

Osteoarthritis and Cartilage



No exponential rise in revision knee replacement surgery over the past 15 years: an analysis from the National Joint Registry



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SUMMARY

Objective: To investigate trends in the incidence rate and the main indication for revision knee replacement (rKR) over the past 15 years in the UK.

Method: Repeated national cross-sectional study from 2006 to 2020 using data from the National Joint Registry (NJR). Crude incidence rates were calculated using population statistics from the Office for National Statistics.

Results: Annual total counts of rKR increased from 2,743 procedures in 2006 to 6,819 procedures in 2019 (149% increase). The incidence rate of rKR increased from 6.3 per 100,000 adults in 2006 (95% CI 6.1 to 6.5) to 14 per 100,000 adults in 2019 (95% CI 14 to 14) (122% increase). Annual increases in the incidence rate of rKR became smaller over the study period. There was a 43.6% reduction in total rKR procedures in 2020 (during the Covid-19 pandemic) compared to 2019. Aseptic loosening was the most frequent indication for rKR overall (20.7% procedures). rKR for aseptic loosening peaked in 2012 and subsequently decreased. rKR for infection increased incrementally over the study period to become the most frequent indication in 2019 (2.7 per 100,000 adults [95% CI 2.6 to 2.9]). Infection accounted for 17.1% first linked rKR, 36.5% second linked rKR and 49.4% third or more linked rKR from 2014 to 2019.

Conclusions: Recent trends suggest slowing of the rate of increase in the incidence of rKR. Infection is now the most common indication for rKR, following recent decreases in rKR for aseptic loosening. Infection was prevalent in re-revision KR procedures.

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Introduction

Knee replacement (KR) is one of the most common elective orthopaedic procedures and, for most patients, results in large improvements in joint function and health-related quality of life¹. Over the past decade, leading up to the Covid-19 pandemic, national joint replacement registers have reported increasing volumes of primary knee replacement (pKR) procedures each year^{2–4}. It has been

suggested that these increases reflect ageing patient populations with a greater prevalence of osteoarthritis⁵ and increases in the demand for surgery from younger patients⁶. In turn, several studies have predicted that the volume of primary joint replacement procedures is set to rise further over the coming decades^{7–10}.

For the majority of patients, it is likely that revision surgery will never be required^{11,12}. However, a greater prevalence of primary joint replacement, coupled with increases in life expectancy¹³ and use of implants in patients who place the greatest demands on them (for example, young patients^{6,14} and those with obesity) have created expectations for a sharp rise in the requirement for revision surgery⁷. On the other hand, there is recent evidence to suggest that, in some countries, increases in the incidence of pKR and revision knee replacement (rKR) may be slowing down, rather than speeding up¹⁵.

