749**	**0.52 (0.38-0.71)**	**2.26 (1.94-2.63)**	**2.99 (2.61-3.43)**	**3.27 (2.86-3.73)**	**3.93 (3.43-4.50)**	*4.40 (3.77-5.14)*
unconstrained, fixed	65-74	3,005	0.66 (0.42-1.03)	2.25 (1.76-2.88)	2.85 (2.28-3.56)	3.30 (2.66-4.08)	3.89 (3.11-4.87)	*3.89 (3.11-4.87)*	2,791	0.56 (0.34-0.92)	2.89 (2.30-3.61)	3.42 (2.77-4.21)	3.67 (3.00-4.50)	4.28 (3.49-5.24)	*4.54 (3.64-5.67)*
unconstrained, mobile	65-74	4,011	0.49 (0.31-0.77)	1.42 (1.08-1.86)	1.84 (1.43-2.35)	2.34 (1.85-2.96)	2.96 (2.32-3.77)	*4.47 (2.26-8.75)*	4,434	0.53 (0.35-0.80)	1.89 (1.51-2.36)	2.75 (2.27-3.33)	3.04 (2.52-3.66)	3.61 (2.97-4.37)	*4.00 (3.19-5.01)*
posterior-stabilised, fixed	65-74	510	1.03 (0.43-2.45)	1.94 (1.01-3.71)	2.87 (1.62-5.05)	*2.87 (1.62-5.05)*	*3.33 (1.90-5.79)*		423	0.24 (0.03-1.67)	2.18 (1.09-4.32)	3.18 (1.76-5.69)	*3.56 (2.03-6.22)*	*4.80 (2.77-8.24)*	*6.41 (3.39-11.97)*
other constraint	65-74	77	*0*	*1.56 (0.22-10.58)*	*1.56 (0.22-10.58)*	*1.56 (0.22-10.58)*			27	*0*	*0*	*0*			
bearing type unknown	65-74	81	*0*	*0*	*5.56 (2.12-14.14)*	*6.97 (2.96-15.94)*	*10.55 (4.46-23.85)*		74	*0*	*1.56 (0.22-10.58)*	*1.56 (0.22-10.58)*	*1.56 (0.22-10.58)*	*4.38 (1.05-17.29)*	
All hybrid	**65-74**	**1,544**	**0.54 (0.27-1.07)**	**2.06 (1.44-2.95)**	**2.31 (1.64-3.26)**	**2.59 (1.87-3.60)**	**3.33 (2.42-4.59)**	*3.70 (2.62-5.23)*	**1,788**	**0.57 (0.31-1.06)**	**1.74 (1.21-2.50)**	**1.95 (1.38-2.75)**	**2.27 (1.64-3.15)**	**2.69 (1.96-3.68)**	*2.98 (2.12-4.18)*
unconstrained, fixed	65-74	1,126	0.27 (0.09-0.84)	1.88 (1.21-2.89)	2.09 (1.38-3.15)	2.32 (1.56-3.45)	3.06 (2.09-4.48)	*3.52 (2.32-5.32)*	1,243	0.33 (0.12-0.86)	1.16 (0.69-1.94)	1.24 (0.75-2.06)	1.64 (1.05-2.57)	2.16 (1.43-3.26)	*2.50 (1.60-3.90)*
unconstrained, mobile	65-74	253	*1.35 (0.44-4.13)*	*1.35 (0.44-4.13)*	*2.14 (0.78-5.83)*	*3.13 (1.24-7.78)*	*3.13 (1.24-7.78)*		389	1.61 (0.72-3.54)	*3.76 (2.13-6.60)*	*4.43 (2.52-7.73)*	*4.43 (2.52-7.73)*	*4.43 (2.52-7.73)*	
posterior-stabilised, fixed	65-74	80	*1.27 (0.18-8.65)*	*4.01 (1.31-11.93)*	*4.01 (1.31-11.93)*	*4.01 (1.31-11.93)*	*6.75 (2.42-18.09)*		90	*0*	*1.22 (0.17-8.34)*	*2.50 (0.63-9.64)*	*2.50 (0.63-9.64)*	*2.50 (0.63-9.64)*	
other constraint	65-74	65	*0*	*0*	*0*	*0*	*0*		43	*0*	*0*	*0*	*0*	*0*	
bearing type unknown	65-74	20	*5.00 (0.72-30.53)*	*17.18 (5.77-44.98)*	*17.18 (5.77-44.98)*	*17.18 (5.77-44.98)*			23		*9.57 (2.47-33.22)*	*9.57 (2.47-33.22)*			

Note: 1 Excludes 181 cases where either gender was not specified and/or ages were invalid and NHS trace not complete. Total sample on which results are based is 975,558 primary knee replacements.

Continued >

Table 3.25 (b) (continued)

Fixation group	Age at primary (years)	Males							Females						
		n	Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is:						n	Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is:					
			1 year	3 years	5 years	7 years	10 years	13 years		1 year	3 years	5 years	7 years	10 years	13 years
All unicondylar	65-74	15,261	0.90 (0.76-1.07)	3.24 (2.95-3.57)	4.60 (4.22-5.01)	5.91 (5.44-6.41)	8.23 (7.53-9.00)	12.29 (10.28-14.66)	12,095	0.84 (0.69-1.03)	3.38 (3.04-3.76)	5.20 (4.75-5.69)	7.07 (6.50-7.68)	10.49 (9.60-11.45)	14.18 (12.40-16.18)
fixed	65-74	4,674	0.59 (0.40-0.87)	3.26 (2.71-3.90)	4.76 (4.05-5.61)	5.97 (5.08-7.02)	6.94 (5.80-8.29)	11.51 (7.67-17.08)	3,607	0.49 (0.30-0.80)	2.89 (2.32-3.61)	4.38 (3.61-5.32)	5.87 (4.86-7.07)	8.48 (6.84-10.48)	9.51 (7.46-12.09)
mobile	65-74	10,455	1.05 (0.87-1.27)	3.27 (2.92-3.66)	4.58 (4.15-5.07)	5.91 (5.37-6.49)	8.65 (7.81-9.57)	12.44 (10.17-15.16)	8,357	1.00 (0.81-1.25)	3.61 (3.20-4.08)	5.55 (5.01-6.15)	7.50 (6.83-8.24)	11.12 (10.08-12.26)	15.52 (13.37-17.96)
bearing type unknown	65-74	132	0	1.56 (0.39-6.08)	2.52 (0.81-7.67)	4.69 (1.95-11.01)	4.69 (1.95-11.01)		131	0	1.65 (0.42-6.45)	2.64 (0.85-7.99)	6.09 (2.76-13.18)	9.67 (4.75-19.14)	
All patellofemoral	65-74	592	2.33 (1.36-3.99)	7.78 (5.74-10.52)	11.26 (8.66-14.58)	13.56 (10.53-17.37)	18.84 (13.96-25.16)		1,854	0.85 (0.51-1.41)	4.94 (3.99-6.11)	8.11 (6.83-9.61)	10.94 (9.35-12.78)	16.99 (14.37-20.03)	23.03 (18.93-27.86)
All types	75+	118,460	0.38 (0.35-0.42)	1.08 (1.02-1.15)	1.43 (1.35-1.51)	1.76 (1.67-1.87)	2.16 (2.03-2.31)	2.48 (2.24-2.75)	178,106	0.36 (0.33-0.39)	0.99 (0.94-1.04)	1.35 (1.29-1.41)	1.61 (1.54-1.69)	1.98 (1.88-2.08)	2.46 (2.20-2.76)
All cemented	75+	105,766	0.34 (0.31-0.38)	0.98 (0.92-1.05)	1.29 (1.21-1.37)	1.56 (1.46-1.66)	1.87 (1.74-2.01)	2.12 (1.92-2.35)	163,365	0.32 (0.29-0.35)	0.88 (0.83-0.93)	1.18 (1.12-1.25)	1.40 (1.33-1.47)	1.69 (1.59-1.79)	2.00 (1.79-2.22)
unconstrained, fixed	75+	71,166	0.33 (0.29-0.38)	0.95 (0.88-1.04)	1.22 (1.12-1.32)	1.48 (1.36-1.60)	1.76 (1.60-1.92)	1.98 (1.75-2.24)	106,373	0.28 (0.25-0.31)	0.84 (0.78-0.90)	1.09 (1.02-1.17)	1.28 (1.20-1.37)	1.56 (1.45-1.69)	1.74 (1.56-1.95)
unconstrained mobile	75+	3,679	0.40 (0.24-0.67)	1.03 (0.74-1.44)	1.71 (1.30-2.25)	1.92 (1.47-2.50)	2.19 (1.66-2.87)	2.19 (1.66-2.87)	6,208	0.41 (0.28-0.61)	1.01 (0.78-1.31)	1.46 (1.17-1.83)	1.64 (1.32-2.04)	2.02 (1.61-2.53)	2.15 (1.68-2.75)
posterior-stabilised, fixed	75+	25,580	0.37 (0.30-0.45)	1.02 (0.89-1.17)	1.37 (1.21-1.55)	1.66 (1.47-1.88)	2.07 (1.79-2.40)	2.50 (2.01-3.10)	41,915	0.34 (0.29-0.40)	0.93 (0.83-1.03)	1.31 (1.19-1.44)	1.58 (1.44-1.74)	1.88 (1.69-2.08)	2.16 (1.88-2.48)
posterior-stabilised, mobile	75+	998	0.62 (0.28-1.38)	1.54 (0.92-2.59)	1.73 (1.04-2.88)	2.02 (1.20-3.39)	2.02 (1.20-3.39)		1,553	0.60 (0.31-1.14)	1.06 (0.64-1.76)	1.41 (0.88-2.25)	1.69 (1.07-2.66)	1.88 (1.20-2.96)	
constrained, condylar	75+	683	0.68 (0.26-1.82)	1.73 (0.85-3.50)	1.73 (0.85-3.50)	1.73 (0.85-3.50)	1.73 (0.85-3.50)		1,625	0.87 (0.51-1.50)	1.30 (0.80-2.12)	1.71 (1.04-2.79)	2.13 (1.22-3.71)	2.13 (1.22-3.71)	
monobloc polyethylene tibia	75+	2,538	0.21 (0.09-0.51)	1.19 (0.80-1.78)	1.47 (1.00-2.17)	1.98 (1.32-2.99)	1.98 (1.32-2.99)		3,709	0.44 (0.26-0.72)	0.78 (0.53-1.15)	1.01 (0.69-1.48)	1.20 (0.77-1.85)	1.52 (0.88-2.60)	
bearing type unknown	75+	1,122	0.09 (0.01-0.65)	0.61 (0.27-1.35)	1.02 (0.53-1.97)	1.41 (0.76-2.61)	2.16 (1.14-4.09)	2.16 (1.14-4.09)	1,982	0.72 (0.43-1.21)	1.42 (0.97-2.08)	1.85 (1.31-2.62)	2.26 (1.62-3.16)	2.57 (1.83-3.59)	7.07 (2.38-19.98)
All uncemented	75+	4,908	0.53 (0.36-0.79)	1.37 (1.07-1.77)	1.71 (1.35-2.16)	2.14 (1.71-2.68)	2.33 (1.86-2.92)	2.33 (1.86-2.92)	6,449	0.56 (0.40-0.78)	1.28 (1.02-1.60)	1.61 (1.31-1.97)	1.87 (1.53-2.28)	1.94 (1.59-2.37)	3.81 (1.93-7.45)
unconstrained, fixed	75+	1,913	0.60 (0.33-1.08)	1.14 (0.74-1.77)	1.51 (1.02-2.23)	1.73 (1.17-2.53)	2.02 (1.37-2.96)	2.02 (1.37-2.96)	2,493	0.71 (0.44-1.13)	1.47 (1.05-2.05)	1.79 (1.31-2.43)	1.85 (1.36-2.50)	1.85 (1.36-2.50)	3.10 (1.61-5.93)
unconstrained, mobile	75+	2,622	0.56 (0.33-0.94)	1.43 (1.02-2.00)	1.79 (1.30-2.45)	2.20 (1.62-2.98)	2.34 (1.72-3.18)	2.34 (1.72-3.18)	3,473	0.44 (0.27-0.73)	1.17 (0.84-1.61)	1.41 (1.04-1.90)	1.76 (1.32-2.34)	1.84 (1.38-2.45)	2.15 (1.48-3.13)

Note: 1 Excludes 181 cases where either gender was not specified and/or ages were invalid and NHS trace not complete. Total sample on which results are based is 975,558 primary knee replacements.

Table 3.25 (b) (continued)

Fixation group	Age at primary (years)	Males							Females						
		n	Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is:						n	Cumulative percentage probability of a first revision (95% CI) at time shown if time elapsed since primary operation is:					
			1 year	3 years	5 years	7 years	10 years	13 years		1 year	3 years	5 years	7 years	10 years	13 years
posterior-stabilised, fixed	75+	278	0	*2.67 (1.20-5.86)*	*2.67 (1.20-5.86)*	*4.11 (2.03-8.21)*	*4.11 (2.03-8.21)*		390	0.53 (0.13-2.11)	1.14 (0.43-3.03)	*2.54 (1.19-5.38)*	*3.65 (1.87-7.08)*	*4.36 (2.29-8.21)*	*11.19 (3.35-33.88)*
other constraint	75+	40	*0*	*2.70 (0.39-17.68)*	*2.70 (0.39-17.68)*	*2.70 (0.39-17.68)*			9						
bearing type unknown	75+	55	*0*	*0*	*0*	*3.45 (0.49-22.05)*	*3.45 (0.49-22.05)*		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)*	
All hybrid	**75+**	**1,052**	**0.50 (0.21-1.19)**	**1.04 (0.56-1.93)**	**1.49 (0.86-2.58)**	**1.68 (0.98-2.86)**	*2.31 (1.34-3.98)*	*2.31 (1.34-3.98)*	**1,553**	**0.67 (0.36-1.24)**	**1.32 (0.84-2.06)**	**1.58 (1.04-2.40)**	**2.04 (1.38-3.01)**	**2.22 (1.50-3.27)**	*2.22 (1.50-3.27)*
unconstrained, fixed	75+	761	0.41 (0.13-1.27)	0.99 (0.47-2.07)	1.56 (0.84-2.89)	1.78 (0.98-3.22)	2.57 (1.42-4.64)	2.57 (1.42-4.64)	1,082	0.57 (0.25-1.25)	1.06 (0.59-1.90)	1.39 (0.83-2.35)	1.81 (1.12-2.91)	2.02 (1.26-3.24)	2.02 (1.26-3.24)
unconstrained, mobile	75+	175	*1.15 (0.29-4.52)*	*1.15 (0.29-4.52)*	*1.15 (0.29-4.52)*	*1.15 (0.29-4.52)*	*1.15 (0.29-4.52)*		344	1.28 (0.48-3.37)	*1.75 (0.72-4.21)*	*1.75 (0.72-4.21)*	*2.91 (1.13-7.34)*	*2.91 (1.13-7.34)*	
posterior-stabilised, fixed	75+	50	*0*	*2.27 (0.32-15.06)*	*2.27 (0.32-15.06)*	*2.27 (0.32-15.06)*			69	*0*	*4.99 (1.63-14.69)*	*4.99 (1.63-14.69)*	*4.99 (1.63-14.69)*		
other constraint	75+	52	*0*	*0*	*0*	*0*	*0*		39	*0*	*0*	*0*	*0*	*0*	
bearing type unknown	75+	14		0					19		0	0			
All unicondylar	**75+**	**6,342**	**0.86 (0.66-1.13)**	**2.32 (1.94-2.77)**	**3.29 (2.80-3.85)**	**4.48 (3.83-5.23)**	**6.14 (5.18-7.26)**	*7.84 (5.41-11.27)*	**5,760**	**1.19 (0.94-1.52)**	**3.22 (2.76-3.75)**	**4.65 (4.06-5.32)**	**6.00 (5.28-6.82)**	**8.18 (7.15-9.35)**	*10.31 (7.99-13.25)*
fixed	75+	1,908	0.51 (0.27-0.98)	1.71 (1.15-2.53)	2.94 (2.08-4.15)	3.86 (2.71-5.47)	5.49 (3.74-8.03)		1,697	0.85 (0.49-1.46)	2.57 (1.83-3.58)	3.70 (2.74-4.98)	4.36 (3.25-5.84)	5.34 (3.86-7.35)	
mobile	75+	4,382	1.02 (0.76-1.38)	2.57 (2.10-3.14)	3.47 (2.89-4.15)	4.70 (3.94-5.60)	6.11 (5.05-7.39)	7.58 (5.04-11.33)	4,005	1.33 (1.01-1.75)	3.47 (2.91-4.13)	4.99 (4.28-5.81)	6.53 (5.66-7.53)	8.93 (7.70-10.36)	11.44 (8.60-15.15)
bearing type unknown	75+	52		1.96 (0.28-13.11)	1.96 (0.28-13.11)	4.93 (1.22-18.85)	18.00 (7.49-39.71)		58	1.82 (0.26-12.21)	3.67 (0.93-13.89)	5.60 (1.84-16.37)	8.46 (3.18-21.46)		
All patellofemoral	**75+**	**386**	**0.57 (0.14-2.28)**	*3.70 (2.06-6.60)*	*5.15 (3.05-8.62)*	*5.85 (3.50-9.72)*	*8.27 (4.21-15.89)*		**969**	**0.54 (0.22-1.29)**	**2.88 (1.93-4.27)**	**5.70 (4.20-7.70)**	**6.88 (5.14-9.17)**	*9.32 (6.81-12.70)*	
Others/unknown		**13**							**19**						

Note: 1 Excludes 181 cases where either gender was not specified and/or ages were invalid and NHS trace not complete. Total sample on which results are based is 975,558 primary knee replacements.

3.5.2.4 Revisions for different clinical causes after primary knee replacement surgery

The Kaplan-Meier estimates of the cumulative probability of a first revision of an implant that have been presented so far, have been shown irrespective of the clinical reason given for the revision surgery. This sub-section looks more closely at the various reasons recorded for revision on the MDS form.

Clinicians can indicate more than one diagnosis as the indication for revision surgery on the MDS form.

This means that the reasons for revision are not mutually exclusive of each other. In addition, over the last 13 years, there have been a number of versions of the MDS form and the reasons for revision options available have varied across these versions. As a result of these inconsistencies, we opt to use person-time incidence rates (PTIR) for each reason for revision on record so that the incidence rates for each reason, taking into account the different time periods of availability, can be compared.

Methodological note: Patient-time incidence rate (PTIR)

Incidence rates for each reason have been calculated using patient–time incidence rates (PTIRs). This is found by dividing the total number of times a revision for that specific reason has been given in a period of time by the total number of years all patients have been at risk of revision (for any reason) over the time period.

The PTIRs are given in the tables as the number of revisions for that reason per 1,000 patient-years at risk for the period of time considered.

The PTIR method assumes that the hazard rate remains constant over the whole time period. When this may not be appropriate, PTIR incidence rates for sub-divisions of the whole time period of interest can be calculated to see whether the hazard rate holds constant across smaller time intervals.

In the earliest version of the MDS form for revision, form MDSv1, both arthritis and incorrect sizing were available as clinical reasons for revision surgery to be performed. Subsequent forms, however, omitted these options. Similarly, stiffness became available as a clinical reason for revision surgery on the later forms MDSv2, MDSv3 and MDSv6 but was not an option on the MDSv1 form.

As the number of cases of incorrect sizing is small and the MDSv1 form on which it was an option ceased to be used after 2004, we have added incorrect sizing to the Other indication category for estimating PTIRs.

In the case of stiffness, an adjustment needs to be made to the total number of patients considered to be at risk as any revisions occurring before the MDSv2 form was issued could not have been at risk of this reason for revision as it could not be selected by the clinician. Checking the year of the primary operation against all knee joints which have been revised over the life of the registry, the MDSv2 and later versions were being used to record reasons for revision in over 95% of all revision surgeries for primary operations which took place from 2005 onwards. Thus, for the PTIR calculation for stiffness, we have restricted the period a primary replaced knee joint is at risk of revision for stiffness to all primary knee joint replacement surgeries which took place from 1 January 2005 onwards. This explains why fewer patient-years at risk are shown for stiffness in the tables discussed in this section.

Table 3.26 shows the revision incidence rates, for each reason recorded on the MDS forms for knee revision surgery, for all cases and then sub-divided by fixation type and whether the primary procedure was a TKR or an UKR.

Table 3.27 shows these first knee revision PTIRs for each reason broken down further by fixation, constraint and bearing type.

For TKRs, the highest PTIRs, in descending order, were for revision due to aseptic loosening, pain and infection. Revision incidences for pain and aseptic loosening were

slightly higher for implants which were uncemented compared to prosthesis implanted using a hybrid or cemented fixation.

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

Interest also lies in whether PTIRs for different reasons remain the same for different time intervals after primary surgery and whether certain reasons for revision are more pronounced in the short, medium or longer term after primary surgery. To this end, PTIRs for each revision reason have been calculated for the following time periods; <1 year, 1 to 3 years, 3 to 5 years, 5 to 7, 7 to 10 and 10 to 13 years after the primary surgery took place.

Table 3.28 shows the PTIR for each specified reason for first revision for different periods of time after primary surgery. It is clear that most of the PTIRs for a particular reason do vary, especially for infection, aseptic loosening and pain 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 less likely than other reasons. Conversely, revision between one and three years after surgery is more likely for aseptic loosening and pain, with incidence rates dropping off for pain later on. Aseptic loosening PTIRs continue to remain relatively higher than other indicated reasons for revision for implants surviving for longer periods after surgery.

Table 3.26 Revision rates (95% CI), expressed as number of revisions per 1,000 patient-years (PTIRs), for each recorded reason for first knee revision. Rates shown are for all revised cases by total replacement fixation method and by type of partial replacement.

Fixation	Patient-years at risk (x1,000)	Number of revisions per 1,000 patient-years (95% CI) for: All causes	Pain	Dislocation/ subluxation	Infection	Aseptic loosening	Lysis	Peri-prosthetic fracture	Implant fracture[1]	Implant wear[1]	Instability	Mal-alignment	Other indication[2]	Patient-years at risk (x1,000)	Revisions per 1,000 patient-years for stiffness[3]
All types	4,951.1	**4.81 (4.75-4.87)**	0.92 (0.89-0.94)	0.19 (0.18-0.20)	0.95 (0.92-0.98)	1.27 (1.24-1.30)	0.24 (0.23-0.25)	0.15 (0.14-0.16)	0.03 (0.02-0.03)	0.28 (0.26-0.29)	0.69 (0.67-0.72)	0.39 (0.38-0.41)	1.08 (1.06-1.11)	4,521.9	0.34 (0.32-0.36)
TKR by fixation method															
Cemented	4,130.6	3.79 (3.73-3.85)	0.63 (0.61-0.66)	0.12 (0.11-0.13)	1.01 (0.98-1.04)	1.01 (0.98-1.04)	0.22 (0.20-0.23)	0.14 (0.13-0.15)	0.02 (0.02-0.03)	0.17 (0.16-0.18)	0.65 (0.62-0.67)	0.34 (0.32-0.36)	0.59 (0.57-0.61)	3,784.3	0.35 (0.33-0.37)
Uncemented	257.6	4.78 (4.52-5.05)	1.03 (0.92-1.16)	0.20 (0.15-0.26)	0.71 (0.61-0.82)	1.67 (1.52-1.83)	0.29 (0.23-0.37)	0.15 (0.11-0.20)	0.06 (0.04-0.10)	0.28 (0.23-0.36)	0.79 (0.69-0.91)	0.43 (0.35-0.51)	0.77 (0.67-0.89)	228.7	0.38 (0.31-0.47)
Hybrid	62.7	4.00 (3.54-4.53)	0.72 (0.54-0.96)	0.14 (0.07-0.28)	1.00 (0.78-1.29)	1.15 (0.91-1.45)	0.21 (0.12-0.36)	0.13 (0.06-0.26)	0.05 (0.02-0.15)	0.37 (0.24-0.55)	0.69 (0.51-0.92)	0.33 (0.22-0.51)	0.43 (0.30-0.63)	50.5	0.24 (0.13-0.42)
UKR type															
Unicondylar	436.8	12.49 (12.16-12.83)	2.89 (2.74-3.06)	0.78 (0.70-0.86)	0.58 (0.51-0.66)	3.42 (3.25-3.60)	0.43 (0.38-0.50)	0.27 (0.23-0.33)	0.04 (0.03-0.07)	1.07 (0.97-1.17)	1.02 (0.93-1.12)	0.70 (0.63-0.79)	4.70 (4.50-4.91)	399.8	0.22 (0.17-0.27)
Patellofemoral	63.0	19.58 (18.51-20.70)	5.54 (4.99-6.15)	0.83 (0.63-1.08)	0.44 (0.31-0.64)	2.46 (2.10-2.88)	0.19 (0.11-0.34)	0.22 (0.13-0.38)	0.16 (0.09-0.30)	1.76 (1.46-2.12)	1.02 (0.80-1.30)	1.48 (1.21-1.81)	10.45 (9.68-11.28)	58.5	0.55 (0.39-0.77)

Note: 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. The latter cause for revision is now indicated separately as implant fracture. 2 Other indication now includes arthritis and incorrect sizing. Both these reasons were only asked in MDSv1 and so are associated with primaries which took place in the first few years of the registry with little potential for long term follow-up of the incidence of revision for these specific clinical reasons. 3 This reason was asked in versions MDSv2, v3 and v6 of the clinical assessment forms for joint replacement/revision surgery and hence, for these reasons, there are fewer patient-years at risk.

Table 3.27 Revision rates (95% CI), expressed as number of revisions per 1,000 patient-years (PTIRs), for each recorded reason for first knee revision. Rates shown are broken down by constraint and bearing sub-group for each total replacement fixation method and for unicondylar partial replacements.

By fixation, constraint and bearing sub-groups	Patient-years at risk (x1,000)	Number of revisions per 1,000 patient-years (95% CI) for: All causes	Pain	Dislocation/ subluxation	Infection	Aseptic loosening	Lysis	Peri-prosthetic fracture	Implant fracture[1]	Implant wear[1]	Instability	Malalignment	Other indication[2]	Patient-years at risk (x1,000)	Revision per 1,000 patient-years for stiffness[3]
Total knee replacement															
Cemented															
unconstrained, fixed	2,685.6	3.45 (3.38-3.52)	0.62 (0.59-0.65)	0.10 (0.09-0.11)	0.92 (0.88-0.96)	0.84 (0.81-0.88)	0.19 (0.17-0.21)	0.10 (0.09-0.12)	0.02 (0.01-0.02)	0.15 (0.14-0.17)	0.60 (0.57-0.63)	0.33 (0.31-0.36)	0.58 (0.55-0.61)	2,458.3	0.34 (0.31-0.36)
unconstrained, mobile	221.3	4.60 (4.32-4.89)	0.87 (0.75-1.00)	0.23 (0.18-0.30)	1.05 (0.92-1.19)	1.39 (1.24-1.55)	0.33 (0.27-0.42)	0.15 (0.11-0.22)	0.04 (0.02-0.07)	0.27 (0.21-0.35)	0.98 (0.85-1.12)	0.47 (0.39-0.57)	0.47 (0.39-0.57)	203.8	0.50 (0.41-0.61)
posterior-stabilised, fixed	1,023.3	4.32 (4.19-4.45)	0.59 (0.54-0.63)	0.11 (0.09-0.13)	1.22 (1.15-1.29)	1.32 (1.25-1.39)	0.26 (0.23-0.29)	0.21 (0.18-0.24)	0.02 (0.01-0.03)	0.18 (0.16-0.21)	0.67 (0.62-0.72)	0.33 (0.30-0.37)	0.60 (0.55-0.64)	935.3	0.33 (0.30-0.37)
posterior-stabilised, mobile	68.7	4.79 (4.30-5.33)	0.92 (0.72-1.17)	0.19 (0.11-0.33)	0.92 (0.72-1.17)	1.15 (0.92-1.43)	0.28 (0.18-0.43)	0.26 (0.16-0.42)	0.06 (0.02-0.16)	0.28 (0.18-0.43)	1.03 (0.82-1.30)	0.22 (0.13-0.36)	0.93 (0.73-1.19)	64.1	0.70 (0.52-0.94)
constrained, condylar	20.7	5.59 (4.66-6.71)	0.39 (0.19-0.77)	0.53 (0.29-0.96)	2.75 (2.12-3.56)	1.01 (0.66-1.55)	0.19 (0.07-0.51)	0.39 (0.19-0.77)	0.0	0.29 (0.13-0.64)	0.72 (0.44-1.20)	0.24 (0.10-0.58)	0.48 (0.26-0.90)	19.2	0.26 (0.11-0.63)
monobloc polyethylene tibia	51.2	3.36 (2.89-3.90)	0.57 (0.39-0.81)	0.16 (0.08-0.31)	0.90 (0.67-1.20)	0.74 (0.54-1.02)	0.16 (0.08-0.31)	0.21 (0.12-0.39)	0.04 (0.01-0.16)	0.10 (0.04-0.23)	0.62 (0.44-0.88)	0.43 (0.28-0.65)	0.51 (0.35-0.75)	50.0	0.34 (0.21-0.55)
bearing type unknown	59.8	5.65 (5.08-6.29)	1.04 (0.81-1.33)	0.18 (0.10-0.33)	1.17 (0.93-1.48)	1.50 (1.22-1.85)	0.25 (0.15-0.42)	0.18 (0.10-0.33)	0.10 (0.05-0.22)	0.33 (0.22-0.52)	0.79 (0.59-1.05)	0.45 (0.31-0.66)	1.20 (0.96-1.52)	53.5	0.26 (0.15-0.44)
Uncemented															
unconstrained, fixed	103.6	4.90 (4.50-5.35)	0.87 (0.71-1.07)	0.12 (0.07-0.20)	0.67 (0.53-0.84)	1.88 (1.64-2.17)	0.26 (0.18-0.38)	0.15 (0.09-0.25)	0.05 (0.02-0.12)	0.26 (0.18-0.38)	0.81 (0.65-1.00)	0.42 (0.31-0.56)	0.89 (0.72-1.09)	92.9	0.38 (0.27-0.52)
unconstrained, mobile	131.5	4.39 (4.04-4.76)	1.04 (0.88-1.23)	0.24 (0.17-0.34)	0.74 (0.60-0.90)	1.43 (1.24-1.65)	0.24 (0.17-0.34)	0.12 (0.07-0.20)	0.06 (0.03-0.12)	0.26 (0.18-0.36)	0.70 (0.57-0.86)	0.37 (0.28-0.49)	0.62 (0.50-0.77)	117.0	0.35 (0.26-0.48)
posterior-stabilised, fixed	17.5	6.95 (5.82-8.30)	1.77 (1.24-2.51)	0.46 (0.23-0.91)	0.85 (0.52-1.42)	1.94 (1.38-2.71)	0.80 (0.47-1.35)	0.28 (0.12-0.68)	0.11 (0.03-0.46)	0.57 (0.31-1.06)	1.14 (0.74-1.77)	0.91 (0.56-1.49)	1.25 (0.83-1.90)	15.1	0.53 (0.27-1.06)
other constraint	1.2	4.18 (1.74-10.05)	4.18 (1.74-10.05)	0.84 (0.12-5.94)	0.0	0.84 (0.12-5.94)	0.0	0.0	0.0	0.0	0.84 (0.12-5.94)	0.0	0.84 (0.12-5.94)	1.2	1.72 (0.43-6.87)
bearing type unknown	3.7	4.88 (3.08-7.75)	0.81 (0.26-2.52)	0.0	0.27 (0.04-1.93)	2.99 (1.65-5.39)	0.81 (0.26-2.52)	0.27 (0.04-1.93)	0.0	0.54 (0.14-2.17)	1.90 (0.91-3.98)	0.54 (0.14-2.17)	0.54 (0.14-2.17)	2.6	0.38 (0.05-2.71)
Hybrid															
unconstrained, fixed	47.5	3.58 (3.08-4.16)	0.63 (0.44-0.90)	0.17 (0.08-0.34)	0.93 (0.69-1.24)	0.99 (0.74-1.32)	0.19 (0.10-0.36)	0.08 (0.03-0.22)	0.04 (0.01-0.17)	0.38 (0.24-0.60)	0.57 (0.39-0.83)	0.34 (0.21-0.55)	0.36 (0.22-0.58)	37.4	0.19 (0.09-0.39)
unconstrained, mobile	8.0	4.62 (3.35-6.38)	0.62 (0.26-1.50)	0.12 (0.02-0.89)	1.00 (0.50-2.00)	1.62 (0.94-2.80)	0.37 (0.12-1.16)	0.12 (0.02-0.89)	0.0	0.50 (0.19-1.33)	0.75 (0.34-1.67)	0.62 (0.26-1.50)	0.62 (0.26-1.50)	6.7	0.30 (0.07-1.19)
posterior-stabilised, fixed	3.6	6.08 (4.01-9.24)	1.11 (0.42-2.95)	0.0	1.94 (0.92-4.06)	1.94 (0.92-4.06)	0.28 (0.04-1.96)	0.55 (0.14-2.21)	0.0	0.0	1.38 (0.58-3.32)	0.0	0.0	3.1	0.32 (0.05-2.29)
other constraint	2.7	4.43 (2.52-7.81)	1.85 (0.77-4.44)	0.0	0.74 (0.18-2.95)	0.37 (0.05-2.62)	0.0	0.37 (0.05-2.62)	0.0	0.37 (0.05-2.62)	1.48 (0.55-3.94)	0.0	0.74 (0.18-2.95)	2.6	0.76 (0.19-3.05)
bearing type unknown	0.8	11.99 (6.45-22.28)	1.20 (0.17-8.51)	0.0	2.40 (0.60-9.59)	4.80 (1.80-12.78)	0.0	0.0	1.20 (0.17-8.51)	0.0	1.20 (0.17-8.51)	0.0	3.60 (1.16-11.15)	0.7	0.0

Continued >

Note: 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. The latter cause for revision is now indicated separately as implant fracture. 2 Other indication now includes arthritis and incorrect sizing. Both these reasons were only asked in MDSv1 and so are associated with primaries which took place in the first few years of the Registry with little potential for long term follow-up of the incidence of revision for these specific clinical reasons. 3 This reason was asked in versions MDSv2, v3 and v6 of the clinical assessment forms for joint replacement/revision surgery and hence, for these reasons, there are fewer patient-years at risk.

Table 3.27 (continued)

By fixation, constraint and bearing sub-groups	Patient-years at risk (x1,000)	Number of revisions per 1,000 patient-years (95% CI) for: All causes	Pain	Dislocation/ subluxation	Infection	Aseptic loosening	Lysis	Peri-prosthetic fracture	Implant fracture[1]	Implant wear[1]	Instability	Malalignment	Other indication[2]	Patient-years at risk (x1,000)	Revision per 1,000 patient-years for stiffness[3]
Unicompartmental knee replacemental															
Unicondylar															
fixed	121.8	11.46 (10.88-12.08)	3.01 (2.72-3.34)	0.11 (0.06-0.18)	0.66 (0.53-0.82)	3.37 (3.06-3.71)	0.37 (0.28-0.49)	0.25 (0.18-0.36)	0.06 (0.03-0.12)	0.93 (0.77-1.12)	0.81 (0.67-0.99)	0.63 (0.51-0.79)	4.18 (3.83-4.56)	114.6	0.28 (0.20-0.39)
mobile	308.7	12.93 (12.53-13.33)	2.83 (2.65-3.03)	1.05 (0.94-1.17)	0.56 (0.48-0.65)	3.45 (3.25-3.66)	0.47 (0.40-0.55)	0.29 (0.23-0.35)	0.04 (0.02-0.06)	1.13 (1.01-1.25)	1.09 (0.98-1.21)	0.73 (0.64-0.83)	4.91 (4.67-5.16)	279.6	0.19 (0.15-0.25)
bearing type unknown	6.3	11.12 (8.80-14.06)	3.50 (2.30-5.31)	0.16 (0.02-1.13)	0.32 (0.08-1.27)	2.86 (1.80-4.54)	0.0	0.16 (0.02-1.13)	0.16 (0.02-1.13)	0.79 (0.33-1.91)	1.43 (0.74-2.75)	0.64 (0.24-1.69)	4.45 (3.07-6.44)	5.6	0.0
Others/unknown	**0.5**	**2.14 (0.30-15.21)**	**0.0**	**0.0**	**0.0**	**2.14 (0.30-15.21)**	**0.0**	**0.0**	**0.0**	**2.14 (0.30-15.21)**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Note: 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. The latter cause for revision is now indicated separately as implant fracture. 2 Other indication now includes arthritis and incorrect sizing. Both these reasons were only asked in MDSv1 and so are associated with primaries which took place in the first few years of the Registry with little potential for long term follow-up of the incidence of revision for these specific clinical reasons. 3 This reason was asked in versions MDSv2, v3 and v6 of the clinical assessment forms for joint replacement/revision surgery and hence, for these reasons, there are fewer patient-years at risk.

Table 3.28 Revision rates (95% CI) broken down by time period in which primary was revised, expressed as number of revisions per 1,000 patient-years (PTIRs), for each recorded reason for first knee revision.

Time period (years) since primary	Patient-years at risk (x1,000)	Number of revisions per 1,000 patient-years (95% CI) for:												Patient-years at risk (x1,000)	Revision per 1,000 patient-years for stiffness[3]
		All causes	Pain	Dislocation/ subluxation	Infection	Aseptic loosening	Lysis	Peri-prosthetic fracture	Implant fracture[1]	Implant wear[1]	Instability	Mal-alignment	Other indication[2]		
All cases	4,951.1	4.81 (4.75-4.87)	0.92 (0.89-0.94)	0.19 (0.18-0.20)	0.95 (0.92-0.98)	1.27 (1.24-1.30)	0.24 (0.23-0.25)	0.15 (0.14-0.16)	0.03 (0.02-0.03)	0.28 (0.26-0.29)	0.69 (0.67-0.72)	0.39 (0.38-0.41)	1.08 (1.06-1.11)	4,734	0.33 (0.32-0.35)
<1	920.5	4.56 (4.42-4.70)	0.59 (0.54-0.64)	0.38 (0.34-0.42)	1.64 (1.56-1.73)	0.62 (0.57-0.67)	0.11 (0.09-0.13)	0.27 (0.23-0.30)	0.01 (0.01-0.02)	0.19 (0.16-0.22)	0.57 (0.52-0.62)	0.35 (0.31-0.39)	0.69 (0.64-0.74)	900.3	0.32 (0.29-0.36)
1-3	1,507.6	6.61 (6.48-6.74)	1.58 (1.52-1.65)	0.21 (0.19-0.23)	1.25 (1.20-1.31)	1.63 (1.56-1.69)	0.26 (0.24-0.29)	0.12 (0.10-0.14)	0.03 (0.02-0.04)	0.23 (0.21-0.26)	0.97 (0.92-1.02)	0.59 (0.55-0.63)	1.41 (1.35-1.47)	1,468.3	0.56 (0.52-0.60)
3-5	1,098.4	4.16 (4.04-4.28)	0.88 (0.82-0.93)	0.10 (0.08-0.12)	0.62 (0.58-0.67)	1.31 (1.24-1.38)	0.25 (0.22-0.28)	0.11 (0.09-0.13)	0.02 (0.02-0.03)	0.22 (0.20-0.25)	0.63 (0.58-0.67)	0.35 (0.32-0.39)	0.98 (0.93-1.04)	1,061.5	0.27 (0.24-0.30)
5-7	739.2	3.48 (3.34-3.61)	0.53 (0.48-0.59)	0.09 (0.07-0.12)	0.50 (0.45-0.55)	1.20 (1.13-1.29)	0.26 (0.23-0.30)	0.11 (0.09-0.13)	0.03 (0.02-0.04)	0.31 (0.28-0.36)	0.50 (0.45-0.55)	0.27 (0.24-0.31)	0.98 (0.91-1.05)	704.9	0.16 (0.13-0.19)
7-10	554.4	3.51 (3.36-3.67)	0.39 (0.34-0.44)	0.11 (0.09-0.14)	0.38 (0.33-0.44)	1.30 (1.20-1.39)	0.32 (0.28-0.38)	0.17 (0.14-0.21)	0.04 (0.02-0.06)	0.47 (0.41-0.53)	0.54 (0.48-0.61)	0.19 (0.16-0.23)	1.13 (1.04-1.22)	508.5	0.12 (0.09-0.15)
10-13	131.0	4.43 (4.09-4.81)	0.27 (0.19-0.37)	0.14 (0.09-0.22)	0.36 (0.27-0.48)	1.80 (1.59-2.05)	0.39 (0.30-0.51)	0.25 (0.18-0.35)	0.07 (0.04-0.13)	0.94 (0.79-1.12)	0.70 (0.57-0.86)	0.23 (0.16-0.33)	1.37 (1.19-1.59)	90.6	0.09 (0.04-0.18)

Note: 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. The latter cause for revision is now indicated separately as implant fracture. 2 Other indication now includes arthritis and incorrect sizing. Both these reasons were only asked in MDSv1 and so are associated with primaries which took place in the first few years of the registry with little potential for long term follow-up of the incidence of revision for these specific clinical reasons. 3 This reason was asked in versions MDSv2, v3 and v6 of the clinical assessment forms for joint replacement/ revision surgery and hence, for these reasons, there are fewer patient-years at risk.

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

Tables 3.29 and 3.30 show the Kaplan-Meier estimates of the cumulative percentage probability of first revision, for any reason, of a primary TKR (Table 3.29) and primary UKR (Table 3.30) by implant brand. We have only included those brands that have been used in a primary knee procedure in 1,000 or more operations. Figures in *blue italics* indicate those time points where fewer than 250 primary knee joint replacements remain at risk. No attempt has been made to adjust for other factors that may influence the chance of revision so the figures are unadjusted probabilities. In addition, simple indicators of the age profile and proportion of male patients who typically receive that implant brand are shown.

Table 3.31 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. Again, patient summaries of age and gender by brand are also given.

Table 3.29 Kaplan-Meier estimated cumulative percentage probability of first revision (95% CI) of a primary total knee replacement by main type of implant brand at the indicated number of years after primary operation[1].

Brand[2]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Cumulative percentage probability of first revision (95% CI) if time elapsed since primary operation is:					
				1 year	3 years	5 years	7 years	10 years	13 years
All total knee replacements	**878,191**	**70 (63-76)**	**43%**	**0.40 (0.39-0.42)**	**1.52 (1.50-1.55)**	**2.17 (2.14-2.21)**	**2.68 (2.63-2.72)**	**3.39 (3.33-3.45)**	**4.24 (4.11-4.37)**
ACS	1,996	68 (62-74)	47%	0.69 (0.40-1.18)	3.20 (2.44-4.18)	3.76 (2.92-4.84)	4.45 (3.48-5.69)	*5.45 (4.13-7.15)*	
Advance MP	7,941	70 (63-76)	47%	0.50 (0.36-0.69)	2.10 (1.79-2.47)	2.94 (2.55-3.39)	3.63 (3.17-4.16)	4.35 (3.72-5.10)	*4.35 (3.72-5.10)*
Advance MP Stature	1,317	69 (62-75)	15%	0.08 (0.01-0.57)	1.82 (1.18-2.81)	3.18 (2.19-4.61)	*3.18 (2.19-4.61)*		
Advance PS	1,122	72 (66-77)	45%	0.55 (0.25-1.23)	2.39 (1.59-3.58)	3.19 (2.22-4.58)	4.29 (3.06-6.00)	*5.90 (4.10-8.47)*	*5.90 (4.10-8.47)*
AGC	65,138	71 (64-77)	43%	0.30 (0.26-0.34)	1.50 (1.40-1.60)	2.11 (1.99-2.23)	2.66 (2.53-2.80)	3.57 (3.38-3.77)	4.91 (4.48-5.38)
Attune	9,878	68 (61-75)	44%	0.30 (0.20-0.46)	1.00 (0.66-1.52)				
Columbus	11,143	70 (64-76)	43%	0.46 (0.35-0.62)	1.84 (1.57-2.16)	2.63 (2.26-3.05)	2.89 (2.47-3.38)	*3.58 (2.71-4.73)*	
E-Motion Bicondylar Knee	3,111	67 (61-74)	44%	0.69 (0.45-1.06)	2.39 (1.88-3.04)	3.19 (2.56-3.97)	4.08 (3.30-5.05)	*4.40 (3.52-5.48)*	
Endo Rotating Hinge	1,164	76 (68-83)	28%	1.51 (0.93-2.45)	3.82 (2.76-5.27)	5.35 (3.98-7.18)	*6.08 (4.54-8.12)*	*8.82 (5.84-13.22)*	
Genesis 2	58,549	71 (65-77)	42%	0.39 (0.34-0.45)	1.41 (1.30-1.52)	1.95 (1.82-2.10)	2.39 (2.23-2.57)	2.96 (2.71-3.22)	*3.14 (2.82-3.50)*
Genesis 2 Oxinium	8,254	59 (54-64)	41%	0.56 (0.42-0.75)	2.26 (1.93-2.64)	3.40 (2.97-3.90)	4.19 (3.67-4.78)	5.51 (4.74-6.40)	*5.51 (4.74-6.40)*
†Insall-Burstein 2	2,588	71 (65-77)	45%	0.27 (0.13-0.57)	1.64 (1.21-2.22)	2.90 (2.31-3.65)	3.76 (3.07-4.60)	5.36 (4.48-6.41)	*6.52 (5.34-7.94)*
†Kinemax	10,958	71 (64-77)	43%	0.25 (0.17-0.36)	1.76 (1.53-2.03)	2.68 (2.39-3.01)	3.51 (3.17-3.89)	4.68 (4.27-5.13)	5.79 (5.24-6.39)
†LCS	2,050	70 (63-76)	41%	0.64 (0.37-1.10)	1.79 (1.30-2.47)	2.37 (1.78-3.14)	2.65 (2.03-3.47)	3.09 (2.40-3.97)	3.40 (2.65-4.34)
LCS Complete	25,297	70 (63-76)	44%	0.46 (0.38-0.55)	1.69 (1.53-1.87)	2.59 (2.38-2.82)	3.15 (2.91-3.42)	3.72 (3.42-4.05)	
Maxim	2,191	70 (63-77)	42%	0.37 (0.18-0.74)	1.79 (1.31-2.46)	2.66 (2.05-3.46)	3.38 (2.66-4.29)	4.92 (3.93-6.14)	*7.74 (4.47-13.22)*
MRK	10,534	70 (64-77)	42%	0.28 (0.20-0.41)	1.19 (0.98-1.45)	1.62 (1.36-1.94)	2.26 (1.90-2.68)	2.88 (2.36-3.51)	*2.88 (2.36-3.51)*
Natural Knee II	2,840	70 (64-76)	42%	0.32 (0.17-0.61)	1.30 (0.94-1.80)	2.22 (1.72-2.87)	3.36 (2.69-4.19)	3.99 (3.20-4.97)	*6.35 (4.27-9.39)*
Nexgen	133,343	70 (63-76)	43%	0.38 (0.35-0.42)	1.42 (1.35-1.50)	2.15 (2.05-2.24)	2.80 (2.69-2.93)	3.63 (3.46-3.81)	4.50 (4.12-4.93)

† Denotes a brand that has been discontinued/withdrawn/not implanted in last three years.
Note: 1 Estimates in *blue italics* indicate that fewer than 250 cases remain at risk at the time shown. Blank cells indicate the number at risk is below ten and therefore estimates are omitted as they are unreliable. 2 Brands shown have been used in at least 1,000 primary total knee replacement operations. Excludes 7,202 primary operations where the knee brand was not recorded.

Table 3.29 (continued)

Brand[2]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Cumulative percentage probability of first revision (95% CI) if time elapsed since primary operation is:					
				1 year	3 years	5 years	7 years	10 years	13 years
NRG	12,843	70 (64-76)	43%	0.39 (0.30-0.52)	1.58 (1.37-1.82)	2.39 (2.12-2.70)	2.87 (2.55-3.24)	*3.49 (3.03-4.01)*	
Optetrak	2,447	69 (63-76)	43%	0.70 (0.44-1.12)	2.86 (2.26-3.61)	4.31 (3.55-5.23)	5.23 (4.35-6.27)	7.45 (6.02-9.20)	
PFC Sigma Bicondylar Knee	296,366	70 (64-76)	43%	0.38 (0.35-0.40)	1.37 (1.32-1.41)	1.88 (1.82-1.93)	2.20 (2.14-2.27)	2.65 (2.57-2.74)	3.07 (2.93-3.21)
Profix	3,983	73 (67-78)	44%	0.38 (0.23-0.63)	1.34 (1.02-1.75)	1.89 (1.51-2.38)	2.33 (1.89-2.87)	2.87 (2.35-3.51)	*3.15 (2.45-4.04)*
Profix Oxinium	1,003	61 (56-67)	43%	0.80 (0.40-1.59)	2.82 (1.95-4.06)	3.23 (2.30-4.54)	3.66 (2.66-5.04)	4.12 (3.02-5.61)	*4.68 (3.40-6.43)*
Rotaglide	1,472	71 (63-77)	39%	0.43 (0.19-0.96)	2.18 (1.51-3.15)	3.47 (2.56-4.70)	4.19 (3.12-5.60)	*4.43 (3.30-5.95)*	
†Rotaglide +	2,115	70 (63-76)	44%	0.62 (0.36-1.06)	3.01 (2.35-3.84)	3.93 (3.17-4.87)	4.73 (3.88-5.76)	6.35 (5.29-7.61)	*7.90 (6.14-10.15)*
Scorpio	25,288	71 (64-77)	42%	0.43 (0.35-0.52)	1.80 (1.64-1.97)	2.58 (2.39-2.79)	3.20 (2.98-3.43)	3.98 (3.71-4.26)	5.44 (4.74-6.25)
TC Plus	15,430	70 (64-76)	45%	0.67 (0.55-0.81)	1.75 (1.55-1.97)	2.37 (2.13-2.63)	2.78 (2.52-3.07)	3.42 (3.10-3.78)	*4.12 (3.51-4.82)*
Triathlon	78,098	70 (63-76)	43%	0.48 (0.43-0.53)	1.56 (1.46-1.67)	2.15 (2.02-2.29)	2.60 (2.43-2.79)	3.66 (3.15-4.24)	
Vanguard	52,768	70 (63-76)	42%	0.32 (0.28-0.38)	1.43 (1.31-1.55)	2.09 (1.92-2.27)	2.49 (2.26-2.73)	*3.22 (2.50-4.14)*	

† Denotes a brand that has been discontinued/withdrawn/not implanted in last three years.
Note: 1 Estimates in *blue italics* indicate that fewer than 250 cases remain at risk at the time shown. Blank cells indicate the number at risk is below ten and therefore estimates are omitted as they are unreliable. 2 Brands shown have been used in at least 1,000 primary total knee replacement operations. Excludes 7,202 primary operations where the knee brand was not recorded.