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Table 1

Annual totals and incidence rates of rKR

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Annual totals of rKR procedures															
All rKR	2,743	3,776	4,254	4,667	5,142	5,269	5,994	5,646	6,142	6,371	6,552	6,623	6,559	6,819	3,843
No linked primary	2,621	3,187	3,111	2,987	3,017	2,958	2,964	2,684	2,709	2,553	2,442	2,274	2,001	1,958	1,084
First linked rKR	118	553	1,059	1,568	1,957	2,100	2,715	2,608	2,985	3,315	3,541	3,783	3,926	4,208	2,303
Second linked rKR	4	29	77	99	148	186	276	307	378	409	446	442	499	503	356
Third or more linked rKR	0	7	7	13	20	25	39	47	70	94	123	124	133	150	100
Incidence rates of rKR															
Crude incidence rate per 100,000 adults	6.3 (6.1–6.5)	8.6 (8.3–8.9)	9.6 (9.3–9.9)	10.4 (10.1–10.7)	11.4 (11.1–11.7)	11.6 (11.2–11.7)	13.1 (12.7–11.9)	12.2 (11.9–12.5)	13.2 (12.9–12.5)	13.6 (13.2–13.5)	13.8 (13.5–13.9)	13.9 (13.6–14.2)	13.7 (13.3–14)	14.1 (13.8–14.5)	7.9 (7.7–8.2)
Age-specific incidence rate per 100,000 persons															
18–49 years	0.4 (0.3–0.5)	0.6 (0.5–0.7)	0.6 (0.5–0.7)	0.9 (0.8–1)	1 (0.9–1.1)	0.8 (0.7–0.9)	1 (0.9–1.2)	0.9 (0.8–1)	1 (0.8–1.1)	0.9 (0.8–1.1)	0.9 (0.8–1)	0.9 (0.8–1)	0.8 (0.7–0.9)	0.7 (0.6–0.8)	0.4 (0.4–0.5)
50–59 years	5.5 (4.9–6.1)	7.4 (6.8–8.1)	9.7 (9–10.5)	10.8 (10.1–11.7)	11.6 (10.8–12.5)	11.7 (10.9–12.6)	14.8 (13.9–15.7)	13.1 (12.3–14)	13.3 (12.5–14.2)	13.1 (12.3–13.9)	13.2 (12.4–14)	12.8 (12.1–13.7)	11.4 (10.7–12.1)	12.3 (11.5–13.1)	6.2 (5.7–6.7)
60–69 years	16.6 (15.5–17.8)	23.7 (22.4–25)	24.1 (22.8–25.4)	25.8 (24.6–27.2)	27.8 (26.5–29.2)	28.1 (26.8–29.4)	31.8 (30.4–33.3)	29.2 (27.8–30.5)	30.7 (29.4–32.1)	31.5 (30.2–32.9)	31.6 (30.2–33)	32.1 (30.7–33.5)	32.3 (30.9–33.7)	32.2 (30.8–33.6)	16.6 (15.6–17.6)
70–79 years	26.1 (24.5–27.8)	34.9 (33.1–36.9)	39.4 (37.4–41.4)	40.8 (38.8–42.8)	44.8 (42.7–46.9)	46.7 (44.6–48.9)	48 (45.8–50.2)	44.8 (42.7–46.9)	50.5 (48.3–52.7)	50.9 (48.8–53.1)	52 (49.9–54.2)	50.9 (48.8–53.1)	48.8 (46.9–50.9)	50.1 (48.2–52.2)	28.5 (27.1–30)
80+ years	19.1 (17.3–21.1)	23.9 (21.9–26.1)	27 (24.9–29.3)	28 (25.9–30.3)	29.7 (27.5–32)	29.8 (27.6–32)	33.4 (31.2–35.8)	34 (31.7–36.3)	35 (32.8–37.4)	38.1 (35.8–40.6)	38.7 (36.3–41.1)	39 (36.7–41.5)	40.4 (38–42.9)	41.1 (38.8–43.6)	26.2 (24.3–28.2)

In the UK, count data for annual numbers of primary (pKR) and rKR procedures are regularly published by the National Joint Registry (NJR) for England, Wales, Northern Ireland, the Isle of Man and the States of Guernsey¹⁶. These data appear to show a degree of 'levelling off' of increases in both pKR and rKR. However, whilst these data are useful for resource planning - for example, to understand the operative workload nationally - without a reference to the size and structure of the underlying population, further inferences are limited. For example, these data do not help us to understand whether increases in joint replacement activity simply reflect growth in population size, ageing of the population, a 'true' increase in the rate of intervention or a combination of these possibilities. Furthermore, count data and crude incidence rates limit the ability to compare between different countries and regions. Whilst several studies have described international variation in the intervention rate for joint replacement^{15,17}, the failure to standardise for differences in population structure limits interpretation beyond the sample population.

Following on from this, it is evident that comparatively little is understood about the epidemiology of re-revision KR (that is second or subsequent revision procedures), despite their considerable impact on individual patients and their potential to consume large amounts of health resource¹⁸. A recent multi-registry study from Australia, Sweden and the United States found that the proportion of rKR performed for infection had increased in recent years¹⁹, with one hypothesis that an increase in the rate of re-revision KR may be responsible.

The main purpose of our study was to investigate longer-term trends in the incidence rate and the main indication for rKR over the past 15 years in the UK. A secondary aim was to investigate the effect of the Covid-19 pandemic on rKR activity in 2020.

Patients and methods

This study is reported according to the RECORD checklist²⁰. Ethical approval was obtained from the London-Bromley Research Ethics Committee (20/LO/0428) and data access approvals were obtained from the NJR. Data for patients who chose not to consent to the NJR audit were not included.