Table 3.30 Kaplan-Meier estimates of the cumulative percentage probability of first revision (95% CI) of a primary unicompartmental knee replacement by main type of implant brand at the indicated number of years after primary operation[1].

Brand[2]	Number of knee joints	Median (IQR) age at primary	Percentage (%) males	Cumulative percentage probability of first revision (95% CI) if time elapsed since primary operation is:					
				1 year	3 years	5 years	7 years	10 years	13 years
All unicompartmental knee replacements	**97,503**	**63 (56-70)**	**49%**	**1.09 (1.03-1.16)**	**4.34 (4.20-4.49)**	**6.64 (6.46-6.83)**	**8.78 (8.55-9.01)**	**12.25 (11.92-12.60)**	**16.99 (16.18-17.85)**
Unicondylar									
AMC/Uniglide	2,848	64 (57-72)	50%	2.12 (1.65-2.73)	5.80 (4.97-6.76)	7.36 (6.41-8.44)	9.58 (8.42-10.88)	11.65 (10.20-13.28)	*14.63 (11.84-18.02)*
†MG Uni	2,381	62 (56-70)	54%	0.93 (0.61-1.40)	3.94 (3.22-4.80)	5.94 (5.05-6.97)	7.56 (6.55-8.71)	10.09 (8.84-11.50)	*12.22 (10.16-14.67)*
Oxford Partial Knee	55,447	64 (57-71)	52%	1.14 (1.05-1.24)	4.06 (3.88-4.24)	6.10 (5.87-6.33)	8.06 (7.78-8.34)	11.53 (11.11-11.96)	15.73 (14.76-16.77)
*Physica ZUK	10,246	63 (55-69)	55%	0.37 (0.26-0.51)	2.48 (2.13-2.88)	3.95 (3.45-4.52)	5.29 (4.60-6.07)	*6.66 (5.54-8.01)*	
†Preservation	1,515	62 (56-69)	55%	2.32 (1.67-3.21)	7.73 (6.49-9.20)	11.34 (9.83-13.06)	14.24 (12.55-16.13)	17.09 (15.19-19.19)	*26.23 (22.38-30.59)*
Sigma HP	7,587	62 (55-69)	57%	0.80 (0.61-1.04)	3.57 (3.10-4.10)	5.01 (4.38-5.74)	*5.68 (4.88-6.61)*		
Patellofemoral									
Avon	5,277	59 (50-68)	22%	0.77 (0.56-1.05)	4.24 (3.69-4.87)	7.47 (6.71-8.32)	10.08 (9.14-11.10)	14.43 (13.12-15.87)	*20.22 (17.47-23.33)*
FPV	1,587	59 (51-68)	23%	0.90 (0.53-1.51)	6.74 (5.56-8.15)	9.61 (8.15-11.31)	12.47 (10.65-14.57)		
Journey PFJ Oxinium	1,572	58 (50-67)	23%	2.08 (1.47-2.94)	7.39 (6.11-8.91)	12.63 (10.87-14.64)	17.84 (15.55-20.43)	*22.37 (19.35-25.77)*	
Sigma HP	1,164	58 (51-66)	22%	2.46 (1.69-3.57)	8.74 (7.09-10.75)	12.85 (10.64-15.48)	*16.90 (13.60-20.90)*		
Zimmer PFJ	1,774	57 (50-65)	22%	0.64 (0.35-1.19)	4.41 (3.39-5.75)	6.98 (5.43-8.95)	*9.54 (7.09-12.78)*		

† Denotes a brand that has been discontinued/withdrawn/not implanted in last three years.
* Denotes that this brand is now marketed by Lima
Note: 1 Estimates in *blue italics* indicate that fewer than 250 cases remain at risk at the time shown. Blank cells indicate the number at risk is below ten and therefore estimates are omitted as they are unreliable. 2 Brands shown have been used in at least 1,000 primary total knee replacement operations. Excludes 141 primary operations where the knee brand was not recorded.

Table 3.31 Kaplan-Meier estimates of the cumulative percentage probability of first revision (95% CI) of a total knee replacement or unicompartmental knee replacement at the indicated number of years after primary operation, by main implant brands and, within brand, by type of fixation, constraint and bearing sub-group[1,3].

Brand[2]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Cumulative percentage probability of a first revision (95% CI) if time elapsed since primary operation is:					
				1 year	3 years	5 years	7 years	10 years	13 years
Total knee replacements									
AGC									
Cement, unconstrained fixed	61,690	71 (64-77)	42%	0.26 (0.22-0.31)	1.43 (1.33-1.53)	2.03 (1.92-2.15)	2.56 (2.42-2.71)	3.44 (3.25-3.65)	4.76 (4.32-5.24)
Uncemented hybrid, unconstrained fixed	2,115	70 (63-76)	50%	1.15 (0.77-1.70)	3.28 (2.59-4.14)	4.11 (3.33-5.06)	4.76 (3.91-5.80)	6.22 (5.07-7.62)	*9.07 (5.76-14.15)*
Advance MP									
Cement, unconstrained fixed	7,705	70 (63-76)	47%	0.49 (0.35-0.68)	2.04 (1.73-2.41)	2.79 (2.41-3.24)	3.51 (3.04-4.05)	4.25 (3.61-5.01)	*4.25 (3.61-5.01)*
Advance MP Stature									
Cement, unconstrained fixed	1,311	69 (62-75)	14%	0.08 (0.01-0.57)	1.83 (1.18-2.82)	3.20 (2.20-4.64)	*3.20 (2.20-4.64)*		
Advance PS									
Cement, posterior-stabilised fixed	1,122	72 (66-77)	45%	0.55 (0.25-1.23)	2.39 (1.59-3.58)	3.19 (2.22-4.58)	4.29 (3.06-6.00)	*5.90 (4.10-8.47)*	*5.90 (4.10-8.47)*
Attune									
Cement, unconstrained fixed	5,490	68 (61-75)	44%	0.27 (0.15-0.49)	*1.23 (0.61-2.48)*				
Cement, posterior-stabilised fixed	2,759	69 (61-76)	42%	0.49 (0.27-0.89)	*1.17 (0.60-2.29)*				
Columbus									
Cement, unconstrained fixed	9,931	70 (64-76)	44%	0.43 (0.31-0.59)	1.78 (1.50-2.12)	2.51 (2.14-2.95)	2.79 (2.37-3.30)	*3.59 (2.60-4.94)*	
E-Motion Bicondylar Knee									
Cement, unconstrained mobile	1,079	67 (61-74)	35%	0.49 (0.20-1.17)	3.01 (2.07-4.38)	3.92 (2.76-5.57)	*4.24 (2.97-6.05)*	*4.24 (2.97-6.05)*	
Uncemented hybrid, unconstrained mobile	1,974	67 (61-74)	49%	0.83 (0.51-1.34)	2.03 (1.47-2.79)	2.78 (2.09-3.70)	3.80 (2.91-4.95)	*4.16 (3.18-5.44)*	
Endo Rotating Hinge									
Cement, bearing/ constraint unknown	1,066	76 (68-83)	29%	1.33 (0.77-2.27)	3.38 (2.37-4.82)	4.95 (3.61-6.78)	*5.69 (4.17-7.74)*	*8.44 (5.47-12.89)*	
Genesis 2									
Cement, unconstrained fixed	42,087	71 (65-77)	43%	0.33 (0.28-0.39)	1.27 (1.16-1.40)	1.75 (1.61-1.91)	2.17 (1.98-2.36)	2.60 (2.35-2.88)	*2.72 (2.43-3.05)*
Cement, posterior-stabilised fixed	14,377	71 (65-77)	39%	0.58 (0.46-0.72)	1.74 (1.52-2.01)	2.47 (2.17-2.82)	2.96 (2.59-3.39)	3.85 (3.12-4.76)	
Genesis 2 Oxinium									
Cement, unconstrained fixed	5,137	59 (54-64)	41%	0.48 (0.32-0.72)	1.94 (1.57-2.41)	3.03 (2.53-3.63)	3.51 (2.94-4.18)	4.95 (4.08-5.99)	*4.95 (4.08-5.99)*
Cement, posterior-stabilised fixed	2,695	58 (53-63)	43%	0.71 (0.45-1.13)	2.94 (2.31-3.75)	4.23 (3.40-5.26)	5.81 (4.65-7.24)	*6.90 (5.29-8.97)*	
†Insall-Burstein 2									
Cement, posterior-stabilised fixed	2,394	71 (65-77)	46%	0.30 (0.14-0.62)	1.47 (1.05-2.05)	2.74 (2.14-3.50)	3.43 (2.74-4.27)	4.95 (4.08-6.00)	*6.19 (4.99-7.67)*
†Kinemax									
Cement, unconstrained fixed	10,704	71 (64-77)	43%	0.25 (0.17-0.36)	1.78 (1.54-2.05)	2.70 (2.40-3.03)	3.53 (3.19-3.92)	4.70 (4.28-5.16)	5.76 (5.22-6.36)
†LCS									
Uncemented hybrid, unconstrained mobile	1,364	70 (63-76)	41%	0.74 (0.40-1.37)	1.86 (1.26-2.74)	2.41 (1.71-3.39)	2.49 (1.78-3.49)	2.68 (1.93-3.71)	*3.03 (2.20-4.15)*
LCS Complete									
Cement, unconstrained mobile	10,775	70 (64-76)	42%	0.44 (0.33-0.59)	1.62 (1.39-1.90)	2.73 (2.41-3.10)	3.44 (3.06-3.87)	4.28 (3.76-4.87)	
Uncemented hybrid, unconstrained mobile	14,389	69 (62-75)	46%	0.47 (0.37-0.60)	1.75 (1.54-2.00)	2.49 (2.23-2.80)	2.91 (2.60-3.25)	3.28 (2.93-3.68)	
MRK									
Cement, unconstrained fixed	10,358	70 (64-77)	42%	0.29 (0.20-0.42)	1.20 (0.98-1.46)	1.64 (1.37-1.96)	2.28 (1.92-2.71)	2.91 (2.39-3.55)	*2.91 (2.39-3.55)*

† Denotes a brand that has been discontinued/withdrawn/not implanted in the last three years.
* Denotes that this brand is now marketed by Lima.
Note: 1 Estimates in *blue italics* indicate that fewer than 250 cases remain at risk at the time shown. 2 Brands shown have been used in at least 1,000 primary knee replacement operations for that type of fixation and bearing type. 3 Excludes 6,062 joint replacements with no record of main brand.

Table 3.31 (continued)

Brand[2]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Cumulative percentage probability of a first revision (95% CI) if time elapsed since primary operation is:					
				1 year	3 years	5 years	7 years	10 years	13 years
Maxim									
Cement, unconstrained fixed	1,322	69 (63-76)	43%	0.15 (0.04-0.61)	1.48 (0.94-2.30)	2.13 (1.47-3.10)	3.05 (2.21-4.22)	4.32 (3.21-5.81)	*8.12 (3.71-17.30)*
NRG									
Cement, unconstrained fixed	7,886	70 (64-76)	43%	0.34 (0.23-0.50)	1.48 (1.22-1.79)	2.36 (2.00-2.77)	2.83 (2.41-3.32)		
Cement, posterior-stabilised fixed	4,728	70 (63-77)	44%	0.45 (0.29-0.69)	1.71 (1.37-2.13)	2.40 (1.98-2.91)	2.86 (2.38-3.45)	*3.53 (2.77-4.50)*	
Natural Knee II									
Cement, unconstrained fixed	2,695	70 (64-76)	41%	0.34 (0.18-0.65)	1.37 (0.99-1.90)	2.21 (1.70-2.87)	3.20 (2.53-4.03)	3.87 (3.07-4.88)	*5.07 (3.92-6.55)*
Nexgen									
Cement, unconstrained fixed	60,528	70 (63-76)	43%	0.30 (0.25-0.34)	1.10 (1.01-1.20)	1.60 (1.47-1.73)	2.12 (1.96-2.29)	2.56 (2.34-2.81)	*2.68 (2.41-2.98)*
Cement, posterior-stabilised fixed	62,539	70 (64-77)	41%	0.44 (0.39-0.50)	1.61 (1.50-1.72)	2.54 (2.39-2.69)	3.31 (3.13-3.50)	4.45 (4.18-4.73)	5.44 (4.91-6.04)
Cement, PS mobile	1,110	67 (60-74)	39%	1.03 (0.57-1.84)	2.83 (1.96-4.07)	3.60 (2.58-5.02)	5.12 (3.81-6.87)	7.13 (5.43-9.32)	*9.73 (6.76-13.90)*
Uncemented hybrid, unconstrained fixed	5,126	65 (59-72)	55%	0.54 (0.37-0.78)	2.24 (1.86-2.70)	2.84 (2.41-3.36)	3.28 (2.80-3.84)	3.58 (3.06-4.19)	*4.24 (3.34-5.38)*
Uncemented hybrid, ps fixed	2,204	66 (59-73)	54%	0.38 (0.19-0.75)	1.70 (1.21-2.39)	2.27 (1.67-3.09)	2.75 (2.05-3.70)	3.28 (2.45-4.40)	
Optetrak									
Cement, posterior-stabilised fixed	1,620	70 (63-76)	41%	0.56 (0.29-1.07)	2.66 (1.97-3.59)	4.56 (3.63-5.73)	5.43 (4.38-6.73)	*8.01 (6.22-10.27)*	
PFC Sigma Bicondylar Knee									
Cement, unconstrained fixed	191,293	70 (64-76)	43%	0.35 (0.32-0.37)	1.25 (1.19-1.30)	1.71 (1.64-1.77)	2.00 (1.93-2.08)	2.37 (2.27-2.47)	2.80 (2.63-2.98)
Cement, unconstrained mobile	7,842	64 (58-72)	48%	0.61 (0.46-0.81)	1.93 (1.64-2.28)	2.73 (2.37-3.14)	3.15 (2.75-3.60)	3.89 (3.36-4.50)	*4.06 (3.45-4.77)*
Cement, posterior-stabilised fixed	74,909	71 (64-77)	41%	0.40 (0.35-0.45)	1.51 (1.42-1.61)	2.09 (1.97-2.20)	2.44 (2.31-2.58)	3.01 (2.83-3.19)	3.45 (3.18-3.75)
Cement, PS mobile	6,820	65 (59-72)	46%	0.68 (0.51-0.91)	2.12 (1.79-2.50)	2.79 (2.41-3.24)	3.36 (2.91-3.87)	4.06 (3.47-4.75)	*4.19 (3.56-4.94)*
Cement, bearing/ constraint unknown	2,092	71 (64-77)	47%	0.34 (0.16-0.71)	1.53 (1.07-2.18)	2.29 (1.70-3.08)	2.90 (2.20-3.81)	3.11 (2.37-4.09)	*3.11 (2.37-4.09)*
monobloc polyethylene tibia	9,763	75 (70-79)	41%	0.34 (0.24-0.48)	1.30 (1.07-1.58)	1.64 (1.36-1.99)	1.92 (1.54-2.39)	*2.17 (1.61-2.92)*	
Uncemented hybrid, unconstrained fixed	1,727	70 (64-76)	46%	0.35 (0.16-0.78)	1.19 (0.77-1.84)	1.78 (1.24-2.55)	1.84 (1.29-2.63)	2.19 (1.55-3.09)	*2.49 (1.69-3.65)*
Uncemented hybrid, unconstrained mobile	1,052	68 (62-75)	49%	0.78 (0.39-1.54)	1.65 (1.01-2.69)	2.06 (1.31-3.22)	2.43 (1.57-3.75)	*3.14 (1.98-4.96)*	
Profix									
Uncemented hybrid, unconstrained fixed	2,311	73 (66-78)	45%	0.26 (0.12-0.59)	1.25 (0.86-1.80)	1.53 (1.10-2.14)	1.76 (1.28-2.41)	2.20 (1.61-2.99)	*2.59 (1.74-3.84)*
Rotaglide									
Cement, unconstrained mobile	1,393	71 (63-77)	39%	0.30 (0.11-0.80)	2.05 (1.39-3.03)	3.29 (2.39-4.53)	3.71 (2.72-5.06)	*3.97 (2.89-5.44)*	
†Rotaglide +									
Cement, unconstrained mobile	1,711	70 (64-77)	43%	0.47 (0.24-0.94)	2.82 (2.13-3.74)	3.65 (2.84-4.67)	4.22 (3.34-5.33)	5.61 (4.51-6.96)	*6.28 (5.04-7.82)*
Scorpio									
Cement, unconstrained fixed	10,765	71 (64-77)	41%	0.44 (0.33-0.58)	1.85 (1.61-2.13)	2.61 (2.32-2.93)	3.14 (2.82-3.51)	3.83 (3.44-4.25)	*5.83 (4.47-7.58)*
Cement, unconstrained mobile	1,173	69 (63-75)	43%	0.34 (0.13-0.91)	2.54 (1.77-3.63)	3.63 (2.68-4.89)	4.48 (3.41-5.87)	*5.57 (4.24-7.29)*	
Cement, posterior-stabilised fixed	6,107	71 (65-77)	41%	0.23 (0.14-0.39)	1.59 (1.30-1.94)	2.37 (2.01-2.80)	3.07 (2.65-3.56)	3.85 (3.35-4.43)	*5.25 (4.34-6.33)*
Cement, PS mobile	1,369	68 (61-76)	44%	0.37 (0.15-0.88)	1.49 (0.96-2.30)	2.19 (1.53-3.14)	2.54 (1.81-3.56)	3.27 (2.38-4.48)	*3.75 (2.70-5.20)*
Uncemented hybrid, unconstrained fixed	4,824	71 (64-77)	45%	0.61 (0.42-0.87)	1.79 (1.45-2.21)	2.50 (2.08-2.99)	3.15 (2.67-3.71)	4.15 (3.51-4.91)	*5.07 (4.10-6.26)*

† Denotes a brand that has been discontinued/withdrawn/not implanted in the last three years.
* Denotes that this brand is now marketed by Lima.
Note: 1 Estimates in *blue italics* indicate that fewer than 250 cases remain at risk at the time shown. 2 Brands shown have been used in at least 1,000 primary knee replacement operations for that type of fixation and bearing type. 3 Excludes 6,062 joint replacements with no record of main brand.

Table 3.31 (continued)

Brand[2]	Number of knee joints	Median (IQR) age at primary	Percentage (%) male	Cumulative percentage probability of a first revision (95% CI) if time elapsed since primary operation is: 1 year	3 years	5 years	7 years	10 years	13 years
TC Plus									
Cement, unconstrained fixed	7,947	70 (64-76)	46%	0.75 (0.58-0.96)	1.89 (1.61-2.21)	2.56 (2.23-2.93)	2.98 (2.62-3.38)	3.54 (3.08-4.05)	*4.23 (3.42-5.22)*
Cement, unconstrained mobile	4,954	70 (64-76)	44%	0.53 (0.36-0.78)	1.44 (1.14-1.83)	2.00 (1.64-2.45)	2.45 (2.03-2.95)	3.13 (2.63-3.74)	
Uncemented hybrid, unconstrained mobile	2,125	71 (64-77)	40%	0.49 (0.26-0.90)	1.47 (1.01-2.15)	2.11 (1.52-2.92)	2.39 (1.74-3.28)	*3.30 (2.40-4.52)*	
Triathlon									
Cement, unconstrained fixed	61,067	70 (63-76)	43%	0.43 (0.38-0.49)	1.48 (1.37-1.60)	2.01 (1.87-2.17)	2.50 (2.30-2.72)	3.20 (2.79-3.66)	
Cement, posterior-stabilised fixed	14,666	70 (63-76)	41%	0.62 (0.50-0.77)	1.73 (1.50-1.99)	2.53 (2.22-2.87)	2.87 (2.51-3.28)		
Uncemented hybrid, unconstrained fixed	1,528	69 (62-76)	48%	0.83 (0.46-1.50)	2.76 (1.92-3.98)	3.37 (2.38-4.76)	*3.90 (2.61-5.80)*		
Vanguard									
Cement, unconstrained fixed	42,667	70 (63-76)	42%	0.31 (0.26-0.37)	1.37 (1.24-1.51)	2.02 (1.84-2.21)	2.36 (2.12-2.62)	*3.23 (2.25-4.62)*	
Cement, posterior-stabilised fixed	6,798	70 (63-77)	40%	0.44 (0.31-0.64)	1.91 (1.56-2.34)	2.75 (2.25-3.37)	3.58 (2.79-4.58)	*3.58 (2.79-4.58)*	
Cement, constrained condylar	1,760	69 (63-76)	38%	0.27 (0.10-0.71)	1.08 (0.56-2.06)	*1.66 (0.74-3.68)*			
Unicondylar knee replacements									
AMC/Uniglide									
Unicondylar, fixed	1,379	67 (60-75)	47%	0.30 (0.11-0.80)	2.98 (2.16-4.11)	4.41 (3.35-5.79)	6.44 (5.00-8.27)	*8.49 (6.45-11.15)*	
Unicondylar, mobile	1,453	62 (56-68)	53%	3.84 (2.96-4.98)	8.47 (7.12-10.06)	10.16 (8.67-11.89)	12.42 (10.71-14.37)	*14.43 (12.47-16.66)*	*15.46 (12.81-18.59)*
†MG Uni									
Unicondylar, fixed	2,341	63 (56-70)	55%	0.90 (0.59-1.38)	3.96 (3.24-4.84)	5.95 (5.06-7.00)	7.55 (6.53-8.72)	10.03 (8.78-11.45)	*12.24 (10.12-14.76)*
Oxford Partial Knee									
Unicondylar, mobile	54,376	64 (57-71)	53%	1.15 (1.06-1.25)	4.07 (3.90-4.26)	6.13 (5.90-6.37)	8.09 (7.81-8.38)	11.54 (11.12-11.98)	15.77 (14.78-16.82)
***Physica ZUK**									
Unicondylar, fixed	10,110	62 (55-69)	55%	0.37 (0.26-0.52)	2.45 (2.10-2.85)	3.94 (3.44-4.52)	5.31 (4.60-6.11)	*6.67 (5.51-8.07)*	
†Preservation									
Unicondylar, fixed	1,219	63 (57-70)	54%	1.81 (1.20-2.74)	6.89 (5.60-8.48)	10.21 (8.62-12.07)	12.95 (11.16-15.00)	15.09 (13.09-17.37)	*20.04 (16.54-24.17)*
Sigma HP									
Unicondylar, fixed	7,575	62 (55-69)	57%	0.80 (0.61-1.04)	3.56 (3.09-4.09)	5.01 (4.37-5.73)	*5.67 (4.87-6.60)*		
Patellofemoral knee replacements									
Avon									
Patello-femoral	5,278	59 (50-68)	22%	0.77 (0.56-1.05)	4.24 (3.69-4.87)	7.47 (6.70-8.32)	10.07 (9.14-11.10)	14.43 (13.12-15.86)	*20.21 (17.47-23.33)*
FPV									
Patello-femoral	1,587	59 (51-68)	23%	0.90 (0.53-1.51)	6.74 (5.56-8.15)	9.61 (8.15-11.31)	12.47 (10.65-14.57)		
Journey PFJ Oxinium									
Patello-femoral	1,572	58 (50-67)	23%	2.08 (1.47-2.94)	7.39 (6.11-8.91)	12.63 (10.87-14.64)	17.84 (15.55-20.43)	*22.37 (19.35-25.77)*	
Sigma HP									
Patello-femoral	1,164	58 (51-66)	22%	2.46 (1.69-3.57)	8.74 (7.09-10.75)	12.85 (10.64-15.48)	*16.90 (13.60-20.90)*		
Zimmer PFJ									
Patello-femoral	1,775	57 (50-65)	22%	0.64 (0.34-1.19)	4.41 (3.38-5.74)	6.97 (5.43-8.94)	*9.53 (7.08-12.77)*		

† Denotes a brand that has been discontinued/withdrawn/not implanted in the last three years.
* Denotes that this brand is now marketed by Lima.
Note: 1 Estimates in *blue italics* indicate that fewer than 250 cases remain at risk at the time shown. 2 Brands shown have been used in at least 1,000 primary knee replacement operations for that type of fixation and bearing type. 3 Excludes 6,062 joint replacements with no record of main brand.

3.5.3 Mortality after primary knee surgery

This section looks at differences in the likelihood of a patient dying at increasing lengths of time after primary operation according to a patient's gender and age at primary. Kaplan-Meier estimates of the cumulative percentage probabilities of a patient undergoing knee surgery dying in the short term (30 or 90 days after the primary operation) and in the longer term, up to 13 years after their primary operation are shown. 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 statistical methodology note III).

Of the 975,739 records of a primary knee replacement operation over the period 1 April 2003 to 31 December 2016, 10,597 were bilateral operations in which the patient had both knees replaced on the same day. Patients identified as having a bilateral operation have had the second recorded joint excluded from the sample used for mortality analysis.

Furthermore, 179 were excluded as they did not have an NHS number (176) and therefore any record of their death could not be traced or had missing information on their age (one) or gender (two).

This identified a mortality analysis sample of 964,963 distinct patients who had a primary operation to replace one or both knees within the NJR and 116,504 of these patients died in the postoperative time period up to 31 December 2016.

Table 3.32 shows the Kaplan-Meier estimated cumulative percentage probability of a patient dying at the indicated number of years after surgery stratified by age group 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.

Table 3.32 Kaplan-Meier estimated cumulative percentage probability (95% CI) of a patient dying at the indicated number of years after a primary knee joint replacement operation by age group and gender.