Study dataset

The NJR is a prospective register of primary and revision joint replacement procedures in England, Wales, Northern Ireland, the Isle of Man and the States of Guernsey. Data collection started in 2003 and the submission of records to the NJR is mandatory for both National Health Service (NHS) and independent centres within its geographic remit. Records are submitted to the NJR using Minimum Data Set (MDS) forms that specify the procedures to be recorded. Each form is specific to a particular joint (e.g., knee) and broad category of procedure (e.g., primary or revision). For example, data for rKR are collected on K2 forms and include patient demographics, operation details and surgeon details. Surgeons are guided on the types of procedure that should be reported to the NJR by several sources, including the publication "*Operations included in the NJR*"²¹; a list of procedures displayed on MDS K2 forms²²; and a definition of revision joint replacement provided in the glossary of each NJR annual report. The NJR 1st annual report defined revision joint replacement as any "operation performed to remove and replace one or more components of a total joint prosthesis, for whatever reason"²³. Since then, a number of amendments have been issued including instructions to report: (1) secondary patella resurfacing procedures (from 01/12/2013) and (2) Debridement, Antibiotics and Implant Retention (DAIR) procedures with or

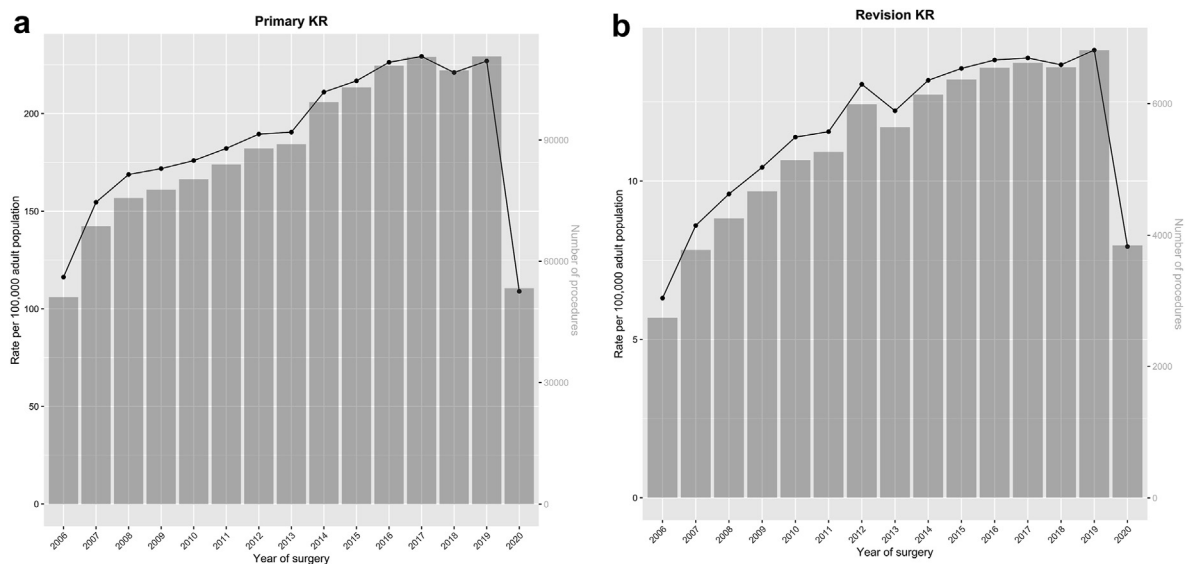


Fig. 1

Osteoarthritis and Cartilage

Annual crude incidence rates (line, left y-axis) and total counts (bars, right y-axis) of (a) pKR and (b) rKR from 2006 to 2020. Note the differences in y-axis scales for pKR and rKR. Note that arthroplasty services were severely disrupted by the COVID-19 pandemic in 2020.

without modular exchange (from 25/06/2018). Further information on all amendments can be found at the sources listed above.