Age group (years)	Number of patients	Cumulative percentage probability of patient death (95% CI) if time elapsed since primary operation is:							
		30 days	90 days	1 year	3 years	5 years	7 years	10 years	13 years
Males									
<55	29,490	0.04 (0.02-0.07)	0.06 (0.04-0.10)	0.25 (0.20-0.31)	1.01 (0.89-1.14)	1.87 (1.70-2.07)	3.08 (2.82-3.36)	5.29 (4.84-5.78)	*8.33 (7.15-9.71)*
55-59	37,346	0.06 (0.04-0.09)	0.11 (0.08-0.15)	0.39 (0.33-0.46)	1.45 (1.32-1.59)	2.82 (2.62-3.03)	4.78 (4.49-5.08)	8.24 (7.76-8.74)	12.83 (11.67-14.11)
60-64	66,256	0.07 (0.05-0.09)	0.12 (0.10-0.15)	0.47 (0.42-0.53)	1.95 (1.84-2.07)	3.94 (3.77-4.12)	6.46 (6.21-6.71)	11.31 (10.90-11.74)	19.12 (18.02-20.28)
65-69	82,979	0.10 (0.08-0.12)	0.18 (0.16-0.21)	0.67 (0.61-0.72)	2.80 (2.68-2.93)	5.88 (5.69-6.08)	9.88 (9.61-10.17)	17.76 (17.28-18.24)	28.37 (27.21-29.57)
70-74	82,155	0.15 (0.13-0.18)	0.29 (0.26-0.33)	1.11 (1.04-1.19)	4.59 (4.43-4.75)	9.64 (9.40-9.89)	16.22 (15.88-16.57)	28.61 (28.06-29.17)	44.60 (43.36-45.86)
75-79	67,283	0.30 (0.26-0.34)	0.54 (0.49-0.60)	1.88 (1.78-1.99)	7.24 (7.03-7.46)	15.26 (14.94-15.59)	25.37 (24.92-25.82)	44.85 (44.16-45.54)	64.90 (63.53-66.27)
80-84	36,657	0.66 (0.58-0.74)	1.09 (0.99-1.21)	3.22 (3.04-3.42)	12.21 (11.84-12.58)	24.65 (24.12-25.19)	40.15 (39.46-40.85)	63.95 (63.01-64.89)	*83.18 (81.52-84.78)*
85+	13,681	1.23 (1.06-1.43)	2.12 (1.89-2.38)	5.85 (5.46-6.27)	20.26 (19.52-21.02)	39.28 (38.27-40.31)	59.09 (57.88-60.30)	*82.37 (80.93-83.76)*	
Females									
<55	41,673	0.02 (0.01-0.04)	0.04 (0.03-0.07)	0.14 (0.11-0.19)	0.71 (0.62-0.81)	1.40 (1.27-1.55)	2.19 (2.01-2.40)	4.04 (3.70-4.42)	5.90 (5.09-6.82)
55-59	48,806	0.02 (0.01-0.04)	0.05 (0.03-0.07)	0.22 (0.18-0.27)	0.88 (0.79-0.98)	1.95 (1.80-2.10)	3.43 (3.22-3.65)	6.18 (5.82-6.57)	9.71 (8.91-10.58)
60-64	76,832	0.04 (0.03-0.06)	0.08 (0.07-0.11)	0.33 (0.29-0.37)	1.34 (1.25-1.43)	2.77 (2.64-2.91)	4.54 (4.35-4.74)	8.74 (8.39-9.12)	13.49 (12.65-14.38)
65-69	99,398	0.07 (0.05-0.09)	0.12 (0.10-0.15)	0.43 (0.39-0.48)	1.88 (1.79-1.97)	3.85 (3.71-4.00)	6.39 (6.19-6.61)	12.61 (12.22-13.00)	20.63 (19.72-21.57)
70-74	105,165	0.10 (0.08-0.12)	0.19 (0.16-0.22)	0.67 (0.62-0.72)	2.79 (2.69-2.91)	6.11 (5.94-6.29)	10.69 (10.44-10.94)	20.91 (20.47-21.36)	33.44 (32.46-34.45)
75-79	95,671	0.17 (0.14-0.19)	0.32 (0.29-0.36)	1.16 (1.10-1.24)	4.76 (4.61-4.91)	10.40 (10.17-10.63)	18.10 (17.77-18.43)	34.31 (33.77-34.85)	53.22 (52.06-54.39)
80-84	57,999	0.31 (0.27-0.36)	0.62 (0.56-0.69)	1.96 (1.84-2.07)	7.75 (7.52-7.99)	16.92 (16.56-17.29)	28.76 (28.27-29.27)	52.30 (51.54-53.06)	*73.12 (71.73-74.50)*
85+	23,572	0.66 (0.56-0.77)	1.28 (1.15-1.44)	3.70 (3.46-3.95)	13.93 (13.45-14.43)	28.88 (28.18-29.59)	47.25 (46.37-48.15)	72.47 (71.35-73.58)	*88.77 (86.69-90.66)*
All cases	**964,963**	**0.17 (0.16-0.18)**	**0.31 (0.30-0.32)**	**1.03 (1.01-1.05)**	**4.07 (4.03-4.11)**	**8.55 (8.48-8.61)**	**14.32 (14.22-14.41)**	**25.43 (25.27-25.58)**	**37.82 (37.47-38.16)**

Note: 1 Estimates in *blue italics* indicate that fewer than 250 cases remain at risk at the time shown. 2 Excluded 10,597 bilateral operation performed on the same day and a further 179 with unverifiable age or gender.

Part 3

3.6 Revisions of knee replacements

3.6.1 Overview of knee revisions

This section looks at knee revision procedures performed since the registry began on 1 April 2003 up to the end of December 2016, for all patients with valid patient identifiers.

In total there were 60,680 joint revision operations recorded for 48,960 individual patients on 51,241 individual patient-sides. As well as the 24,339 first revisions of primary patient sides reported on earlier in section 3.5 there are 26,842 additional revisions for a patient-side for which we have no associated primary operation record.

Revisions are classified as single-stage, Stage one or Stage two of two-stage revisions. Information about Stage one and Stage two of two-stage revisions are entered into the database separately, whereas Stage one and Stage two revisions in practice will be linked when both records have been properly recorded in the NJR. Stage one procedures have been entered without Stage two, and vice versa, making identification of individual revision surgical episodes difficult. An attempt to link these multiple stages and/or other information to identify an overall revision episode is made later in this section.

An outline of the main revision themes explored in this section are as follows: we look at numbers of knee revision operations recorded in the NJR over time by type of revision operation (single stage or part of a two-stage procedure), the reasons given for knee joint revision by stage of operation and the survival of the first documented revision of the joint to re-revision. The sensitivity of model survival estimates for re-revision in relation to the choice of the starting point of the first revision episode and resulting survival times to the next re-revision is explored. Reasons for re-revision are also presented.

An overview of all knee joint revision procedures carried out each year since April 2003[6] is given in Table 3.33. There were up to a maximum of nine documented revision procedures associated with any individual patient-side (discussed later in this section). The increase in the number of operations over time reflects the increasing number of at-risk implants prevailing in the database.

Table 3.33 Numbers of knee joint revision operations carried out each year, by revision operation type. The percentages of each revision operation type for each year is shown in brackets.

Year of revision surgery	Number of revision joint operations of each revision stage type per year (% of all revision joint operations in a year)			Total revision joint operations
	Single stage	Stage one of two-stage	Stage two of two-stage	
2003*	630 (100.0)	- - - -	- - - -	630
2004	980 (80.0)	80 (6.5)	165 (13.5)	1,225
2005	1,471 (73.6)	211 (10.6)	316 (15.8)	1,998
2006	1,945 (75.2)	285 (11.0)	358 (13.8)	2,588
2007	2,597 (74.8)	387 (11.1)	490 (14.1)	3,474
2008	3,286 (75.4)	477 (10.9)	596 (13.7)	4,359
2009	3,656 (75.9)	527 (10.9)	631 (13.1)	4,814
2010	4,129 (76.9)	573 (10.7)	670 (12.5)	5,372
2011	4,268 (77.2)	616 (11.1)	647 (11.7)	5,531
2012	4,932 (78.3)	628 (10.0)	742 (11.8)	6,302
2013	4,616 (78.1)	628 (10.6)	664 (11.2)	5,908
2014	4,964 (77.6)	736 (11.5)	694 (10.9)	6,394
2015	4,868 (79.1)	648 (10.5)	637 (10.4)	6,153
2016	4,784 (80.6)	566 (9.5)	582 (9.8)	5,932
All years	47,126	6,362	7,192	60,680

* 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.

[6] A second procedure had been entered on the same operation date for 139 patient-sides. For these cases, a review of both the components entered for the surgery and information on all remaining revision surgeries linkable to the patient and side was carried out by one of the orthopaedic surgeons in the NJR Bristol team. This led to a decision to drop 139 of the duplicated patient side records with the same operation date and to a reclassification of 18 of the remaining revision operations which had been duplicated originally. In addition, the nine knee joint revision procedures which had been misclassified as a hip revision procedure in the original raw data set were reclassified as a knee revision after checking records of the type of components used during the surgery.

Table 3.34 below shows the stated reasons for the revision surgery. Note that, as several reasons can be stated for the same operation, the reasons are not mutually exclusive and so the column percentages do not add up to 100%. Aseptic loosening accounts for approximately two fifths of single stage revision operations and pain almost a fifth. Of the two-stage revision operations, infection is the main reason recorded for revision surgery in over 75% of either Stage one or Stage two procedures.

Table 3.34 Percentage of all revision knee procedures of each stage type with the indicated reason for revision.

Reason for revision	Percentage of all revision joint operations of each stage type with the stated reason for revision		
	Single stage (n= 47,122)[1]	Stage one of two-stage (n= 6,362)	Stage two of two-stage (n= 7,187)[2]
Aseptic loosening	39.5	12.0	11.4
Other indication	19.8	4.1	5.8
Pain	17.8	5.1	4.0
Instability	17.7	4.4	4.1
Implant wear	14.8	3.6	2.0
Lysis	9.9	10.3	6.3
Malalignment	8.1	1.5	1.6
Infection	5.6	83.8	78.7
Dislocation/subluxation	4.3	1.6	1.1
Periprosthetic fracture	3.9	1.5	1.4
Implant fracture	1.3	0.4	0.3
Stiffness[3]	5.9 n=46,218	2.7 n=6,362	1.9 n=7,187

Notes: 1 Four single stage procedures had a missing entry for the reason for revision and have not been included in the percentage calculations. 2 Five stage two of a two-stage procedure had a missing entry for the reason for revision and have not been included in the percentage calculations. 3 This reason was not recorded in the earliest phase of the registry; only in MDS v2, v3 and v6. The number of joints on which the percentage is based is stated beside the percentage figure.

3.6.2 Survival of first recorded knee revision to any subsequent re-revision procedure

For a given patient-side, we have looked at the survival following the first NJR documented revision procedure (n=51,241). The majority of first revision procedures (84.7%) were carried out as a single stage revision, however, in the remaining 15.3% of first revisions, the process of first revision involved either stage of a two-stage procedure. 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 took an initial Stage one followed, subsequently, by either a Stage one or a Stage two as being the same revision episode and any interim stages were disregarded, looking instead for the start of a second revision episode. On this premise, the maximum number of distinct revision episodes for any patient-side was found to be eight.

Kaplan-Meier estimates of the cumulative percentage probability of having a subsequent revision (re-revision) were found. There were 4,518 re-revisions and, for 7,238 cases, the patient died without having been revised. The censoring date for the remainder was the end of 2016. Estimates were found for two approaches to modelling the start-time to next failure: (i) taking the start time as the time of the first revision episode and (ii) taking the start time to be the end of the first revision episode. This would make a difference only for those whose first revision was not a single stage revision, by shortening their follow-up time. A plot comparing the cumulative percentage probabilities for the two methods of re-revision is shown in Figures 3.20 (a) and (b). The rates at 1, 3, 5, 7, 10 and 13 years after first revision along with their associated 95% Confidence Intervals are given in Table 3.35 (a). The effect on the overall failure rates was negligible as is illustrated in Figures 3.20 (a) and (b) and shown in Table 3.35 (a).

The first revisions in Figure 3.20 (c) have been divided into those with a primary recorded in the NJR (n=24,339) and the remainder (n=26,842). The Kaplan-Meier estimates of the cumulative percentage chance of having a re-revision after the first revision (and 95% CI) for these two groups are shown in Table 3.35 (b). The survival of the first revisions without a linked NJR primary was much better than those with a linked NJR primary. Those without primaries in the NJR are likely to have been performed before 2003 and so imply a long period between the original primary or previous revision surgery that was not recorded in the NJR and the recorded episode of revision surgery. On the other hand, revisions linked to primaries in the NJR are likely to represent shorter times to the first revision of the joint.

Figure 3.20 (d) and Table 3.35 (c) illustrate this difference in early (within the first three years) risk of re-revision for those with primaries in the NJR and those without a recorded primary in the NJR. The 24,339 with a NJR primary on record have been grouped by time interval to the first failure (less than 1 year, 1 to 3 years, 3 to 5 years and 5 years or more). It is clear that the risk of re-revision is higher for those primaries which have already failed for the first time in the first few years (under 3 years after the primary replacement) compared to those which were revised at later times after the primary and the group without a known primary on record. The risk of re-revision is similar for both the first revision after 3 to 5 and 5+ year groups with a primary procedure recorded in the NJR and the group of first revisions without a primary procedure recorded in the NJR. A more in-depth future investigation of the reasons for first revision and the next re-revision of the joints with linked NJR primaries and those without and the patient case mix for each type may yield further insights into why there are the differences described above.

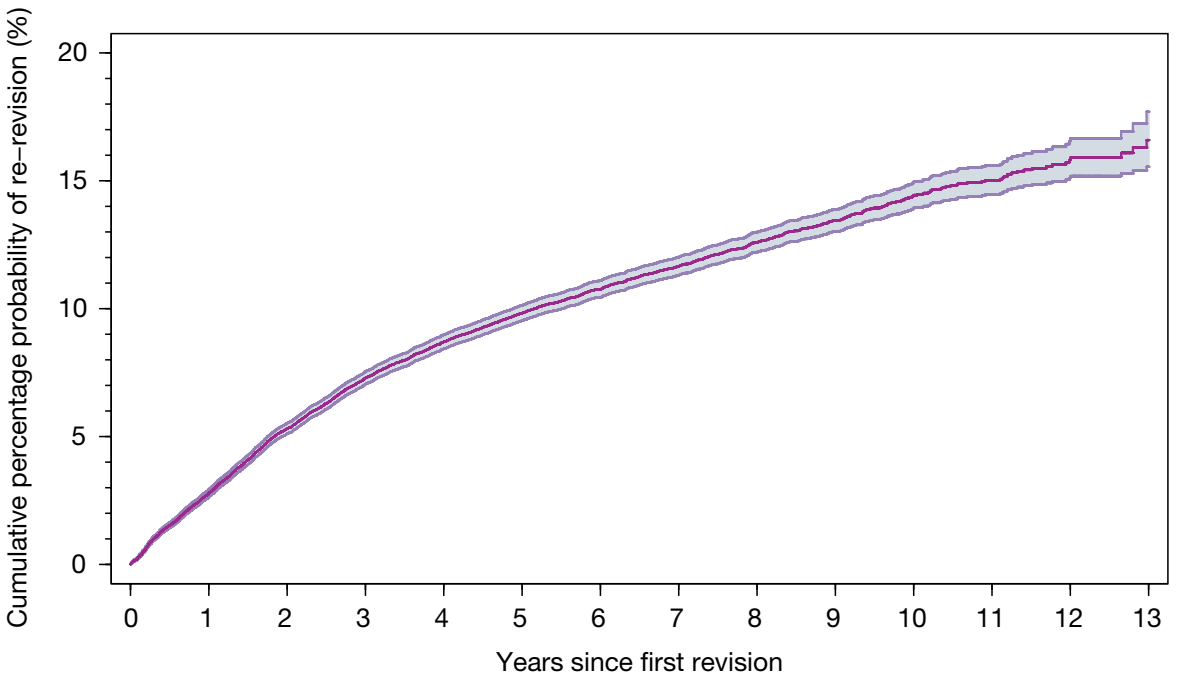
In an earlier section of this report, a link between time to first revision and the cited reason for revision was found (see section 3.5.2.4). It was shown there that if a knee joint was revised within the first year after primary surgery, infection was the most likely reason for this, followed by pain, aseptic loosening and then other reasons for revision. The most common reasons given for first revision (of the primary) between one and three years were found to be aseptic loosening, pain, other reasons and instability respectively.

Future work will explore the relationship between (i) the time to first revision and the subsequent time to re-revision and (ii) the reason for the first revision and the resulting time to re-revision.

The number of recorded first revisions in the NJR with an associated NJR primary record has increased each year since the start of the registry in 2003. By the end of 2016, 66.3% of all first time records of revision surgery for a joint could be linked to a NJR primary operation (see Tables 3.37 (a) and (b)). This is a further indication that the first revisions with a linked primary in the NJR could be failing sooner than the group of revisions without a linkable primary within the NJR dataset.

Figure 3.20 (a)

Kaplan-Meier estimate of the cumulative percentage probability of a knee re-revision, based on time from the start date of the first revision episode. The shaded area indicate point-wise 95% CIs.

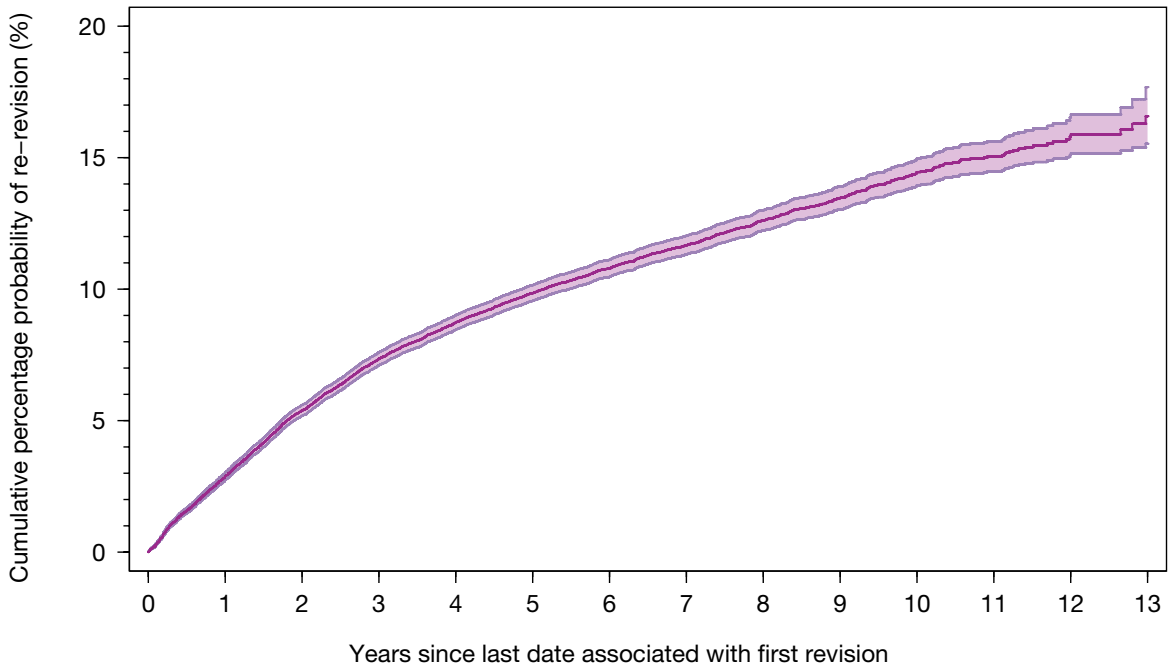


Numbers at risk

51,241	44,307	37,818	31,623	26,220	20,786	16,311	12,129	8,637	5,680	3,448	1,954	902	282

Figure 3.20 (b)

Kaplan-Meier estimate of the cumulative percentage probability of a knee re-revision, based on time from the last date of the first revision episode*. The shaded area indicate point-wise 95% CIs.



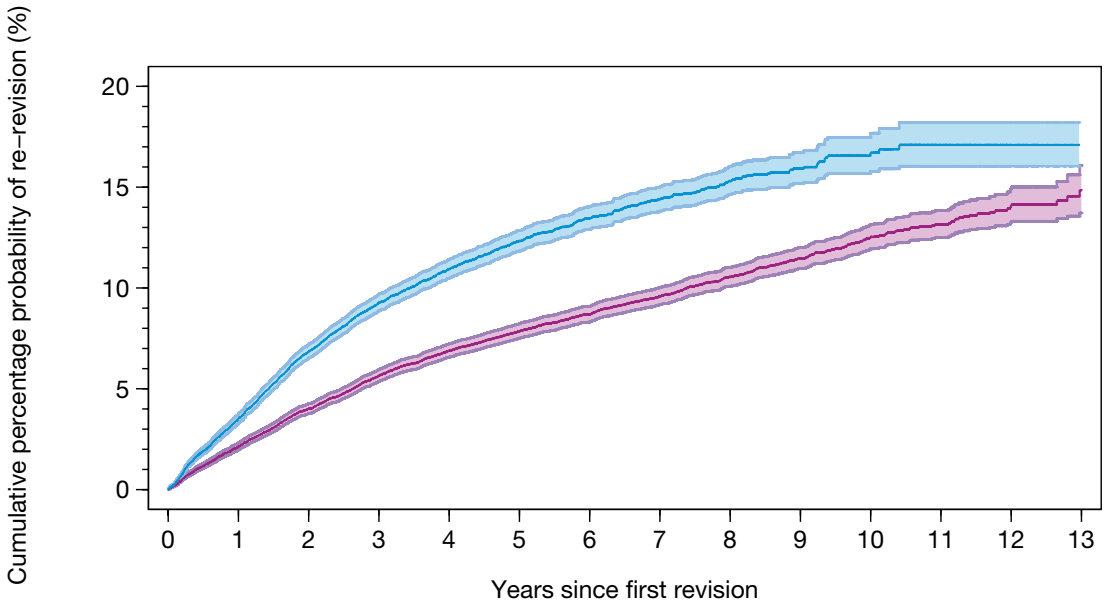
Numbers at risk

51,241	44,112	37,606	31,450	26,074	20,645	16,203	12,019	8,554	5,615	3,413	1,937	893	282

*First documented revision recorded in the NJR.

Figure 3.20 (c)

Kaplan-Meier estimates of the cumulative percentage probability of a knee re-revision, shown for those with documented primaries in NJR* and the remainder. Shaded areas are point-wise 95% CIs for the rate estimates.



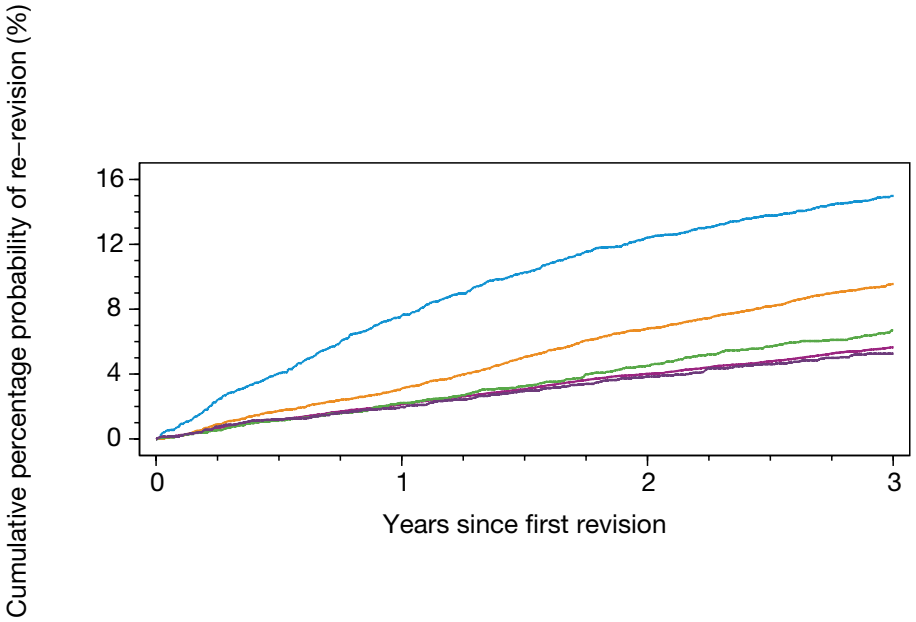
Number at risk

Primary not in NJR	26,842	24,136	21,485	18,667	16,099	13,408	10,973	8,624	6,536	4,561	2,919	1,736	847	278
Primary in NJR	24,399	20,171	16,333	12,956	10,121	7,378	5,338	3,505	2,101	1,119	529	218	55	4

*First documented revision recorded in the NJR.

Figure 3.20 (d)

Kaplan-Meier estimates of the cumulative percentage probability of a knee re-revision up to three years from the first revision*. Those with recorded primaries in the NJR are shown separately from the remainder and have been split into those that had their first revision within 1 year, 1 to 3, 3 to 5 years or more than 5 years after the initial primary.



Primary not in NJR	26,842	24,136	21,485	18,667
1st revision <1 year	4,342	3,595	2,996	2,495
1st revision 1–3 years	10,262	8,871	7,453	6,149
1st revision 3–5 years	4,656	3,933	3,282	2,632
1st revision 5+ years	5,139	3,772	2,602	1,680

*First documented revision recorded in the NJR.

Table 3.35 (a) Kaplan-Meier estimates of cumulative percentage probability of knee re-revision following the first revision using different start points for time at risk of re-revision.

Time point from which time to re-revision was measured	Number of revised joints at risk of re-revision	Cumulative percentage probability of a re-revision (95% CI) at time shown if time elapsed since first revision is:					
		1 year	3 years	5 years	7 years	10 years	13 years
(i) At start of first revision episode	51,241	2.79 (2.65-2.95)	7.29 (7.05-7.54)	9.82 (9.53-10.13)	11.66 (11.31-12.02)	14.44 (13.94-14.96)	16.59 (15.55-17.70)
(ii) End of first revision episode	51,241	2.89 (2.74-3.04)	7.35 (7.11-7.60)	9.85 (9.55-10.15)	11.67 (11.32-12.03)	14.45 (13.95-14.97)	16.58 (15.53-17.68)

Table 3.35 (b) Kaplan-Meier estimates of cumulative percentage probability of knee re-revision following the first revision broken down by whether a primary is on record in the NJR or not.

Revised patient-sides	Number of first revised joints at risk of re-revision	Cumulative percentage probability of a re-revision (95% CI) at time shown if time elapsed since first revision is*:					
		1 year	3 years	5 years	7 years	10 years	13 years
Primary not recorded in the NJR	26,842	2.15 (1.98-2.33)	5.65 (5.36-5.95)	7.86 (7.50-8.23)	9.58 (9.17-10.02)	12.53 (11.94-13.15)	14.85 (13.72-16.07)
Primary recorded in the NJR	24,399	3.53 (3.30-3.78)	9.29 (8.89-9.71)	12.33 (11.83-12.85)	14.40 (13.80-15.02)	16.71 (15.79-17.68)	*17.09 (16.04-18.21)*

*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 year 13 estimate for those with primary recorded in the NJR is only five.

Table 3.35 (c) Kaplan-Meier estimates of the cumulative percentage probability of knee re-revision following the first revision when the group of patient-sides with a primary record in the NJR are stratified by the time intervals in which the first revision took place after the primary operation.

Revised patient-sides	Number of first revised joints at risk of re-revision	Cumulative percentage probability of a re-revision (95% CI) at time shown if time elapsed since first revision is:	
		1 year	3 years
Primary not in the NJR	26,842	2.15 (1.98-2.33)	5.65 (5.36-5.95)
Primary in the NJR where the first revision took place:			
<1 year after primary	4,342	7.59 (6.82-8.44)	14.99 (13.88-16.17)
1-3 years after primary	10,262	3.12 (2.79-3.49)	9.55 (8.95-10.20)
3-5 years after primary	4,656	2.22 (1.82-2.70)	6.73 (5.96-7.59)
5+ years after primary*	5,139	1.96 (1.60-2.41)	5.26 (4.53-6.09)

* The maximum of this interval was 13.5 years.

3.6.3 Reason for knee re-revision

Table 3.36 shows a breakdown of the stated reasons for the first revision and for any subsequent revision. The reasons are not mutually exclusive. The four columns show the number of joints which indicated each type of reason for revision when the revision was (i) the first recorded revision in the NJR, (ii) the first revision and the implant was not subsequently revised, (iii) the first revision and the implant was subsequently re-revised and (iv) the re-revision of the first revision.

Table 3.36 Reasons given for first knee revision and re-revision.

Reason for revision	(i) Number of cases for each given reason for first revision n=51,233[1]	Reasons for the first recorded revision for those who were: (ii) Not subsequently re-revised n=46,717[2]	(iii) Subsequently re-revised n=4,516[3]	(iv) Number of cases for each given reason for re-revision n=4,518
Aseptic loosening	18,393	17,013	1,380	1,200
Pain	8,245	7,430	815	527
Infection	8,370	7,241	1,129	1,550
Instability	7,844	7,149	695	783
Implant wear	6,973	6,496	477	237
Lysis	5,176	4,817	359	283
Malalignment	3,684	3,384	300	253
Dislocation/subluxation	1,905	1,702	203	205
Periprosthetic fracture	1,806	1,681	125	137
Implant fracture	563	517	46	54
Stiffness[4]	2,641 n=50,345	2,402 n=45,965	239 n=4,380	285 n=4,380
Other indication	9,291	8,745	546	442

Note: 1 Reasons for revision for eight first (recorded) revisions were missing. 2 Reasons for first revision for six joints not re-revised were missing. 3 Reasons for first revision for two subsequently re-revised joints were missing. 4 Stiffness as a reason for revision was not recorded in MSDv1. The denominator number of joints on which stiffness is based is stated beside the total figure.

Table 3.37 Temporal changes in first knee revisions reported in the NJR and associated indications.

(a) Number of first knee revisions by year of surgery and proportions with an associated knee primary in the NJR.

Year of first revision in the NJR*	Number of (first) revisions	Number of first revisions (%) with the associated primary in the NJR
2003	622	11 (1.8)
2004	1,172	83 (7.1)
2005	1,842	275 (14.9)
2006	2,343	499 (21.3)
2007	3,108	852 (27.4)
2008	3,800	1,358 (35.7)
2009	4,155	1,767 (42.5)
2010	4,579	2,156 (47.1)
2011	4,641	2,290 (49.3)
2012	5,245	2,899 (55.3)
2013	4,842	2,772 (57.2)
2014	5,151	3,122 (60.6)
2015	4,938	3,130 (63.4)
2016	4,803	3,185 (66.3)
Total	51,241	24,399 (47.6)

*First documented revision in the NJR.

(b) Numbers of first recorded knee revisions by stage and whether or not primary was 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	611	11	0	0
2004	905	62	184	21
2005	1,239	196	328	79
2006	1,497	379	347	120
2007	1,856	638	400	214
2008	2,046	1,056	396	302
2009	1,999	1,444	389	323
2010	2,070	1,758	353	398
2011	2,057	1,862	294	428
2012	2,080	2,441	266	458
2013	1,829	2,340	241	432
2014	1,812	2,624	217	498
2015	1,643	2,691	165	439
2016	1,473	2,792	145	393
All years	23,117	20,294	3,725	4,105

3.6.4 Conclusions

The current year's analysis demonstrates an extension of the trends observed in previous years. In general, total knee replacements have excellent implant survivorship out to 13 years whilst unicompartmental, and patellofemoral knee replacements have higher implant revision rates. However, implant survivorship is not the only metric of success and patients and surgeons need to consider patient demographics, disease pattern and severity, pain relief, function, participation in society and post-operative mortality when making choices about whether to undergo surgical intervention and the type of surgical intervention that is appropriate for them.

Cementation of the primary prosthesis in total knee replacements continues to be the most commonly used method of fixation (84.9%) in total knee replacement surgery. Conversely uncemented fixation for primary TKR continues to decline in use making up only 2.0% of all surgeries last year. UKR (medial and lateral unicondylar and patellofemoral knee replacement) still represents one in ten of all primary knee surgeries (10.3%) and this proportion overall has remained relatively consistent over the 2003 to 2016 period.

Unicondylar replacements are far more common (8.7% of the total) than patellofemoral replacements (1.2% of the total).

In terms of choice of bearing/constraint in cemented TKR surgery and the cumulative chance of revision of the implant, the majority of these perform similarly over time (Figures 3.19 (a) and Table 3.25 (a)). The best 13-year survivorship is observed in the cemented unconstrained (cruciate retaining) fixed bearings compared to the unconstrained mobile, posterior stabilized fixed and mobile and constrained condylar implants although the numbers are small at the longest term follow-up so estimates are less reliable. Promising survivorship results are seen in the monobloc polyethylene tibia implants but the numbers at risk are small beyond the medium term. The risk of revision is higher in the uncemented (particularly for posterior-stabilised designs) and hybrid fixation groups.

Unicondylar fixed and mobile constraints again perform similarly overall but, compared to any TKR constraint choice, fare worse in terms of the need for revision surgery. The use of a patellofemoral implant incurs the highest risk of revision over all surgical choices. Although patients that receive this type of

implant are typically younger (by about ten years) and it has therefore previously been assumed that the difference in revision rates may be because patients receiving these implants are more active than those receiving a TKR. We have this year analysed revision rates by age group in each gender (Table 3.25 (b)). It can be seen that the revision rates are higher for unicondylar knee replacements and higher still for patellofemoral replacements across all age groups in males and females.

The volume of procedures of different types performed by consultants shows interesting trends. 34% of total knee replacement consultants in 2016 performed 25 or less during the year, accounting for only 7% of total replacements. This compares to unicondylar knee replacement consultants where 82% were performing 20 or less a year (accounting for 37.4% of all unicondylar replacements) and 25% of consultants performed only one or two cases in the year. This trend was similar for patellofemoral replacements where 95% of consultants were performing ten or less a year accounting for 76% of all patellofemoral replacements. 54% of patellofemoral consultants performed only one or two cases in the year. The effect of the volume of procedures on the risk of revision is not yet clear and requires further exploration.

Unlike the hip surgery findings in the last section, gender differences in the chance of needing revision surgery following total knee replacement are only small, with males at slightly higher risk than females for all ages. However, as also seen in hip replacement surgery, younger patients are at far higher risk of requiring first knee revision surgery than patients belonging to older age groups.

The most common clinical reasons for revision cited for TKR were aseptic loosening, pain, infection and other indication (excluding dislocation/subluxation, lysis, periprosthetic fracture, implant fracture, implant wear, instability, malalignment and stiffness), each of which account for approximately one revision per 1,000 patient-years or more across all cases. However, for UKRs, the incidence rates of revision for pain, aseptic loosening and other indication each account for around four revisions per 1,000 patient-years. The indicated reasons for revision of a primary patellofemoral knee resemble those of unicondylar indications for revision surgery, but PTIRs are even higher than those reported for revision of a unicondylar implant with pain and other indication having PTIRs of approximately 6 and 10 revisions per 1,000 patient-years respectively.

In the first year after primary surgery, revision due to infection has the highest PTIR. Between one and three years post primary surgery, aseptic loosening and pain become more prevalent as reasons for revision surgery and in the longer term, aseptic loosening is the dominant reason for revision.

The risk of death remains higher in men than women in the same age group in the short, medium and long term after primary knee surgery, and the risk of dying increases the older the patient is when they initially undergo primary surgery. The risk of death within 90 days of surgery in primary knee replacement is 0.31%, with the death rate rising to 1.03% at 1 year, 8.55% at 5 years, 25.4% at 10 years and 37.8% at 13 years.

Part 3

3.7 Outcomes after primary ankle replacement

3.7.1 Overview of primary ankle surgery

This section looks at revision and mortality for all primary ankle operations performed up to 31 December 2016. There were 3,899 primary ankle operations in total (see Tables 3.1 and 3.2), including four bilateral operations (both sides done on the same date). Although ankles were entered routinely from 2010, 14 primary operations have been entered that had been carried out before this date.

The median age at primary surgery was 68 years (IQR 61-74 years), with an overall range of 17 to 92 years. More procedures were performed in men (59.1%) than women. Of the 3,899 primary procedures, 3,457 (88.7%) used uncemented and 439 (11.3%) used cemented fixation methods for the implant. There were three (0.8%) joints where the fixation type was hybrid.

A total of 229 consultants carried out these primary procedures; 106 (44.3%) of them entered ten or more procedures over the seven-year period of data capture. The maximum number of procedures for any consultant was 239 over the same time period. Similarly, the total number of units involved was 269; 89 (38%) of which carried out ten or more over the seven-year time period. The maximum number of procedures carried out by any unit was 234. Table 3.38 (a) shows how the caseload of ankle surgery for units and consultants has changed during the seven-year period.

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

Number of primary replacements during each year	Year of surgery						
	2010*	2011	2012	2013	2014	2015	2016
Number of procedures in year	416	521	581	546	543	602	690
Number of units providing primary replacements each year	111	127	145	132	137	140	134
Mean number of primary replacements per unit	3.7	4.1	4.0	4.1	4.0	4.3	5.1
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 (1-6)
Number of units who entered >10 procedures each year	10	7	10	9	10	10	16
Number of units who entered >20 procedures each year	3	3	3	3	4	5	5
Number of consultants providing primary replacements during each year	114	126	144	131	126	139	132
Mean number of primary replacements per consultant	3.6	4.1	4.0	4.2	4.3	4.3	5.2
Median (IQR) number of any primary replacements per consultant	2 (1-4)	3 (2-5)	2 (1-5)	3 (1-5)	3 (2-5)	2 (1-6)	3 (1-7.5)
Number of consultants who entered >10 procedures each year	9	10	10	11	8	13	15
Number of consultants who entered >20 procedures each year	2	2	2	2	2	4	5

*Includes 14 operation dates prior to 2010.

Figure 3.21 further illustrates how a large proportion of ankle arthroplasty procedures are performed by a minority of consultants or units over the last three years. For example, in the last year (2016) 15 of 132 (11%) consultants submitting ankle arthroplasty procedures performed 286 cases. This accounts for 41% of all ankle arthroplasty procedures that year.

The data for units resembles that of the consultants, with 12% of units performing 315 procedures which accounts for 46% of all ankle procedures in 2016. The consultant data and unit data are very similar as 87 units (65%) have just one consultant performing ankle procedures. There were only four units (3%) where three or more consultants operated in 2016.

Figure 3.21

Exploring unit and consultant frequency of primary ankle surgery, and total caseload in the NJR between 2014 and 2016.

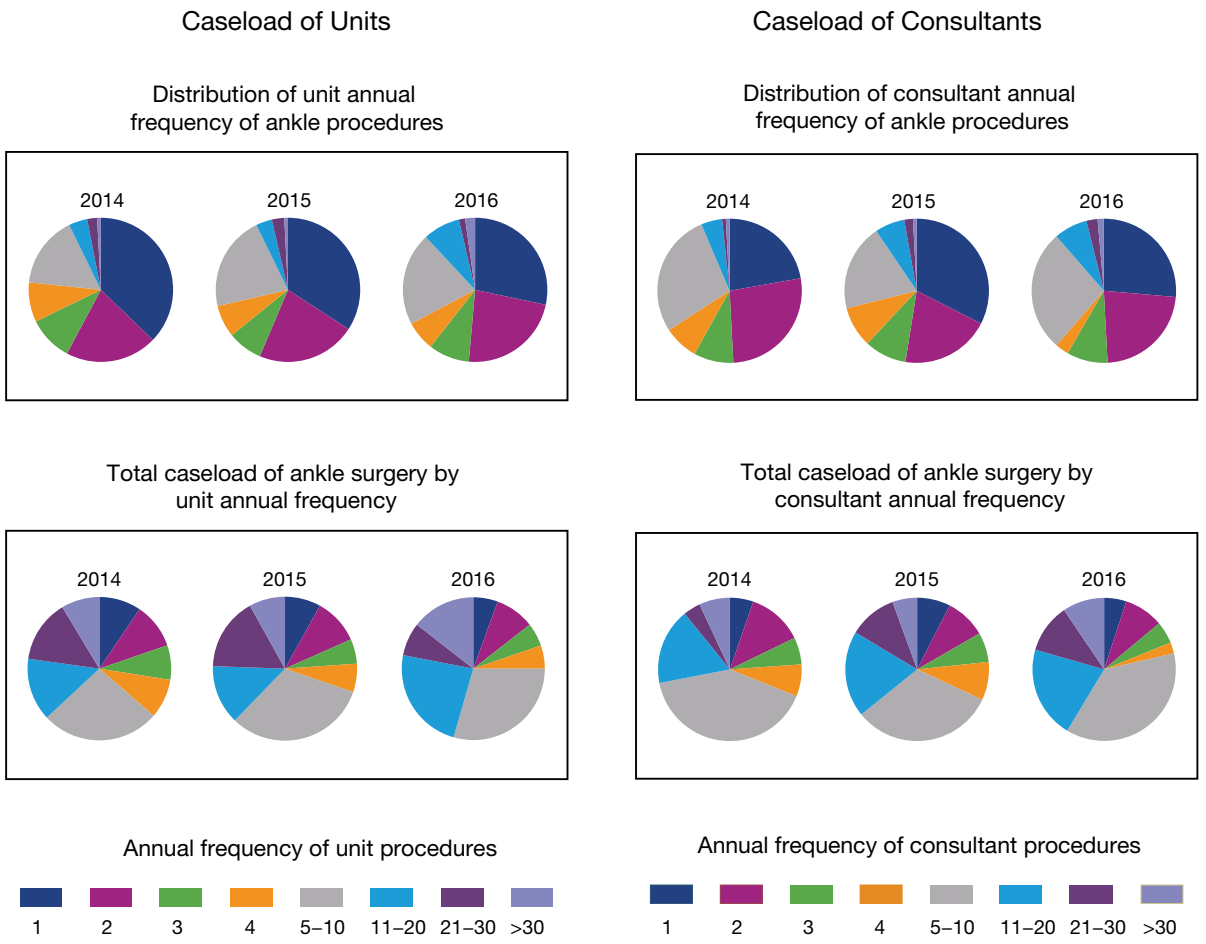


Table 3.38 (b) shows an overall breakdown of brands used and further breakdowns by year of primary operation. Please note that 14 procedures had dates of operation before 2010 (one in 2006, four in 2008 and nine in 2009) and these have been combined with those performed in 2010. The most common brand overall was Mobility, which was used in just under half of the procedures overall but whose usage since 2012 declined and in June 2014 was withdrawn from the market. In 2016, the most common brand used was the Infinity (30.1%), followed by the Box (18%) and the Zenith (14.8%).

Table 3.38 (b) 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
Mobility	1,125 (28.9)	258 (62.0)	295 (56.6)	285 (49.1)	200 (36.6)	87 (16.0)	0 (0.0)	0 (0.0)
Zenith	853 (21.9)	78 (18.8)	109 (20.9)	126 (21.7)	133 (24.4)	150 (27.6)	155 (25.7)	102 (14.8)
Box	486 (12.5)	23 (5.5)	29 (5.6)	45 (7.7)	50 (9.2)	84 (15.5)	131 (21.8)	124 (18.0)
Salto	289 (7.4)	23 (5.5)	29 (5.6)	39 (6.7)	44 (8.1)	56 (10.3)	54 (9.0)	44 (6.4)
Hintegra	258 (6.6)	15 (3.6)	18 (3.5)	35 (6.0)	63 (11.5)	45 (8.3)	53 (8.8)	29 (4.2)
Star	328 (8.4)	16 (3.8)	29 (5.6)	31 (5.3)	35 (6.4)	60 (11.0)	81 (13.5)	76 (11.0)
Rebalance	53 (1.4)	0 (0.0)	4 (0.8)	13 (2.2)	13 (2.4)	6 (1.1)	4 (0.7)	13 (1.9)
Inbone	104 (2.7)	0 (0.0)	0 (0.0)	2 (0.3)	4 (0.7)	22 (4.1)	20 (3.3)	56 (8.1)
Infinity	330 (8.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	28 (5.2)	94 (15.6)	208 (30.1)
AKILE	10 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.7)	6 (0.9)
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)
Not known	62 (1.6)	3 (0.7)	8 (1.5)	4 (0.7)	4 (0.7)	5 (0.9)	6 (1.0)	32 (4.6)
Total	**3,899 (100.0)**	**416 (100.0)**	**521 (100.0)**	**581 (100.0)**	**546 (100.0)**	**543 (100.0)**	**602 (100.0)**	**690 (100.0)**

*Includes 14 operation dates prior to 2010.

3.7.2 Revisions after primary ankle surgery

The definition of revision accepted by the British Orthopaedic Foot and Ankle Society (BOFAS) is the removal or exchange of any component of the ankle replacement, except in the case of an incidental exchange of a polythene liner in a mobile bearing implant. In situations where this definition is met, the surgeon should complete a NJR A2 MDS form. Only 153 (3.9%) of the 3,899 procedures had a NJR A2 MDS form completed to indicate revision before the end of 2016. The first revisions shown here include 24 conversions to arthrodesis but no amputations have been recorded.

The estimated cumulative percentage probabilities of (first) revision overall (using Kaplan-Meier estimation) were: 0.13 (95% CI 0.05-0.31) at 90 days; 0.81 (95% CI 0.56-1.17) at 1 year; 2.74 (95% CI 2.21-3.39) at 2 years; 3.93 (95% CI 3.26-4.73) at 3 years; 4.9 (95% CI 4.11-5.84) at 4 years; 6.61 (95% CI 5.57-7.84) at 5 years; and 7.71 (95% CI 5.94-8.47) at 6 years.

BOFAS believes that the small number of revisions reported may indicate under-reporting of the revision procedures as these figures are lower than published data in the literature. BOFAS and the NJR encourage surgeons to complete A2 MDS forms where relevant and wishes to remind surgeons and hospitals that this is a mandated requirement and that all revisions, conversion of an ankle replacement to an arthrodesis, and amputations require the completion of a NJR A2 MDS form.

Table 3.39 Indications for the 153 (first) revisions following primary ankle replacement. Note: these are not mutually exclusive.

Indication		Number
Infection	High suspicion (e.g. pus or confirmed micro)	9
	Low suspicion (awaiting micro/histology)	27
Aseptic loosening*	Tibial component	49
	Talar component	47
Lysis**	Tibia	12
	Talus	15
Malalignement		17
Implant fracture***	Tibial component	3
	Talar component	4
Implant fracture	Meniscal component	3
Wear of polyethylene component		11
Meniscal insert dislocation		3
Component migration/dissociation		9
Pain (undiagnosed)		47
Stiffness		20
Soft tissue impingement		13
Other indications for revision		21

*29 patients had aseptic loosening of both tibial and talar component. ** Six patients had lysis of both tibial and talar component. *** Two patients had implant fracture of both tibial and talar component.

3.7.3 Mortality after primary ankle replacement

Our analysis excluded two procedures where the NHS number was untraceable (and hence the age could not be validated) plus the second of each of the four bilateral procedures. Among the remaining 3,893, a total of 155 patients had died before the end of 2016.

The estimated cumulative percentage mortality (based on Kaplan-Meier estimates) were: 0.08 (95% CI 0.03-0.24) at 90 days; 0.64 (95% CI 0.42-0.97) at 1 year; 1.76 (95% CI 1.35-2.29) at 2 years; 3.07 (95% CI 2.48-3.8) at 3 years; 4.92 (95% CI 4.10-5.89); 5.97 (95% CI 5-7.12) at 5 years; and 9.14 (95% CI 7.59-10.99) at 6 years. Estimates at five and six years were unreliable as too few patients remained at risk.

Table 3.40 shows the estimated cumulative percentage probability of death at different times after surgery by gender and age at primary.

Table 3.40 Kaplan-Meier estimates of the cumulative percentage mortality (95% CI), by gender and age at 90 days, and 1, 2, 3, 4 and 5 years after primary ankle replacement. *Figures in blue italics signify time points where fewer than 250 patients remain at risk.*

Gender	Age at primary (years)	Number of patients	Cumulative percentage probability of patient death (95% CI) if time elapsed since primary operation is:					
			90 days	1 year	2 years	3 years	4 years	5 years
Male	<65	750	0*	0*	1.12 (0.50-2.48)	1.81 (0.94-3.46)	3.07 (1.76-5.31)	*3.07 (1.76-5.31)*
	65+	1,553	0.20 (0.06-0.61)	1.00 (0.60-1.69)	2.31 (1.61-3.32)	4.19 (3.14-5.59)	7.34 (5.76-9.33)	9.52 (7.55-11.97)
Female	<65	621	0*	0.19 (0.03-1.35)	0.90 (0.34-2.38)	1.46 (0.65-3.25)	*1.77 (0.84-3.71)*	*1.77 (0.84-3.71)*
	65+	969	0*	0.82 (0.39-1.72)	1.98 (1.20-3.28)	3.49 (2.34-5.18)	5.27 (3.71-7.45)	*5.87 (4.16-8.24)*

*No events recorded after surgery.

3.7.4 Conclusions

The collection of data relating to ankle primary operations only began in 2010 and hence total number of primaries remain small and numbers of first revisions even smaller, although we believe that there is under-reporting of revision procedures, making outcome analysis difficult. A total of 54% of consultant surgeons and 62% of units have submitted less than ten primary procedures in the seven years the NJR has been capturing data. Since the withdrawal of the market leading brand (Mobility) in 2014, the use of other brands such as Zenith and Box has increased accordingly. The fixed bearing Infinity implant has gained rapid popularity over the last three years and is now the market leader. The cumulative percentage probability of death following primary ankle surgery is very low.

Part 3

3.8 Outcomes after primary shoulder replacement

3.8.1 Overview of primary shoulder replacement surgery

The registry has recorded shoulder replacements since 1 April 2012. This section contains an overview of the (linked) primary shoulder replacements performed up to 31 December 2016 and documents the first revision and mortality for these primaries.

A total of 23,608 linked primary replacements were available for analysis for a total of 22,313 patients. Of these patients, 1,295 had documented replacements on both left and right sides, 20 of which were bilateral operations (left and right on the same day), see Table 3.2 in section 3.2, summary of data sources and linkages.

Due to the rapid expansion of new shoulder arthroplasty designs, the classification system for shoulder arthroplasty will be updated this year to allow for the future accurate data collection of what is a rapidly changing product area.

Table 3.41 demonstrates that the number of primary shoulder replacements has continued to increase year by year and gives a breakdown by the stated type of replacement[7].

A number of cases (401) had discrepancies between the stated type of procedure and the components entered and these are shown under the final row headed Uncertain. This final column comprises cases that were (i) designated as resurfacings but information about either a stem component or a metaphyseal proximal component had been entered, (ii) designated as resurfacings or reverse polarity total prosthetic replacements but for which a uni-polar or a bi-polar head had been entered, (iii) designated as total prosthetic replacements, hemiarthroplasty or reverse polarity total prosthetic replacement but in which information on a humeral resurfacing head component had been entered and (iv) designated as hemi-arthroplasty but glenoid component(s) had been entered.