Timeframe

Data from 1st January 2006 to 31st December 2020 were included. We excluded data from the first 3 years of the NJR (2003–2005) which were known to have the lowest rates of registry compliance^{24,25}. We also excluded data from 2021 because: (1) our NJR data extract was created on 3rd February 2022, which provided only a short opportunity for late submission of data; and (2) population statistics from the Office for National Statistics (ONS) were not available. We hypothesized that data from 2020 were unlikely to be representative of typical arthroplasty practice due to the disruption in services during Covid-19. As such, to investigate longer term trends in practice, we analysed data from 2006 to 2019 and to investigate the effect of the Covid-19 pandemic, we compared data from 2019 (pre-pandemic) to 2020 (pandemic).

Statistical analysis

Information on data preparation is provided as a supplementary file ([Appendix \(A\)](#)). Patients aged less than 18 years of age were excluded from all analyses.

Trends over time in the incidence rate of rKR

The crude incidence rate of rKR was calculated for each calendar year from 2006 to 2020. In some cases a rKR is planned to be performed as a two-stage procedure: consisting of two distinct operations on different days. For a given patient, we considered first- and second-stage rKR procedures to be a single procedure when they met the following criteria: the NJR K2 form indicated the intention to treat the patient in stages and a second-stage procedure was performed within 365 days of the first-

stage procedure. The year of surgery was taken from the date of the first-stage procedure. To calculate crude incidence rates, we used the annual total count of rKR procedures (numerator) and the sum of the mid-year population estimates for adults in England, Wales and Northern Ireland (denominator)³⁴. 95% confidence intervals (CIs) were calculated for these rates using the *phe_rate* function within the *PHEindicatormethods* package in R^{26,27}. We presented crude incidence rates as a line graph overlying bars depicting annual total counts. To calculate the percentage change in the incidence rate over the longer term, we compared the rate in 2019 compared to 2006. To investigate the change in the incidence rate during the Covid-19 pandemic, we compared the rate in 2020 to 2019. In a further analysis, we investigated changes over time in the number of rKR procedures linked to a pKR on the NJR. This was presented using stacked bars depicting annual total counts of *linked* and *not linked* procedures. Due to the large proportion of rKR not linked to a pKR and large changes in this proportion over time, we did not consider it appropriate to present incidence rates for rKR stratified into first- and subsequent rKR procedures.

We used the methodology above to calculate total counts and crude incidence rates for pKR and have presented these for reference. It is important to highlight that the incidence rate of rKR within a given year has little relationship to the incidence rate of pKR in that year (because very few pKR fail within 1 year). The incidence rate of rKR has a more direct relationship to the prevalence of (primary and revision) KR in the population. We did not consider it appropriate to estimate the prevalence of KR given the relatively short existence of the NJR and the longevity of KR implants.

As a supplementary analysis, we used the methodology described in [Appendix \(B\)](#) to create directly standardised rates (DSRs) for pKR and rKR. These allow better comparison of populations with different age-structures.