The proportion of resurfacings (both total and hemi-arthroplasty) has continued to decline with time and the proportion of reverse polarity total replacements has increased again this year. For the 20,123 non-resurfacing implants, the distinction has been made this year between stemmed and stemless humeral components. Table 3.41 demonstrates this breakdown. Stemmed is defined as any part of the humeral component entering the diaphysis, while Stemless is defined as being completely confined to the metaphysis with no part of the stem entering the diaphysis. 19,060 of these were classified directly according to their stated stem brand. A further 490 had no stem brand entered but were able to be classified on the basis of the catalogue numbers of the humeral proximal component; the remaining 573 could not be further sub-divided.

The majority of the replacements were performed on women (men 29.0%; women 71.0%). The median age at the primary operation was 73 years (IQR 67-79 years) overall, with a range of 17-99 years.

[7] Provisional breakdown using the primary procedure as stated, without further validation by the actual components used.

Table 3.41 Numbers of all primary shoulder replacements (elective and acute trauma) by year and percentages of each type.

	All years	Year of primary operation:				
		2012*	2013	2014	2015	2016
All cases	23,608 (100%)	2,544 (100%)	4,345 (100%)	5,224 (100%)	5,551 (100%)	5,944 (100%)
Humeral hemiarthroplasty	3,050 (12.9%)	384 (15.1%)	696 (16.0%)	719 (13.8%)	661 (11.9%)	590 (9.9%)
Stemmed	2,490 (10.5%)	338 (13.3%)	575 (13.2%)	579 (11.1%)	537 (9.7%)	461 (7.7%)
Stemless	485 (2.1%)	31 (1.2%)	95 (2.2%)	124 (2.4%)	112 (2.0%)	123 (2.1%)
Uncertain	75 (0.3%)	15 (0.6%)	26 (0.6%)	16 (0.3%)	12 (0.2%)	6 (0.1%)
Resurfacing humeral hemiarthroplasty	2,251 (9.5%)	461 (18.1%)	565 (13.0%)	525 (10.1%)	363 (6.5%)	337 (5.7%)
Total conventional shoulder arthroplasty	7,105 (30.1%)	678 (26.7%)	1,240 (28.5%)	1,597 (30.6%)	1,778 (32.0%)	1,812 (30.5%)
Stemmed	5,009 (21.2%)	503 (19.8%)	915 (21.1%)	1,148 (22.0%)	1,250 (22.5%)	1,193 (20.1%)
Stemless	1,732 (7.3%)	107 (4.2%)	230 (5.3%)	377 (7.2%)	453 (8.2%)	565 (9.5%)
Uncertain	364 (1.5%)	68 (2.7%)	95 (2.2%)	72 (1.4%)	75 (1.4%)	54 (0.9%)
Resurfacing total shoulder arthroplasty	833 (3.5%)	149 (5.9%)	219 (5.0%)	189 (3.6%)	149 (2.7%)	127 (2.1%)
Reverse polarity total shoulder arthroplasty	9,968 (42.2%)	806 (31.7%)	1,531 (35.2%)	2,100 (40.2%)	2,516 (45.3%)	3,015 (50.7%)
Stemmed	9,748 (41.3%)	772 (30.3%)	1,467 (33.8%)	2,056 (39.4%)	2,471 (44.5%)	2,982 (50.2%)
Stemless	86 (0.4%)	15 (0.6%)	20 (0.5%)	13 (0.2%)	21 (0.4%)	17 (0.3%)
Uncertain	134 (0.6%)	19 (0.7%)	44 (1.0%)	31 (0.6%)	24 (0.4%)	16 (0.3%)
Uncertain	401 (1.7%)	66 (2.6%)	94 (2.2%)	94 (1.8%)	84 (1.5%)	63 (1.1%)

*Includes 36 in the registry with primary operation dates before 2012.

The primary shoulder replacements over the last three years were undertaken by 613 consultant surgeons working across 371 units. A breakdown of the numbers of units and consultants for each year, together with their number of primaries, is shown in Table 3.42 below.

Table 3.42 Numbers of units and consultant surgeons providing primary shoulder replacements over the last three years, 2014-2016.

Year of primary	Number of primary replacements	Number of units providing the primary replacements	Median (IQR) number of primary replacements per unit	Number of consultants providing the primary replacements	Median (IQR) number of primary replacements per consultant
2014	5,224	338	9 (4-20)	453	8 (3-17)
2015	5,551	343	10 (4-22)	479	8 (3-17)
2016	5,944	338	12 (5-23)	476	9 (4-18)

Table 3.43 details the indications for the primary operation, for the cases overall and with further sub-division by type of procedure.

Acute trauma accounts for 2,038 cases. These have been separated from the remaining 21,570 elective cases. Please note, 76 of the 2,038 acute trauma cases had another reason(s) stated in addition to acute trauma; the most common reasons being osteoarthritis (29) and trauma sequelae (21).

The reasons given for the elective cases are documented in Table 3.43. The reasons entered were not all mutually exclusive with some surgeons entering more than one indication. Amongst these 21,570 cases, 1,243 (5.76%) had two or more reasons stated, the most common combinations included osteoarthritis together with cuff tear arthropathy (522).

Table 3.44 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 non-resurfacings have been further divided into stemmed or stemless implants.

Figures 3.22 (a) to (e) illustrate the distributions by gender and age groups of the elective patients, according to the primary patient procedure.

Table 3.45 lists the main stem brands used in the non-resurfacing primary procedures. The table shows the totals in the registry since April 2012 as well as the numbers within the last twelve months (2016). The latter are further sub-divided into acute trauma and elective cases. The numbers of elective cases are further divided into the types of implant. Not all cases had the stem information recorded and a number had multiple stems entered (shown in the bottom row of the table). The total numbers of stemmed and stemless implants in this table are fewer than reported in the earlier table (Table 3.43) because some of the non-resurfacing implants had no humeral stem entered (hence no brand) but could be classified into stemmed or stemless by further inspection of the catalogue details available for their humeral proximal component.

Finally, Table 3.46 shows a similar table for the resurfacing brands used in resurfacing shoulder replacements. Note that Tables 3.45 and 3.46 exclude the 401 cases where the type of procedure was uncertain.

Table 3.43 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	Cuff tear arthropathy	Trauma sequelae	Other inflammatory arthropathy	Avascular necrosis	Other cause**
All cases	2,038	21,570	13,442 (62.3%)	5,877 (27.3%)	1,393 (6.5%)	995 (4.6%)	700 (3.3%)	471 (2.2%)
Humeral hemiarthroplasty	957	2,093	1,376 (65.7%)	156 (7.5%)	278 (13.3%)	159 (7.6%)	233 (11.1%)	65 (3.1%)
Stemmed	941	1,549	938 (60.6%)	143 (9.2%)	248 (16.0%)	127 (8.2%)	181 (11.7%)	47 (3.0%)
Stemless	5	480	387 (80.6%)	11 (2.3%)	27 (5.6%)	31 (6.5%)	44 (9.2%)	13 (2.7%)
Uncertain	11	64	51 (79.7%)	2 (3.1%)	3 (4.7%)	1 (1.6%)	8 (12.5%)	5 (7.8%)
Resurfacing humeral hemiarthroplasty	8	2,243	1,892 (84.4%)	149 (6.6%)	56 (2.5%)	122 (5.4%)	80 (3.6%)	40 (1.8%)
Total conventional shoulder arthroplasty	29	7,076	6,415 (90.7%)	91 (1.3%)	161 (2.3%)	288 (4.1%)	180 (2.5%)	140 (2.0%)
Stemmed	28	4,981	4,543 (91.2%)	77 (1.6%)	100 (2.0%)	191 (3.8%)	122 (2.5%)	86 (1.7%)
Stemless	1	1,731	1,574 (90.9%)	4 (0.2%)	39 (2.3%)	82 (4.7%)	49 (2.8%)	33 (1.9%)
Uncertain	0	364	298 (81.9%)	10 (2.8%)	22 (6.0%)	15 (4.1%)	9 (2.5%)	21 (5.8%)
Resurfacing total shoulder arthroplasty	1	832	731 (87.9%)	26 (3.1%)	19 (2.3%)	47 (5.7%)	15 (1.8%)	13 (1.6%)
Reverse polarity total shoulder arthroplasty	1,041	8,927	2,676 (30.0%)	5,440 (60.9%)	866 (9.7%)	366 (4.1%)	177 (2.0%)	205 (2.3%)
Stemmed	1,032	8,716	2,617 (30.0%)	5,322 (61.1%)	842 (9.7%)	356 (4.1%)	173 (2.0%)	194 (2.2%)
Stemless	1	85	29 (34.1%)	55 (64.7%)	4 (4.7%)	0 (0.0%)	1 (1.2%)	3 (3.5%)
Uncertain	8	126	30 (23.8%)	63 (50.0%)	20 (15.9%)	10 (7.9%)	3 (2.4%)	8 (6.4%)
Uncertain	2	399	352 (88.2%)	15 (3.8%)	13 (3.3%)	13 (3.3%)	15 (3.8%)	8 (2.0%)

*Percentages based on the total numbers of elective cases; note the listed reasons are not mutually exclusive in the sense that more than one reason could have been stated but this was only 5.76% for elective cases.

**Includes 22 metastatic cancer/malignancies that have only been documented separately since November 2014, when MDSv6 was introduced.

Table 3.44 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 at primary in years: Median (IQR**), Range***
Acute trauma	All cases	2,038	458 (22.5%)	74 (67-80), 37-99
	Humeral hemiarthroplasty	957	254 (26.5%)	70 (62-78), 37-96
	Resurfacing humeral hemiarthroplasty	8	2	74, 51-82
	Total conventional shoulder arthroplasty	29	11 (37.9%)	70 (64-77), 40-86
	Resurfacing total shoulder arthroplasty	1	1	
	Reverse polarity total shoulder arthroplasty	1,041	190 (18.3%)	76 (71-81), 51-99
	Uncertain	2	0	57, 54-60
Elective	All cases	21,570	6,384 (29.6%)	73 (67-79), 17-99
	Humeral hemiarthroplasty	2,093	685 (32.7%)	70 (61-77), 17-95
	Stemmed	1,549	461 (29.8%)	71 (63-78), 20-95
	Stemless	480	198 (41.3%)	67 (58-75), 17-91
	Uncertain	64	26 (40.6%)	66 (51-75), 31-90
	Resurfacing humeral hemiarthroplasty	2,243	665 (29.7%)	72 (64-78), 20-95
	Total conventional shoulder arthroplasty	7,076	2,070 (29.3%)	71 (64-76), 22-96
	Stemmed	4,981	1,366 (27.4%)	71 (66-77), 24-96
	Stemless	1,731	580 (33.5%)	69 (62-75), 23-93
	Uncertain	364	124 (34.1%)	68 (60-75), 22-96
	Resurfacing total shoulder arthroplasty	832	253 (30.4%)	70 (62-76), 20-95
	Reverse polarity total shoulder arthroplasty	8,927	2,563 (28.7%)	76 (70-80), 18-99
	Stemmed	8,716	2,484 (28.5%)	76 (70-80), 24-99
	Stemless	85	26 (30.6%)	75 (69-78), 50-92
	Uncertain	126	53 (42.1%)	71 (63-76), 18-92
	Uncertain	399	148 (37.1%)	70 (62-77), 18-92

† Cells are blank when there are too few data for meaningful analysis.

*Percentages not shown where n<10.

**IQR=Inter-quartile range, i.e. 25th to 75th centile – not given where number is small.

***Range is lowest – highest.

Figure 3.22

Gender and age distribution of elective primaries, for each type of primary procedure.

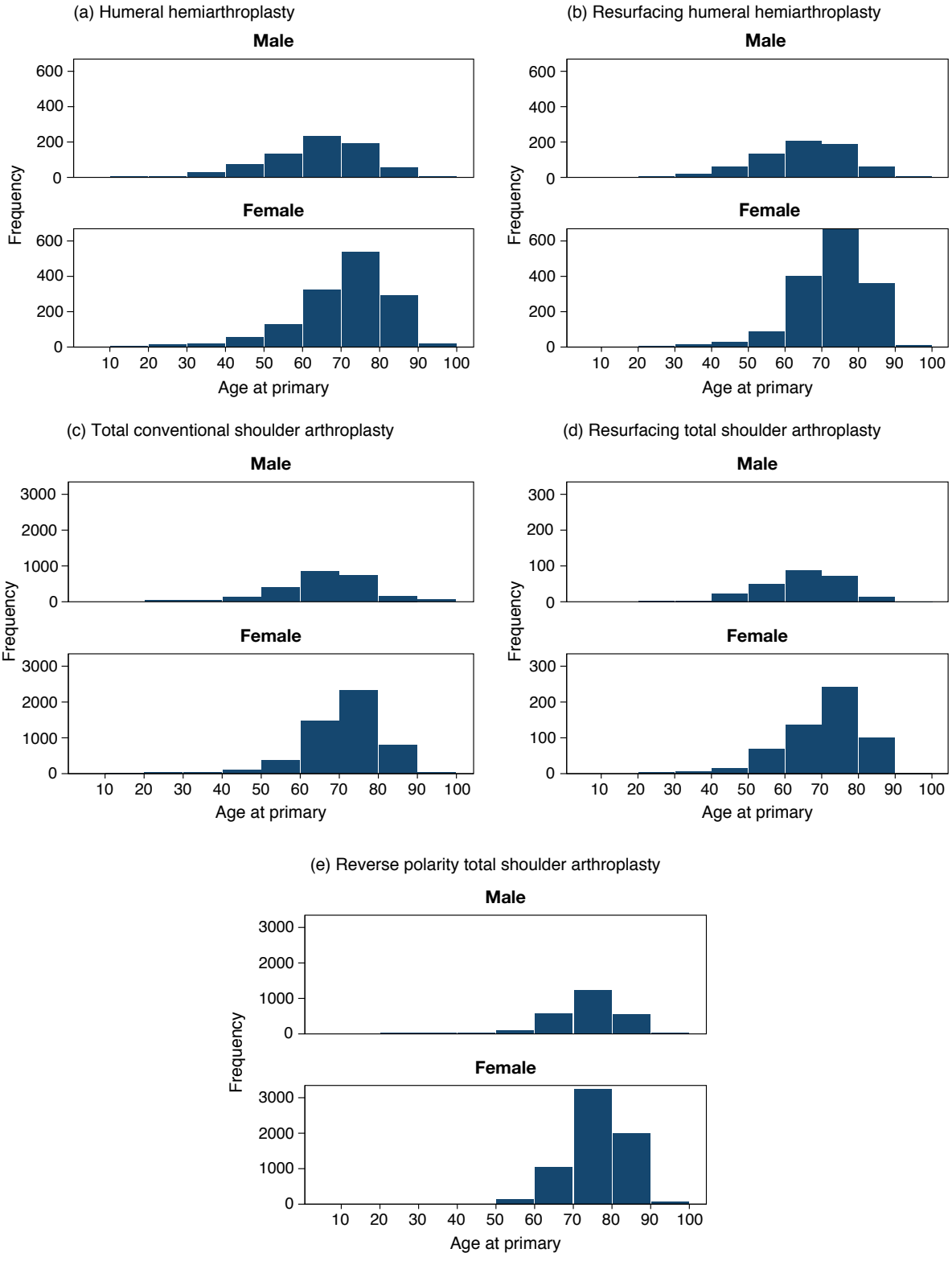


Table 3.45 Stem brands used in primary procedures (not resurfacing).

Stem brands	Total Number of primaries in the registry*	Numbers of primaries implanted within the last year (2016)					
		Number in the last year	Number for Acute trauma	Number for Elective	Type of Elective procedure		
					Humeral hemi-arthroplasty	Total conventional shoulder arthroplasty	Reverse polarity total shoulder arthroplasty
Stemmed							
Oxford Modular	78	12	0	12	11	1	0
Aequalis Ascend	38	1	0	1	1	0	0
Aequalis stem	534	64	20	44	22	22	0
Affiniti Stem	14	0	-	-	-	-	-
Comprehensive	1,823	555	61	494	23	126	345
Delta Xtend	3,055	836	89	747	9	7*	731
Global Unite	418	194	37	157	20	134	3
Global FX	167	18	13	5	4	1	0
Global AP humeral stem	1,108	203	1	202	34	168	0
Global Advantage stem	781	108	10	98	17	80	1
RSP	140	48	4	44	0	0	44
Vaios stem	423	73	10	63	6	11	46
Lima SMR stem	1,339	414	51	363	25	89	249
Affinis stem	110	26	1	25	6	19	0
Arrow	259	48	2	46	3	30	13
Equinoxe Stem	1,566	463	8	455	13	136	306
Mosaic	1	0	-	-	-	-	-
Anatomical shoulder	951	257	34	223	6	70	147
B/F	110	8	1	7	3	4	0
TM reverse	381	118	14	104	4	5	95
EPOCA	603	103	6	97	8	89	0
Verso	271	101	12	89	0	1	88
Bio-Modular shoulder	13	0	-	-	-	-	-
METS Shoulder	13	3	0	3	1	1	1
Polarus	5	0	-	-	-	-	-
Nottingham	49	0	-	-	-	-	-
Aequalis Ascend Flex	1,022	469	3	466	67	181	218
SMR	9	0	-	-	-	-	-
NEER 3	25	0	-	-	-	-	-
Affinis Fracture	175	40	36	4	1	0	3
Affini Inverse	377	122	7	115	1	0	114
Aglion Stem	4	0	-	-	-	-	-
Humelock II	7	0	-	-	-	-	-
Univers Reverse	20	12	0	12	0	2	10
Equinoxe Fracture	245	75	60	15	3	0	12
Aequalis Reversed II	820	181	4	177	3	1	173
Aequalis Reversed	173	62	43	19	0	1	18
Stemless							
TESS	61	0	-	-	-	-	-
UNIC	7	0	-	-	-	-	-
Simpliciti	398	106	0	106	17	89	0
Eclipse Stem	379	117	0	117	14	103	0
Affinis Short	1,088	336	0	336	78	258	0
Multiple brands entered	*22*	*0*	-	-	-	-	-
Missing (no brand entered)	*1,041*	*244*	*3*	*241*	*20*	*175*	*46*
Total	*20,123*	*5,417*	*530*	*4,887*	*420*	*1,804*	*2,663*

*Possible misclassifications that are being investigated further; excludes the 401 primaries where the type of procedure was uncertain.

Table 3.46 Resurfacing brands used in primary resurfacing shoulder replacements, shown separately for acute trauma and elective cases.

Resurfacing humeral head brand	Number of primaries in the NJR*	Numbers of primaries implanted within the last year (2016)				
		Number in the last year	Number for Acute trauma	Number for Elective	Number by Elective group	
					Resurfacing humeral hemi-arthroplasty	Resurfacing total shoulder arthroplasty
Aequalis head	276	37	0	37	32	5
Copeland	1,497	170	0	170	151	19
Global CAP	566	96	1	95	78	17
Vaios head	48	23	0	23	20	3
Lima SMR head	134	35	0	35	28	7
Arrow resurfacing head	42	6	0	6	5	1
Sidus	6	1	0	1	1	0
EPOCA resurfacing	458	78	0	78	14	64
Hemicap	6	1	0	1	1	0
Equinoxe humeral head	13	11	0	11	2	9
Multiple brands entered	*1*	*0*	-	-	-	-
Missing (no brand entered)	*37*	*6*	*0*	*6*	*4*	*2*
Total	**3,084**	**464**	**1**	**463**	**336**	**127**

Note: Excludes the 401 primaries where the type of procedure was uncertain.

Glenoids used in total conventional shoulder arthroplasty

Glenoid components continue to be developed and many are now available on the market. Some manufacturers have more than one glenoid type that can be used as part of their total conventional shoulder arthroplasty brand. This means branding is important in the future so that the performance of these different glenoid implant types can be analysed. Some are metal backed with modular polyethylene inserts, while others are metal backed but have fixed polyethylene bearing surfaces. Most others are all polyethylene and are usually either pegged or keeled and require cement for fixation.

Of the glenoids used in the 7,105 total conventional shoulder arthroplasties; 5,560 of these had information entered about their type which were then sub-divided according to the composition and fixation of the glenoids.

In this registry, if cement is used even partially as it is in some new 'hybrid' fixation glenoids then that component is considered cemented. As such Table 3.47 has three groupings of glenoids and their fixation methods.

Table 3.47 Composition and fixation of standard glenoids used in total conventional shoulder arthroplasty.

Composition	Fixation			Total
	Cemented	Cementless HA coated	Cementless non-HA coated	
Metal (modular)	3	13	33	49
Metal polyethylene (fixed poly)	144	0	233	377
All polyethylene	4,521	0	613	5,134
Total	**4,668**	**13**	**879**	**5,560**

Table 3.48 List of manufacturers of the standard glenoids used in total conventional shoulder arthroplasty.

Manufacturer	Number
DePuy	1,637
JRI Orthopaedics Ltd	3
Zimmer Biomet	524
Stanmore Implants Worldwide	24
Tornier	1,060
Mathys Orthopaedics Ltd	854
Synthes	613
Exactech (UK) Ltd	523
Implantcast GmbH	2
FH Orthopedics	107
Lima	65
Arthrex	145
Innovative Design Orthopaedics	1
FX Solutions	1
Multiple manufacturers entered	*1*
Total	**5,560**

3.8.2 Revisions after primary shoulder replacement surgery

A total of 582 linked shoulder were subsequently revised.

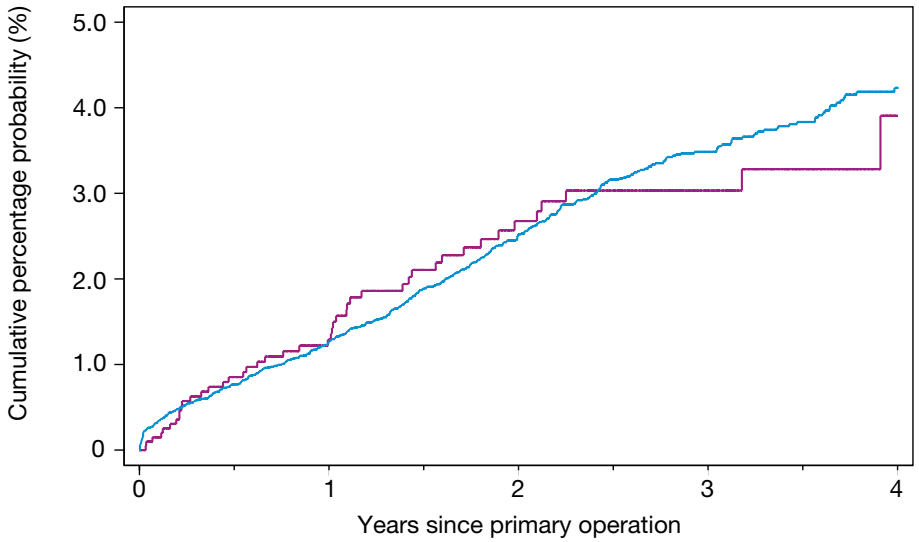
Kaplan-Meier estimates of the cumulative percentage revision at 1, 2, 3 and 4 years after the primary operation, together with 95% Confidence Intervals (CI), for all cases are shown in Table 3.49, together with a separation into acute trauma and elective cases. Figure 3.23 further compares the acute trauma and elective cases for all time points up to four years, after which time point there were too few cases for meaningful summary.

Table 3.49 Kaplan-Meier estimates of cumulative percentage probability of revision (95% CI) by time from shoulder primary procedure, shown separately for acute trauma and elective cases. *Figures in blue italics signify time points where fewer than 250 patients remain at risk.*

	n	Cumulative percentage probability of revision (Kaplan-Meier estimates), together with 95% CI, by years from shoulder primary procedure			
		1 year	2 years	3 years	4 years
All cases	23,608	1.27 (1.12-1.43)	2.54 (2.31-2.78)	3.45 (3.16-3.77)	4.20 (3.82-4.62)
Acute trauma only	2,038	1.29 (0.86-1.94)	2.68 (1.95-3.66)	3.03 (2.23-4.12)	*3.91 (2.59-5.88)*
Elective cases only	21,570	1.27 (1.12-1.43)	2.52 (2.29-2.78)	3.48 (3.18-3.82)	4.23 (3.83-4.67)

Figure 3.23

Kaplan-Meier estimate of the cumulative percentage probability of revision after primary shoulder replacement with acute trauma and elective cases shown separately.



Numbers at risk

Acute trauma	2,038	1,423	886	457	119
Elective	21,570	15,743	10,476	5,768	2,067

A further breakdown by gender and age of the cumulative percentage revisions in the elective cases, shown in Table 3.50, suggests a worse outcome up to four years for men and a trend to worse outcome in younger patients of either gender. Revision rates at four years in patients under 65 is 7.6% for men and 6.4% for women. The acute trauma group remains too small for a similar breakdown.

Table 3.50 Kaplan-Meier estimates of cumulative percentage probability of revision (95% CI) by time from elective shoulder primary, by gender and age at 1, 2, 3 and 4 years from the primary operation.