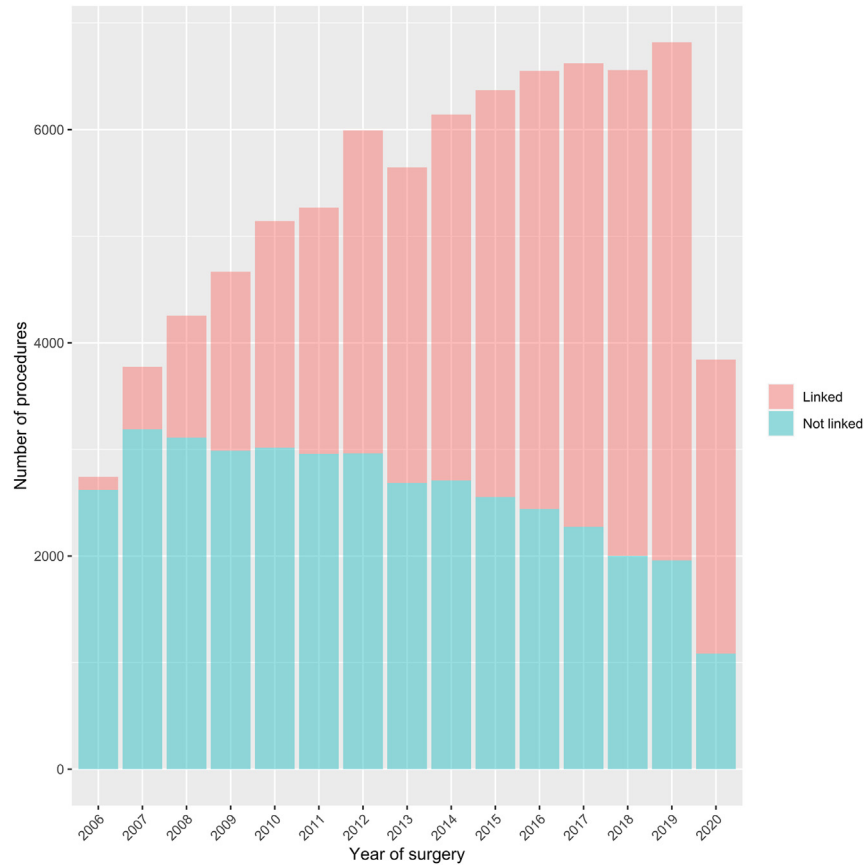


Fig. 2

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Annual total counts of rKR demonstrating the number linked and not linked to a pKR. Note that arthroplasty services were severely disrupted by the COVID-19 pandemic in 2020.

Trends over time in the incidence rate of rKR by patient age

To investigate trends over time in the incidence rate of rKR according to patient age, we stratified the study population into the following groups: 18–49 years/50–59 years/60–69 years/70–79 years/80+ years. Crude incidence rates per 100,000 persons were calculated for each group for each year of analysis and presented graphically.

Trends in the main indication for rKR

Each rKR procedure was assigned a single, dominant diagnosis based on the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) hierarchical model²⁸ [Appendix (C)]. We combined data from 2006 to 2019 to calculate the percentage frequency of each revision diagnosis.

To investigate trends over time in the main indication for revision surgery, we calculated crude incidence rates per 100,000 adults for each diagnosis for each year of the dataset for all rKR procedures and presented these using grouped barplots. As a supplementary analysis, we calculated the annual percentage frequency of each revision diagnosis.

We then investigated the percentage frequency of each revision diagnosis within first- and subsequent rKR procedures and procedures that could not be linked to a pKR. We hypothesized that this analysis may be vulnerable to the maturity of the registry. To

provide some mitigation against this, we restricted the analysis to the 5 years prior to the COVID-19 pandemic (2014–2019). We defined the following groups (after combining staged procedures, if appropriate): *first linked rKR* (the earliest revision procedure for a given patient-side linked to a pKR on the NJR); *second linked rKR* (the next revision procedure for a given patient-side linked to a first linked rKR); *third or more linked rKR* (subsequent revision procedure(s) linked to a second linked rKR); and *no linked primary* (revision procedure(s) not linked to a primary procedure).

Software

Statistical analyses were performed using R version 4.1.2.