Age at primary (years)*	Cumulative percentage probability of revision (Kaplan-Meier estimates), together with 95% CI, by years from shoulder primary procedure									
	Males					Females				
	n	Years from primary operation:				n	Years from primary operation:			
		1 year	2 years	3 years	4 years		1 year	2 years	3 years	4 years
<65	1,943	2.38 (1.76-3.23)	4.77 (3.76-6.04)	6.95 (5.60-8.61)	7.62 (6.11-9.48)	2,202	1.35 (0.92-1.98)	3.14 (2.38-4.14)	4.64 (3.63-5.93)	6.39 (4.90-8.30)
65-74	2,418	1.99 (1.48-2.68)	2.86 (2.19-3.72)	3.52 (2.73-4.54)	4.78 (3.60-6.34)	5,629	0.96 (0.72-1.27)	2.22 (1.81-2.73)	3.34 (2.77-4.02)	3.86 (3.18-4.70)
75+	2,021	2.08 (1.52-2.85)	3.34 (2.55-4.38)	4.12 (3.13-5.41)	4.40 (3.31-5.83)	7,348	0.72 (0.54-0.96)	1.62 (1.31-2.00)	2.09 (1.71-2.56)	2.59 (2.08-3.22)

*Excludes nine cases for whom the NHS number was not traced and therefore age was not validated.

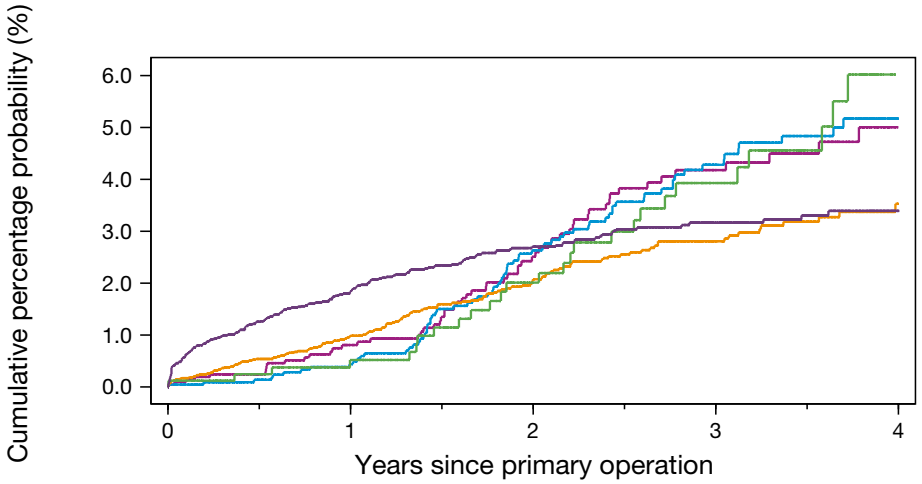
In Figure 3.24 and Table 3.51, the elective cases have been sub-divided by the type of procedure. The cumulative revision rate was worse for the reverse polarity replacement during the first two years after the primary replacement, after which it seems to stabilise and demonstrate the lowest revision rate between years two to four. Total conventional shoulder arthroplasty seems to perform relatively well in terms of revision over the same period while hemiarthroplasty operations (including resurfacing) and resurfacing total shoulder arthroplasty have higher revision rates in years three and four.

The early increased revision rates for reverse shoulder arthroplasty may represent issues with instability and the need to revise modular parts of the implant, however infection was also a common cause in this group (see Table 3.48).

Using revision rate alone, Figure 3.24 may lead readers to only consider total conventional shoulder arthroplasty or reverse shoulder arthroplasty for elective shoulder replacements. However, it is worth noting that sensible options for revision of these two groups are limited and challenging, where revision of hemiarthroplasty and resurfacing implants is more straightforward and often influenced by failing and tearing of the patients rotator cuff shoulder tendons. It therefore does remain difficult to evaluate the true outcomes of shoulder arthroplasty on the basis of revision rates alone and patient reported outcome measures (PROMs) remain a critical adjunct in assessing implant performance and failure. Shoulder PROMs are discussed later in this report.

Figure 3.24

Kaplan-Meier estimates of cumulative percentage probability of revision up to four years from primary shoulder replacement surgery, by type of procedure, for elective cases only.



Numbers at risk

Hemi-arthroplasty	2,093	1,625	1,142	672	242
Resurfacing hemi-arthroplasty	2,243	1,886	1,467	926	401
Total prosthetic replacement	7,076	5,181	3,358	1,791	613
Resurfacing total arthroplasty	832	695	530	341	131
Reverse polarity total prosthetic replacement	8,927	6,029	3,741	1,895	625

Table 3.51 Kaplan-Meier estimates of cumulative percentage probability of revision (95% CI) by time from shoulder primary procedure, for all elective cases, sub-divided by the type of procedure. *Figures in blue italics signify time points at which fewer than 250 patients remain at risk.*

Elective cases	n	Cumulative percentage probability of revision (Kaplan-Meier estimates), together with 95% CI, by years from shoulder primary procedure			
		1 year	2 years	3 years	4 years
All cases	21,570	1.27 (1.12-1.43)	2.52 (2.29-2.78)	3.48 (3.18-3.82)	4.23 (3.83-4.67)
Humeral hemiarthroplasty	2,093	0.81 (0.49-1.34)	2.51 (1.82-3.45)	4.18 (3.20-5.45)	5.01 (3.79-6.59)
Stemmed	1,549*	1.01 (0.60-1.71)	2.53 (1.75-3.64)	4.26 (3.14-5.78)	5.01 (3.67-6.84)
Stemless	480	0.24 (0.03-1.69)	*2.59 (1.29-5.14)*	*3.00 (1.56-5.73)*	*4.43 (2.05-9.1)*
Resurfacing humeral hemiarthroplasty	2,243	0.44 (0.23-0.84)	2.63 (1.98-3.50)	4.28 (3.37-5.43)	5.17 (4.09-6.54)
Total conventional shoulder arthroplasty	7,076	0.99 (0.77-1.27)	2.08 (1.71-2.51)	2.81 (2.35-3.36)	3.53 (2.89-4.31)
Stemmed	4,981*	1.19 (0.90-1.55)	2.33 (1.88-2.87)	3.15 (2.58-3.84)	3.92 (3.17-4.84)
Stemless	1,731	0.46 (0.22-0.98)	1.27 (0.74-2.20)	1.78 (1.07-2.96)	*2.78 (1.28-5.95)*
Resurfacing total shoulder arthroplasty	832	0.52 (0.19-1.38)	2.01 (1.17-3.45)	3.93 (2.58-5.96)	6.02 (4.00-9.02)
Reverse polarity total shoulder arthroplasty	8,927	1.84 (1.56-2.16)	2.70 (2.34-3.12)	3.17 (2.74-3.66)	3.39 (2.91-3.96)
Stemmed	8,716*	1.77 (1.50-2.09)	2.64 (2.28-3.06)	3.06 (2.63-3.55)	3.30 (2.81-3.87)
Stemless	85	*2.71 (0.68-10.41)*	*2.71 (0.68-10.41)*	*2.71 (0.68-10.41)*	*2.71 (0.68-10.41)*

*Groupings as in Table 3.43, but note that cases where there was uncertainty about the groupings have been excluded here.

Table 3.52 gives a breakdown of the number of primaries that were subsequently revised together with the indications for the first revision procedure. Please note the indications for revision were not mutually exclusive and, for 79 of the 582 first revisions, more than one reason was stated.

Table 3.52 Number of first revisions for each type of primary shoulder replacement and indications for revision. Acute trauma and elective cases are shown separately.

(i) Acute trauma cases only

Acute trauma	All cases	Type of primary procedure: Humeral hemi-arthroplasty	Resurfacing humeral hemi-arthroplasty	Total conventional shoulder arthroplasty	Resurfacing total shoulder arthroplasty	Reverse polarity total shoulder arthroplasty	Uncertain
Number of cases	2,038	957	8	29	1	1,041	2
Number revised	45	32	2	0	0	11	0
Reasons for first revision*:							
Infection	4	2	0	0	0	2	0
Instability	11	4	1	0	0	6	0
Cuff insufficiency	15	15	*0*	*0*	*0*	*0*	*0*
Aseptic loosening	3	0	1	0	0	2	0
Periprosthetic fracture	1	1	0	0	0	0	0
*Conversion hemi- to total-***	*13*	*13*	*0*	*N/A*	*N/A*	*N/A*	*0*
Conversion total- to hemi-	*0*	*N/A*	*N/A*	*0*	*0*	*0*	*0*
Other indications	9	8	0	0	0	1	0

*Note the reasons are not mutually exclusive; more than one could be stated; MDSv5 refers to these as "Indications for or findings at the time of revision". Conversions have been italicised to differentiate from actual reasons for revision.

**Listed as 'conversions hemi- to total' but six were revised to reverse polarity total prosthetic replacements and one to a further hemi-arthroplasty

(ii) Elective cases only

Elective	All cases	Type of primary procedure: Humeral hemi-arthroplasty	Resurfacing humeral hemi-arthroplasty	Total conventional shoulder arthroplasty	Resurfacing total shoulder arthroplasty	Reverse polarity total shoulder arthroplasty	Uncertain
Number of cases	21,570	2,093	2,243	7,076	832	8,927	399
Number revised	537	59	80	139	28	139	20
Reasons for first revision*:							
Infection	62	5	6	7	2	40	2
Instability	136	2	4	54	7	66	3
Cuff insufficiency	124	15	27	63	10	5	4
Aseptic loosening	49	5	4	15	1	24	0
Periprosthetic fracture	29	0	1	4	0	23	1
Conversion hemi- to total-	*75*	*27*	*37*	*N/A*	*N/A*	*N/A*	*11*
Conversion total- to hemi-	*12*	*N/A*	*N/A*	*1*	*0*	*11*	*0*
*Conversion - uncertain***	*13*	*1*	*0*	*2*	*8*	*2*	*0*
Other indications	120	14	17	26	3	57	3

*Note the reasons are not mutually exclusive; more than one could be stated; MDSv5 refers to these as "Indications for or findings at the time of revision". Conversions have been italicised to differentiate from actual reasons for revision.

**Listed as 'conversions' but of a type that would be incompatible with the primary implant.

3.8.3 PROMS Oxford Shoulder Scores (OSS) associated with primary shoulder replacement surgery

Last year we presented the results of a three year NJR pilot to collect the OSS on shoulder replacement patients.

This pilot has provided information on the feasibility and usefulness of PROMs for shoulders. In last year's report, 7,131 patients completed the Q1 (pre-op) while 7,503 completed the Q2 (at six months). 3,411 patients completed both the Q1 and Q2 questionnaires. While this cohort did not necessarily represent all 17,199 primaries, 275 of 3,331 elective cases (8%) had worse scores at six months post-surgery than they did pre-surgery (i.e. they were worse off). Further analysis is on-going to see if having a worse score at six months post-operatively than was recorded at the pre-operative time point was predictive of subsequent revision.

As the pilot period has ended, there are no new 2016 PROMs data to add to last year's report but the pilot successfully demonstrated the critical importance of collecting PROMs for shoulder replacements. As a consequence, a full programme of on-going OSS collection has been approved by the NJR Steering Committee and is fully supported by the British Elbow and Shoulder Society and the British Orthopaedic Association and commenced in July 2017.

3.8.4 Mortality after primary shoulder replacement surgery

For this analysis, the second procedure or side of the 20 pairs of bilateral operations performed on the same day (see Table 3.2) were deleted. Of the

remaining 23,588 implants, 1,088 of the recipients had died by the end of December 2016. Estimates of the cumulative percentage probability of mortality in this cohort were 0.40 (95% CI 0.32-0.48) at 90 days and 1.55 (95% CI 1.39-1.73), 3.79 (95% CI 3.51-4.09), 6.44 (95% CI 6.02-6.88) and 9.96 (95% CI 9.28-10.69) respectively at 1, 2, 3 and 4 years after the primary operation.

It is important to separate mortality rates following acute trauma from mortality rates after elective surgery due to the different populations and risks involved. Table 3.53 shows the overall cumulative percentage probability of mortality shown separately for acute trauma and the 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 3.54, the larger elective group has been sub-divided in to gender and age sub-groups; the number remains too small for further breakdown in the acute trauma cases.

Table 3.53 Kaplan-Meier estimates of cumulative percentage probability of mortality (95% CI) by time from shoulder primary, for acute trauma and elective cases at 90 days, 1, 2, 3 and 4 years from the primary shoulder replacement. *Figures in blue italics denote time points where fewer than 250 cases remained at risk, hence the 95% CI are not reliable.*

	Number	Cumulative percentage probability of death (Kaplan-Meier estimates), together with 95% CI, by time from shoulder primary procedure				
		90 days	1 year	2 years	3 years	4 years
Acute trauma	2,031	1.73 (1.24-2.41)	4.08 (3.26-5.10)	8.37 (7.05-9.92)	12.67 (10.82-14.80)	*18.10 (14.97-21.79)*
Elective	21,557	0.27 (0.21-0.35)	1.32 (1.16-1.49)	3.36 (3.09-3.67)	5.87 (5.45-6.32)	9.26 (8.57-10.00)

Table 3.54 Kaplan-Meier estimates of cumulative percentage probability of mortality (95% CI) by time from elective shoulder primary, by age and gender at 90 days, 1, 2, 3 and 4 years from the primary shoulder replacement. *Figures in blue italics denote time points where fewer than 250 cases remained at risk, hence the 95% CI are not reliable.*

Age at primary (years)*	Cumulative percentage probability of death (Kaplan-Meier estimates), together with 95% CI, by time from shoulder primary procedure											
	Males						Females					
	n	Years from primary operation:					n	Years from primary operation:				
		90 days	1 year	2 years	3 years	4 years		90 days	1 year	2 years	3 years	4 years
<65	1,942	0.21 (0.08-0.57)	0.87 (0.53-1.44)	2.25 (1.57-3.20)	3.40 (2.46-4.69)	*4.50 (3.18-6.36)*	2,201	0.05 (0.01-0.33)	0.41 (0.20-0.82)	1.38 (0.91-2.10)	2.31 (1.61-3.33)	4.15 (2.89-5.93)
65-74	2,418	0.25 (0.11-0.57)	1.13 (0.76-1.68)	2.98 (2.27-3.92)	4.38 (3.41-5.61)	*6.59 (5.03-8.61)*	5,625	0.16 (0.09-0.32)	0.67 (0.47-0.94)	1.94 (1.55-2.43)	3.41 (2.81-4.13)	5.86 (4.80-7.16)
75+	2,018	0.71 (0.42-1.20)	3.45 (2.69-4.43)	7.19 (5.96-8.66)	12.53 (10.63-14.74)	*17.77 (14.97-21.02)*	7,344	0.32 (0.21-0.48)	1.70 (1.41-2.05)	4.47 (3.93-5.09)	8.30 (7.45-9.25)	13.54 (12.12-15.11)

*Excludes nine cases whose NHS number was not traced therefore the age could not be validated.

3.8.5 Conclusions

We continue to build and improve the shoulder section of the NJR annual report to produce more granular data and to present it in a useful and informative format to all stakeholders. Due to their fundamental differences, we continue to present shoulder replacements for acute trauma and elective indications separately. This approach has been supported by feedback from the shoulder surgical community.

There are now 23,608 primary shoulder replacements in the NJR after 4.75 years and it continues to grow rapidly. In response to the rapid expansion of shoulder implant types on the market we also present for the first time a more detailed breakdown of stem types to include stemless implants. These in fact do have a short stem but that stem remains within the metaphysis of the humeral neck and does not enter the diaphysis. Some surgeons are starting to use these implants in response to the industry promotion of bone preservation, but the majority at present continue to use the standard stemmed implants. We will continue to observe patterns of use and any variable patterns in revision rates

The use of some shoulder replacements continues to expand from their original intentions and be used across all shoulder pathologies. It remains important to monitor the performance of these implants in these different sub-groups both through revision rates and using PROMs. With data now out to four years, some revision rate patterns can be observed, but again the need to assess these revision rates alongside an on-going PROMs programme is important. This was highlighted last year by the fact that some patients in the elective group (8%) had a worse PROMs score six months after surgery than they did prior to surgery.

Descriptive data on glenoid replacements used as part of conventional total shoulder arthroplasty are also presented for the first time. It should be noted that some manufacturers have more than one brand of glenoid that can be used with their humeral components and there is a need to ensure that such implants are correctly branded within the NJR to allow for future sub-analysis of glenoid types. We plan to expand this section of the report next year.

It should again be noted that overall revision rates are much higher in younger patients, particularly males, and these rates are higher than in similar patients undergoing other joint replacements. As this data grows it is likely to influence decision making by patients and surgeons on joint replacement in younger age groups.

Finally, while the three-year pilot of NJR PROMs collection was completed and presented in last year's annual report, the importance of shoulder PROMs has been recognised and acknowledged. The collection of the OSS as part of the NJR shoulder data is now not just set to continue, but to improve further with Q3 and Q4 collection being planned at years three and five post-shoulder replacement. Combining the growth of the NJR with this new comprehensive shoulder PROMs collection will make this an unparalleled shoulder registry.

Part 3

3.9 Outcomes after primary elbow replacement

3.9.1 Overview of primary elbow replacement surgery

This section contains an overview of the primary elbow replacements with linked[8] revision and mortality data entered into the registry since recording began (1 April 2012) up to the end of 31 December 2016, and documents the first revision and mortality for these primaries. Primary elbow replacement in this section refers to total prosthetic replacements, radial head replacements and lateral resurfacing replacements.

A total of 2,196 primary replacements were available for analysis for a total of 2,134 patients. Of these patients, 62 had documented replacements on both left and right sides, and in one patient these were both performed on the same day (bilateral), see Table 3.2 in section 3.2.

The number of primary elbow replacements entered into the NJR has continued to increase year by year, see Table 3.55[9].

This table also gives a breakdown by the stated type of replacement; the Uncertain group here contains one radial head replacement that also had an ulnar component recorded in the same procedure and two lateral resurfacings that had ulnar components recorded. Some other inconsistencies at the component level have not yet been investigated.

Table 3.55 Numbers of primary elbow replacements by year and percentages of each stated type of procedure.

Procedure type	All years	Year of primary operation				
		2012*	2013	2014	2015	2016
Total	2,196	260	449	448	526	513
Total prosthetic replacement	1,862 (84.8%)	227 (87.3%)	407 (90.6%)	389 (86.8%)	438 (83.3%)	401 (78.2%)
Radial head replacement	314 (14.3%)	23 (8.8%)	36 (8.0%)	57 (12.7%)	88 (16.7%)	110 (21.4%)
Lateral resurfacing	17 (0.8%)	9 (3.5%)	5 (1.1%)	2 (0.4%)	0 (0.0%)	1 (0.2%)
Uncertain	3 (0.1%)	1 (0.4%)	1 (0.2%)	0 (0.0%)	0 (0.0%)	1 (0.2%)

*Includes one primary operation date given as 2010.

The majority of replacements were performed on women (70.5%). The median age at the primary operation was 68 years (IQR 58-77), with an overall range of 14 to 98 years. 79 of the total prosthetic replacements had only a humeral component entered, which either means incomplete data entry or possible distal humeral hemiarthroplasty replacements.

Table 3.56 details the indications for the primary operation. Please note that the reasons are not mutually exclusive as more than one reason could have been stated. A total of 685 (31.1%) were carried out for acute trauma (25 of which also had a second reason stated). In this table, and in subsequent tables, these acute trauma cases have been separated out from the 1,511 remaining elective cases. The indications for the elective cases are listed, the most common reason being Other inflammatory arthropathy. More than one indication for surgery was stated in 74 (4.9%) of the elective cases.

[8] The term "linked" here refers to data linkage not to Linked total elbow arthroplasty.
[9] The number of primaries in 2016 was slightly lower than 2015 but this may reflect that some 2016 primaries had not been entered by the time the date was cut in February 2017.

Table 3.56 Reasons for main types of primary elbow replacements, by year of primary (includes total prosthetic replacements, radial head replacements and lateral resurfacing replacement).

Year of primary	Number of elbow primaries	Acute trauma	Elective						
			Number (%)** for each reason (amongst elective cases only):						
		Number of cases	Number of cases	Osteo-arthritis	Other inflammatory arthropathy	Trauma sequelae	Essex Lopresti	Avascular necrosis	Other cause(s)
All years	2,196	685	1,511	527 (34.9%)	724 (47.9%)	249 (16.5%)	5 (0.3%)	5 (0.3%)	77 (5.1%)
2012*	260	65	195	75 (38.5%)	84 (43.1%)	33 (16.9%)	1 (0.5%)	0 (0.0%)	12 (6.2%)
2013	449	119	330	121 (36.7%)	159 (48.2%)	44 (13.3%)	1 (0.3%)	1 (0.3%)	20 (6.1%)
2014	448	122	326	120 (36.8%)	163 (50.0%)	42 (12.9%)	1 (0.3%)	0 (0.0%)	14 (4.3%)
2015	526	191	335	113 (33.7%)	160 (47.8%)	58 (17.3%)	2 (0.6%)	3 (0.9%)	17 (5.1%)
2016	513	188	325	98 (30.2%)	158 (48.6%)	72 (22.2%)	0 (0.0%)	1 (0.3%)	14 (4.3%)

*Includes one primary operation date given as 2010.

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

Table 3.57 summarizes the type of procedures used in the acute trauma and elective cases.

Table 3.57 Types of primary elbow procedures used in acute trauma and elective cases.

	Year of primary	Type of elbow primary procedure				
		Total prosthetic replacement	Radial head replacement	Lateral resurfacing	Uncertain	Total
Acute trauma	All years	433 (63.2%)	252 (36.8%)	0 (0.0%)	0 (0.0%)	685 (100%)
	2012	50 (76.9%)	15 (23.1%)			65 (100%)
	2013	90 (75.6%)	29 (24.4%)			119 (100%)
	2014	71 (58.2%)	51 (41.8%)			122 (100%)
	2015	120 (62.8%)	71 (37.2%)			191 (100%)
	2016	102 (54.3%)	86 (45.7%)			188 (100%)
Elective	All years	1,429 (94.6%)	62 (4.1%)	17 (1.1%)	3 (0.2%)	1,511 (100%)
	2012	177 (90.8%)	8 (4.1%)	9 (4.6%)	1 (0.5%)	195 (100%)
	2013	317 (96.1%)	7 (2.1%)	5 (1.5%)	1 (0.3%)	330 (100%)
	2014	318 (97.5%)	6 (1.8%)	2 (0.6%)	0 (0.0%)	326 (100%)
	2015	318 (94.9%)	17 (5.1%)	0 (0.0%)	0 (0.0%)	335 (100%)
	2016	299 (92.0%)	24 (7.4%)	1 (0.3%)	1 (0.3%)	325 (100%)

Over the last three years (from 2014), 1,487 of all types of primaries have been entered into the registry (see Table 3.56). These procedures were performed by 320 consultants in total, working across 226 units.

A breakdown of unit and consultant caseload for each year for all primary elbow replacements performed is shown in Table 3.58 below, together with the number of units and consultants entering only acute trauma cases, only elective cases, and both types within that year.

Table 3.58 Number of units and consultant surgeons providing any primary elbow replacements during each year from 2014 to 2016 (includes total prosthetic replacements, radial head replacements and lateral resurfacing replacements).

		Year of primary		
		2014	2015	2016
	Number of primary replacements during each year	448	526	513
Units	Number of units providing any primary replacement types each year	148	161	160
	Mean number of any primary replacements per unit	3	3.3	3.2
	Median (IQR) number of any primary replacements per unit	2 (1-4)	2 (1-4)	2 (1-4)
	Number of units who entered:			
	(i) only acute trauma cases	28	32	29
	(ii) only elective cases	82	74	75
	(iii) both acute trauma and elective cases	38	55	56
Consultants	Number of consultants providing any primary replacement types each year	189	210	210
	Mean number of any primary replacements per consultant	2.4	2.5	2.4
	Median (IQR) number of any primary replacements per consultant	2 (1-3)	2 (1-3)	2 (1-3)
	Number of consultants who entered:			
	(i) only acute trauma cases	34	54	46
	(ii) only elective cases	109	95	106
	(iii) both acute trauma and elective cases	46	61	58

A breakdown of unit and consultant caseload for each year for primary total elbow replacements performed is shown in Table 3.59. Data on the number of units and consultants entering only acute trauma cases, only elective cases, and both types within that year is also shown.

Table 3.59 Number of units and consultant surgeons providing primary total prosthetic replacements.

		Year of primary		
		2014	2015	2016
	Number of primary replacements during each year	389	438	401
Units	Number of units providing total prosthetic replacements	132	144	141
	Mean number of total prosthetic replacements per unit	2.9	3	2.8
	Median (IQR) number of total prosthetic replacements per unit	2 (1-4)	2 (1-4)	2 (1-3)
	Number of units who entered:			
	(i) total prosthetic replacements for acute trauma only	15	19	18
	(ii) total prosthetic replacements for elective cases only	85	80	79
	(iii) total prosthetic replacements for both acute trauma and elective cases	32	45	44
Consultants	Number of consultants providing total prosthetic replacements	167	181	170
	Mean number of total prosthetic replacements per consultant	2.3	2.4	2.4
	Median (IQR) number of total prosthetic replacements per consultant	2 (1-3)	2 (1-3)	2 (1-3)
	Number of consultants who entered:			
	(i) total prosthetic replacements for acute trauma only	17	33	19
	(ii) total prosthetic replacements for elective cases only	115	101	104
	(iii) total prosthetic replacements for both acute trauma and elective cases	35	47	47

A total of 205 units had entered at least one primary total prosthetic replacement (either elective or acute trauma) over the three-year period; the maximum number entered over this three-year period by any one unit was 57, with five units entering 20 or more. However, 115 units (56%) had entered fewer than five elective cases over this same period.

In 2016, taking elective and trauma cases together, the numbers of units and surgeons doing only one primary total prosthetic replacements in that year were 57 and 73 respectively. The numbers of units and surgeons doing fewer than five total prosthetic replacements per year were 119 and 151 respectively.

Table 3.60 lists the humeral brands used in total prosthetic replacements and lateral resurfacings. Acute trauma and elective cases are shown separately with a further sub-division by type of procedure amongst the elective cases only.

Table 3.60 Brands used in total prosthetic replacements and lateral resurfacing replacements.

				Elective cases	
Brand	Total number	Acute trauma	Elective cases	Total prosthetic replacement	Lateral resurfacing
Latitude Humeral	230	63	167	167	0
Discovery	500	94	406	406	0
K Elbow	4	0	4	4	0
IBP	9	0	9	9	0
Coonrad Morrey	994	249	745	745	0
GSB 111	39	3	36	36	0
LRE	13	0	13	0	13
NES	2	0	2	2	0
Mutars Elbow	1	0	1	1	0
Custom made part	*2*	*0*	*2*	*2*	*0*
No humeral part entered	*85*	*24*	*61*	*57*	*4*
Total	1,879	433	1,446	1,429	17

Table 3.61 lists the radial head brands used in total prosthetic replacements, radial head replacements and lateral resurfacings. Acute trauma and elective cases are shown separately with a further sub-division by type of procedure amongst the elective cases only.

Table 3.61 Radial head brands used in total prosthetic replacements, radial head replacements and lateral resurfacing replacements.

				Elective cases		
Brand	Total number	Acute trauma	Elective cases	Total prosthetic replacement	Radial head replacement	Lateral resurfacing
Latitude	6	0	6	5	1	0
RHS	15	7	8	0	8	0
ExploR	21	19	2	0	2	0
Corin Radial Head	19	15	4	0	4	0
Evolve	45	37	8	0	8	0
Anatomic Radial Head	161	137	24	0	24	0
rHead	6	3	3	0	3	0
MoPyC	7	5	2	0	2	0
LRE Radial	14	0	14	0	0	14
Ascension	23	16	7	0	7	0
Liverpool Radial Head	4	3	1	0	1	0
Uni Radial Elbow	1	0	1	0	1	0
Custom made part	1	0	1	0	0	1
Radial stem entered but no head (thus unbranded)	51	1	50	50	0	0
No radial implant included (stem or head)	1,819	442	1,377	1,374	1	2
Total*	2,193	685	1,508	1,429	62	17

*Excludes the uncertain procedures.

3.9.2 Revisions after primary elbow replacement surgery

A total of 55 elbow primaries (nine acute trauma cases and 46 electives) were revised up to the end of 2016, including one excision arthroplasty.

Kaplan-Meier estimates of the cumulative percentage probability of revision up to three years after the primary operation, together with 95% Confidence Intervals, are shown in Table 3.62.

The table also shows separate results for acute trauma and elective cases. Generally the group sizes were too small for meaningful sub-division by type of procedure. However, amongst the 252 radial head replacements carried out for acute trauma, no revisions had been reported up to the end of 2016. The total prosthetic replacements performed for acute trauma cases, however, had similar cumulative revision rates to those for elective cases, as further illustrated in Figure 3.25.

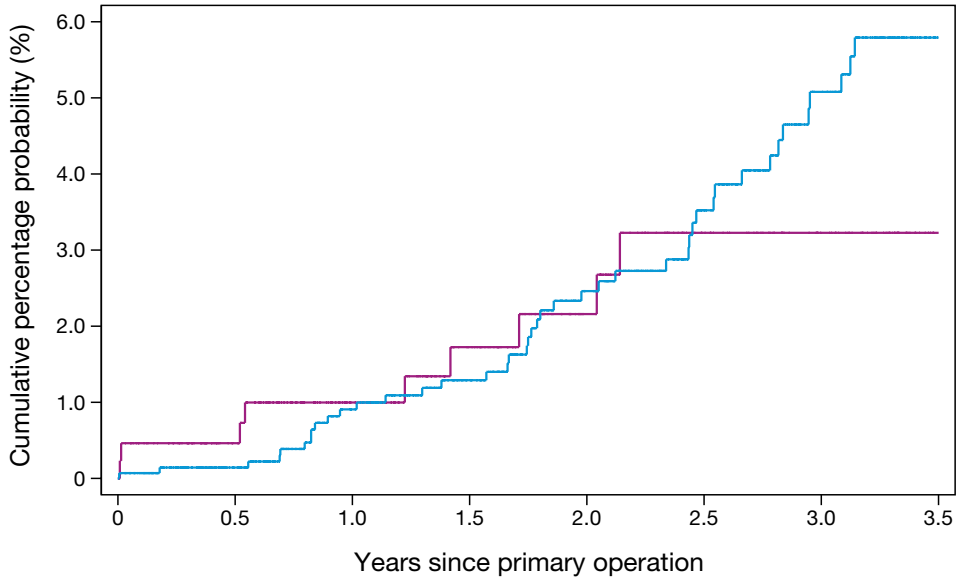
At the current time, there are too few cases for further sub-division into age/gender sub-groups, but we hope to do this in future reports as the numbers increase.

Table 3.62 Kaplan-Meier estimates of cumulative percentage probability of revision (95% CI) by time from elbow primary procedure, shown separately for acute trauma and elective cases. *Figures in blue italics signify time points at which fewer than 250 patients remain at risk.*

Elbow primaries		Number of cases	Number revised	Cumulative percentage probability of revision (Kaplan-Meier estimates), together with 95% CI, by years from elbow primary procedure		
				1 year	2 years	3 years
All cases		2,196	55	0.90 (0.56-1.45)	2.20 (1.57-3.09)	4.35 (3.27-5.77)
Acute Trauma	All acute trauma cases	685	9	0.64 (0.24-1.70)	1.42 (0.66-3.03)	*2.14 (1.08-4.23)*
	Radial head replacements	252	*0*	*0*	*0*	*0*
	Total prosthetic replacements	433	9	1.00 (0.37-2.64)	*2.16 (1.01-4.57)*	*3.23 (1.64-6.32)*
Elective cases	All elective cases	1,511	46	1.01 (0.59-1.74)	2.49 (1.71-3.64)	5.12 (3.76-6.96)
	Total prosthetic replacements	1,429	43	0.91 (0.50-1.63)	2.46 (1.66-3.64)	5.08 (3.68-6.98)

Figure 3.25

Kaplan-Meier estimate of the cumulative percentage probability of revision after primary **total prosthetic replacement** with acute trauma and elective cases shown separately.



Number at risk

Acute trauma	433	375	309	250	190	149	117	67
Elective	1,429	1,268	1,095	931	755	577	433	280

Table 3.63 gives a breakdown of the indications for the first data linked revision procedure, the most common reasons being for infection and for aseptic loosening. Please note, the indications for revision were not mutually exclusive; in five out of the 55 revisions, more than one reason was stated. It is interesting that aseptic loosening is so common within only four years of a primary elective procedure. A few cases once revised had gone on to have more revision procedures (other than planned two-stage revisions for infection).

Table 3.63 Indications for first data linked revision after any primary elbow replacement. Acute trauma and elective cases are shown separately, for all cases and for total prosthetic replacements.

	Acute trauma		Elective	
	All cases	Total prosthetic replacement only	All cases	Total prosthetic replacement only
All cases	685	433	1,511	1,429
Total revised	9	9	46	43
Infection	3	3	18	18
Periprosthetic fracture	2	2	4	4
Instability	1	1	6	4
Other indications	2	2	4	3
Aseptic loosening	2	2	18	18

3.9.3 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) were removed. Among the remaining 2,195 implants, 142 of the recipients had died by the end of December 2016. Estimates of the cumulative percentage probability of mortality in this cohort were 0.46 (95% CI 0.25-0.86) at 90 days and 2.53 (95% CI 1.91-3.33), 5.11 (95% CI 4.14-6.32) and 9.10 (95% CI 7.61-10.88) respectively at 1, 2 and 3 years after the primary operation.

Table 3.64 shows the overall cumulative percentage probability of mortality shown separately for acute trauma and the elective cases, and shows higher rates in the acute trauma group.

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 present further sub-divisions by age and gender, as we have done for other types of joint.

Table 3.64 Kaplan-Meier estimates of cumulative percentage probability of mortality (95% CI) by time from elbow primary, for acute trauma and elective cases at 90 days, 1, 2 and 3 years from the primary elbow replacement. *Figures in blue italics denote time points where fewer than 250 cases remained at risk, hence the 95% CI are not reliable.*

			Cumulative percentage probability of death (Kaplan-Meier estimates), together with 95% CI, by time from elbow primary procedure			
		Number	90 days	1 year	2 years	3 years
Acute trauma	All cases	685	0.59 (0.22-1.58)	4.14 (2.79-6.13)	7.68 (5.59-10.49)	*15.06 (11.51-19.56)*
	Total prosthetic replacements only	433	0.70 (0.23-2.16)	5.54 (3.64-8.39)	*10.34 (7.44-14.28)*	*19.70 (15.05-25.54)*
Elective	All cases	1,510	0.40 (0.18-0.90)	1.83 (1.24-2.70)	4.05 (3.04-5.38)	6.80 (5.34-8.64)
	Total prosthetic replacements only	1,428	0.43 (0.19-0.95)	1.93 (1.30-2.84)	4.25 (3.20-5.65)	7.15 (5.61-9.08)

3.9.4 Conclusions

This is the first year we have presented a report on primary elbow replacements because the numbers performed annually are small. However, the numbers in the registry within 4.75 years from inception are already greater than most other national arthroplasty registers. The data collection compliance rates for primary and revision elbows is still not known, and some anomalies in the report may be explained by incomplete reporting by surgeons not familiar with NJR data entry.

As expected, radial head replacements are more common in acute trauma procedures and total prosthetic replacement more common in elective surgery. Over the 4.75 years these joint replacements took place in a total of 246 units but included all types of replacement.

In 2016, 401 primary total elbow replacements were performed in 141 units by 170 surgeons. A total of 102 were performed for acute trauma and 299 were performed for elective indications. The median number per surgeon and per unit was only two cases.

Besides infection, aseptic loosening was a common cause of revision within four years and this highlights a potentially important issue with elbow replacements and their long term performance. With revision surgery being difficult and with the options for revision surgery being limited, we will continue to monitor this failure rate and whether there are differences between patient groups.

The revision total elbow replacements that took place in 2016 were performed by 64 surgeons across 52 units.

Since the start of the registry, distal humeral hemiarthoplasty has also been introduced and become more commonly used, especially in trauma cases. The minimum dataset classification is due for modification to include this implant type and they will begin to appear as a separate implant type in this report in future years.

Part 4

Implant and unit-level activity and outcomes

Part Four of the annual report gives performance and data entry quality indicators for Trusts, 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 2016 calendar year. Outcomes analysis after hip and knee replacement surgery is also provided for the period 2003 to 2016.

This section now also provides data for implant outliers since 2003 and further information on notification and last usage date.

The full analysis for both units and implants can be found in the Part Four online document at www.njrreports.org.uk – 'Implant and unit-level activity and outcomes'.

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, five hip acetabular (cup) components and 19 hip stem/cup combinations reported. Six knee brands have been notified. Implants notified in the last year are still in use and none of the hip implants are metal-on-metal.

4.2 Clinical activity

Overall in 2016, 150 NHS Trusts and Local Health Boards (comprising 247 separate hospitals) and 177 independent hospitals were open and eligible to report patient procedures to the NJR. All units except for three trauma units submitted data in 2016.

The proportion of all hip and knee joint replacements entered in to the NJR against those carried out (compliance) is only available by NHS Trust and Local Health Board. No data on this is currently available from private providers and figures would also exclude units in Northern Ireland as compliance is not available.

- 26% of NHS providers reported 95% or more of the joint replacements they undertook
- 54% of NHS providers reported between 80% and 95%
- 20% of NHS providers 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

- 48% of NHS hospitals achieved a consent rate of greater than 95%
- 34% achieved a consent rate of 80% to 95%
- 18% recorded a consent rate of less than 80%

Independent hospitals

- 70% of independent hospitals achieved a consent rate greater than 95%
- 21% achieved a consent rate of 80% to 95%
- 8% recorded a consent rate of less than 80%

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 below:

NHS hospitals

- 87% achieved a proportion of patients with a linkable NHS number greater than 95%
- 11% achieved a proportion of 80% to 95%
- 2% recorded a proportion of linkable records of less than 80%

Independent hospitals

- 72% achieved a proportion of patients with a linkable NHS number greater than 95%
- 21% achieved a proportion of 80% to 95%
- 6% recorded a proportion of linkable records of less than 80%

Note: Independent hospitals might be expected to have lower linkability rates than NHS hospitals, as a proportion of their patients may come from abroad and not have an NHS number. Linkability figures are not currently available for Northern Ireland.

4.3 Outlier units for 90-day mortality and revision rates for the period 2003 to 2016

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 life of the registry, a total of 28 hospitals reported higher than expected rates of revision for knee replacement and 41 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 twelve hospitals reporting higher than expected rates for knees, and five for hips.

The 90-day mortality for hip and knee replacement was calculated for all hospitals by plotting standardised mortality ratios for each hospital against the expected number of deaths. One hospital (closed in 2013) had a higher than expected mortality rate for knee replacement while none were identified for hip 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 below

In previous annual reports, the NJR has 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 also reports outlying hospitals based on the last five years of data (1 March 2012 to 1 March 2017 inclusive, the latter date being when the dataset was cut). This five year cut of data excludes from the analysis the majority of withdrawn outlier implants, and metal-on-metal total hip replacements, and thus better represents contemporary practice.

Outlier for Hip mortality rates since 2003[1]
None identified

Outlier for Knee mortality rates since 2003[1]
Redwood Diagnostic Treatment Centre [closed in 2013]

Outliers for Hip revision rates, all linked primaries from 2003[1]
Ashtead Hospital (Surrey)
Basingstoke and North Hampshire Hospital
BMI Esperance (East Sussex)
BMI Gisburne Park Hospital (Lancashire)
BMI Sarum Road Hospital (Hampshire)
BMI The Somerfield Hospital (Kent)
Clifton Park Hospital (North Yorkshire)
Dunedin Hospital (Berkshire)
Homerton University Hospital
Llandough Hospital
Maidstone District General Hospital
Medway Maritime Hospital
Musgrove Park Hospital
Nevill Hall Hospital
New Hall Hospital (Wiltshire)
North Downs Hospital (Surrey)
North Tyneside General Hospital
Northampton General Hospital (Acute)
Nuffield Health Brighton Hospital (East Sussex)
Nuffield Health Haywards Heath Hospital (West Sussex)
Nuffield Health Tees Hospital (Cleveland)
Nuffield Health Wessex Hospital (Hampshire)
Nuffield Health York Hospital (North Yorkshire)
Pilgrim Hospital

Note: 1 Date range 1 April 2003 to 1 March 2017 inclusive. 2 Date range 1 March 2012 to 1 March 2017 inclusive.

Outliers for Hip revision rates, all linked primaries from 2003[1]
Prince Charles Hospital
Rotherham District General Hospital
Royal Cornwall Hospital (Treliske)
Salisbury District Hospital
Shepton Mallet Treatment Centre (Somerset)
Spire Cardiff Hospital (Glamorgan)
Spire Gatwick Park Hospital (Surrey)
Spire Tunbridge Wells Hospital (Kent)
St Albans City Hospital
St Michael's Hospital
Sussex Orthopaedic NHS Treatment Centre
The Royal London Hospital
University Hospital (Coventry)
University Hospital Of Hartlepool
University Hospital Of North Tees
Watford General Hospital
York Hospital

Outliers for Hip revision rates, all linked primaries from 2012[2]
Homerton University Hospital
Southampton General Hospital
St Richard's Hospital
Watford General Hospital
Weston General Hospital

Outliers for Knee revision rates, all linked primaries from 2003[1]
BMI Bishops Wood Hospital (Middlesex)
BMI Goring Hall Hospital (West Sussex)
BMI The Meriden Hospital (West Midlands)
Bradford Royal Infirmary
Cannock Chase Hospital
Charing Cross Hospital
Conquest Hospital
County Hospital Louth
Good Hope Hospital
Hinchingbrooke Hospital
Horton NHS Treatment Centre (Oxfordshire)
Hospital Of St Cross
James Paget University Hospital
King Edward VII Hospital Sister Agnes (Greater London)
Llandough Hospital

Outliers for Knee revision rates, all linked primaries from 2003[1]
New Hall Hospital (Wiltshire)
Peterborough City Hospital
South Tyneside District Hospital
Southampton General Hospital
Southmead Hospital
Spire Alexandra Hospital (Kent)
Spire Clare Park Hospital (Surrey)
Spire Southampton Hospital (Hampshire)
St Albans City Hospital
St Richard's Hospital
University College Hospital
Withybush General Hospital

Outliers for Knee revision rates, all linked primaries from 2012[2]
Ashford Hospital
BMI The London Independent Hospital (Greater London)
BMI The Meriden Hospital (West Midlands)
Broadgreen Hospital
County Hospital Louth
Ealing Hospital
King Edward VII Hospital Sister Agnes (Greater London)
North East London NHS Treatment Centre (Essex)
Spire Southampton Hospital (Hampshire)
St Richard's Hospital
University College Hospital
West Cumberland Hospital

4.4 Better than expected performance

This year we have also listed hospitals where revision rates are statistically better than expected. These are units that lie below the 99.8% control limit.

Better than expected for Hip revision rates, all linked primaries from 2003[1]
Addenbrooke's Hospital
Alexandra Hospital
Bedford Hospital South Wing
Bishop Auckland Hospital
BMI Mount Alvernia Hospital (Surrey)

Note: 1 Date range 1 April 2003 to 1 March 2017 inclusive. 2 Date range 1 March 2012 to 1 March 2017 inclusive.

Better than expected for Hip revision rates, all linked primaries from 2003[1]
BMI Sandringham Hospital (Norfolk)
BMI The Edgbaston Hospital (West Midlands)
Chapel Allerton Hospital
Claremont Hospital (South Yorkshire)
Emersons Green NHS Treatment Centre (Avon)
Euxton Hall Hospital (Lancashire)
Glenfield Hospital [closed 2012]
Goole and District Hospital (Acute)
Harrogate District Hospital
Hereford County Hospital
Ipswich Hospital
Kidderminster Treatment Centre
Leicester General Hospital
London Road Community Hospital [closed 2009]
New Cross Hospital
Northern General Hospital
Nottingham Woodthorpe Hospital (Nottinghamshire)
Nuffield Health Brentwood Hospital (Essex)
Nuffield Health Cambridge Hospital (Cambridgeshire)
Nuffield Health Derby Hospital (Derbyshire)
Nuffield Health Exeter Hospital (Devon)
Nuffield Health Hereford Hospital (Herefordshire)
Nuffield Health Ipswich Hospital (Suffolk)
Nuffield Health Leicester Hospital (Leicestershire)
Nuffield Health North Staffordshire Hospital (Stafordshire)
Nuffield Health Wolverhampton Hospital (West Midlands)
Prince Philip Hospital
Princess Alexandra Hospital
Queen Alexandra Hospital
Queens Hospital Burton Upon Trent
Queens Medical Centre Nottingham University Hospital
Royal Derby Hospital
Royal Devon & Exeter Hospital (Wonford)
Royal Hospital at Haslar Treatment Centre [closed 2012]
Royal Stoke University Hospital
Royal Surrey County Hospital
Russells Hall Hospital
Spire Parkway Hospital (West Midlands)
Spire Portsmouth Hospital (Hampshire)
St Mary's Hospital

Better than expected for Hip revision rates, all linked primaries from 2003[1]
The Cheshire and Merseyside NHS Treatment Centre [closed 2011]
The Great Western Hospital
The Princess Royal Hospital
West Suffolk Hospital
Wrightington Hospital

Better than expected for Hip revision rates, all linked primaries from 2012[2]
Addenbrooke's Hospital
Calderdale Royal Hospital
Ipswich Hospital
Royal Devon & Exeter Hospital (Wonford)
Royal Surrey County Hospital

Better than expected for Knee revision rates, all linked primaries from 2003[1]
Bishop Auckland Hospital
Blackpool Victoria Hospital
BMI Beardwood Private Hospital (Lancashire)
BMI Huddersfield (West Yorkshire)
BMI Three Shires Hospital (Northamptonshire)
Bronglais General Hospital
Chapel Allerton Hospital
City Hospital
Clifton Park Hospital (North Yorkshire)
Darlington Memorial Hospital
Glenfield Hospital [closed 2012]
Ipswich Hospital
London Road Community Hospital [closed 2009]
New Cross Hospital
Nuffield Health Derby Hospital (Derbyshire)
Nuffield Health Ipswich Hospital (Suffolk)
Nuffield Health Leeds Hospital (West Yorkshire)
Nuffield Health York Hospital (North Yorkshire)
Princess Alexandra Hospital
Queen Elizabeth Hospital Woolwich
Queens Hospital Burton Upon Trent
Rivers Hospital (Hertfordshire)
Royal Bournemouth Hospital
Royal Derby Hospital
Royal Orthopaedic Hospital

Note: 1 Date range 1 April 2003 to 1 March 2017 inclusive. 2 Date range 1 March 2012 to 1 March 2017 inclusive.

Better than expected for Knee revision rates, all linked primaries from 2003[1]
Royal Stoke University Hospital
Russells Hall Hospital
Sandwell General Hospital
Spire Hartswood Hospital (Essex)
St Woolos Hospital
Stepping Hill Hospital
Wansbeck Hospital
Worcestershire Royal Hospital
Wrightington Hospital

Better than expected for Knee revision rates, all linked primaries from 2012[2]
Bishop Auckland Hospital
Burnley General Hospital
Calderdale Royal Hospital
New Cross Hospital
North Tyneside General Hospital
Princess Alexandra Hospital
Queens Hospital Burton Upon Trent
Royal Derby Hospital

Note: 1 Date range 1 April 2003 to 1 March 2017 inclusive. 2 Date range 1 March 2012 to 1 March 2017 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 Healthcare 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 indentified 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 during a single operation.
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.

Compliance 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)	Used instead of Kaplan-Meier to estimate the cumulative probability of 'failure' in the presence of a 'competing risk(s)'. A competing risk event can prevent the event of interest from occurring; 'death' for example is a 'competing risk' for revision because once unrevised patients die they can no longer experience revision. Instead of 'censoring' for death (which technically assumes that such patients might still be at risk of revision but that no further information is available), cumulative incidence functions make appropriate adjustment.
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 2016 and 31 March report analysis 2017 – the 2016/17 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 2016 inclusive – the 2016 calendar year. The NJR Annual Report Part Three reports on hip, knee, ankle and shoulder joint replacement revision rates for procedures that took place between 1 April 2003 and 31 December 2016.
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	
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). 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.
Glenoid head	Domed head portion of the glenoid component of the reverse shoulder replacement attached to the scapula.
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)	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)	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 cup	The shallow socket of a reverse shoulder replacement attached to the scapula.
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. '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 the analysis period (end of 2016) without having been revised. The estimates do not adjust for any confounding factors.

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.
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	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 Surgical Operations and Procedures, 4th Revision – 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'.
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 Demographic 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 total joint replacement operation is performed on any individual joint in a patient.
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.
PROMs	Patient Reported Outcome Measures.

PTIR	Patient-Time Incidence Rate. The total number of events (e.g. first revisions) divided by the total of the lengths of times the patients were at risk (see 'patient-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 remove (and usually replace) one or more components of a total joint prosthesis for whatever reason.
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 embolus 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.

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.

The NJR shall have no liability (including but not limited to liability by reason of negligence) for any loss, damage, cost or expense incurred or arising by reason of any person using or relying on the data within this report and whether caused by reason of any error, omission or misrepresentation in the report or otherwise. This report is not to be taken as advice. Third parties using or relying on the data in this report do so at their own risk and will be responsible for making their own assessment and should verify all relevant representations, statements and information with their own professional advisers.

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' Information Governance 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, the Patient Episode Database Wales (PEDW), data from the NHS England Patient Reported Outcomes Measures (PROMs) programme, and data from the Office of National Statistics. 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 Agency 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 whose processing of the data is also subject to strict guidelines set out in an approved System Level Security Policy. 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 work is based on aggregated data, rather than individual record level data. This means that no patient could be identified.

NJR Centre contact details

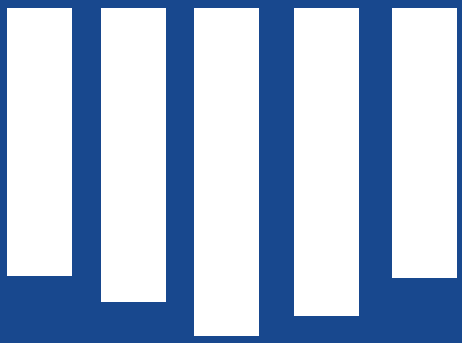
National Joint Registry
based at Northgate Public Services (UK) Ltd
Peoplebuilding 2
Peoplebuilding Estate
Maylands Avenue
Hemel Hempstead
Hertfordshire
HP2 4NW

Telephone: 0845 345 9991
Fax: 0845 345 9992

Email: **enquiries@njrcentre.org.uk**
Website: **www.njrcentre.org.uk**

Produced by Pad Creative Ltd www.padcreative.co.uk

www.njrcentre.org.uk
www.njrreports.org.uk



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.

/nationaljointregistry @jointregistry