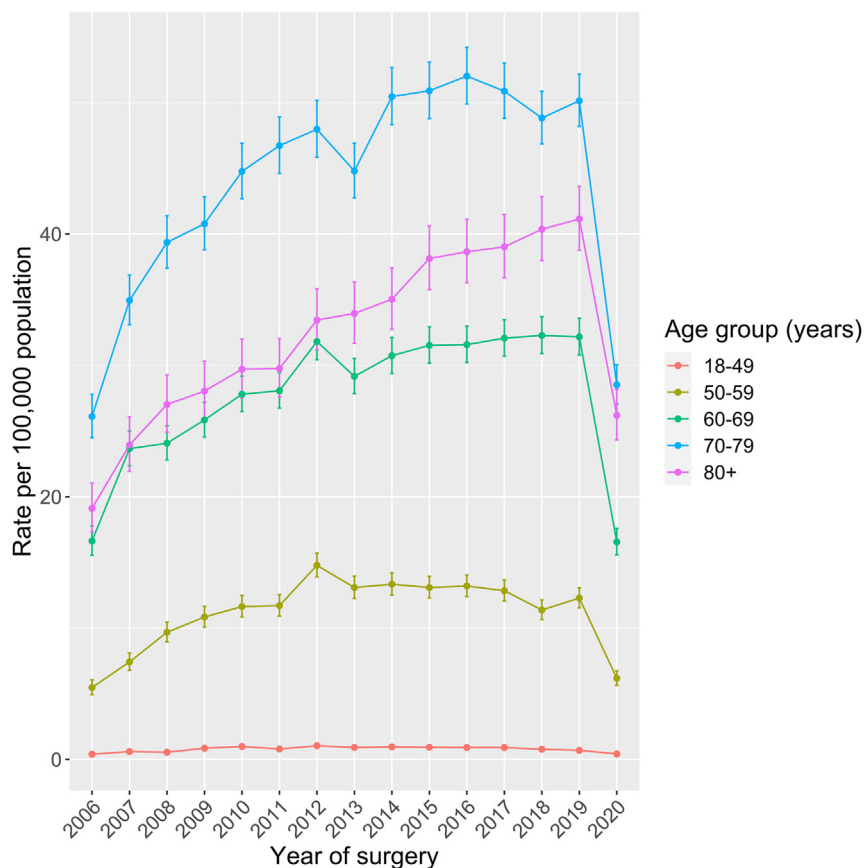
Results

Data cleaning and linkage

A flowchart to illustrate attrition of study records during data cleaning is provided in Fig. 6.

Trends over time in the incidence rate of rKR

The annual totals of rKR procedures submitted to the NJR and the crude incidence rates are presented in Table 1 and Fig. 1. Annual totals of rKR procedures increased year-on-year from 2006 to 2019,

**Fig. 3**

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Annual incidence rates of first linked rKR from 2006 to 2020 by age group. Note that arthroplasty services were severely disrupted by the Covid-19 pandemic in 2020.

with the exception of 2013 and 2018. There were 2,743 rKRs reported to the NJR in 2006, compared to 6,819 rKRs in 2019. The incidence rate of rKR increased from 6.3 per 100,000 adults in 2006 (95% CI 6.1 to 6.5) to 14 per 100,000 adults in 2019 (95% CI 14 to 14). These represented a 149% increase in the total count of rKR and a 124% increase in the incidence rate. Annual increases in the incidence rate of rKR became smaller over the study period, indicating a slowing in the rate of increase. The percentage of rKR procedures linked to a pKR on the NJR increased from 4.4% in 2006 to 71.3% in 2019 (with a further increase to 71.8% in 2020) (see Fig. 2).

There were 3,843 rKR procedures reported to the NJR in 2020 (during the Covid-19 pandemic). We calculated an incidence rate of rKR of 7.9 (95% CI 7.7 to 8.2) per 100,000 adults in 2020. This represented a 43.6% reduction in the total count of rKR and a 43.9% reduction in the incidence rate of rKR in 2020.

There were large increases in the incidence rate of pKR over the study period from 116 per 100,000 adults in 2006 (95% CI 115 to 117) to 227 per 100,000 adults in 2019 (95% CI 226 to 228) (Fig. 1).

Trends over time in the incidence rate of rKR by patient age

The incidence of rKR increased for all age groups from 2006 to 2019. The largest increases were seen in the 70–79 year age group,

followed by the 80+ year age group. These two age groups also had the highest incidence rates of rKR among the age groups studied. In 2019, the incidence rate of rKR for patients aged 70–79 years was 50 per 100,000 adults [95% CI 48 to 52]) (Fig. 3).

Trends in the main indication for rKR

For the years 2006–2019 combined, aseptic loosening was the most frequent indication for rKR (20.7%), followed by infection (16%) and then instability (15.3%) (Fig. 5). The incidence of rKR for aseptic loosening peaked in 2012 and subsequently declined (Fig. 4). Meanwhile, the incidence rate of rKR for infection increased nearly every year - from 0.9 per 100,000 adults in 2006 (95% CI 0.8 to 1) to 2.7 per 100,000 adults in 2019 (95% CI 2.6 to 2.9). Infection was the most common indication for rKR in 2019, followed by progressive arthritis (2.5 per 100,000 [95% CI 2.3 to 2.6]), then aseptic loosening (2.3 [95% CI 2.2 to 2.5]). The incidence rates of rKR for instability, periprosthetic fracture, progressive arthritis and stiffness demonstrated nearly year-on-year increases over the study period. However, rKR for unexplained pain and 'other' reasons peaked in 2012 and have since declined.

Changes in the annual proportions of each revision indication are presented as supplementary material [Appendix (D), Fig. 8]. These

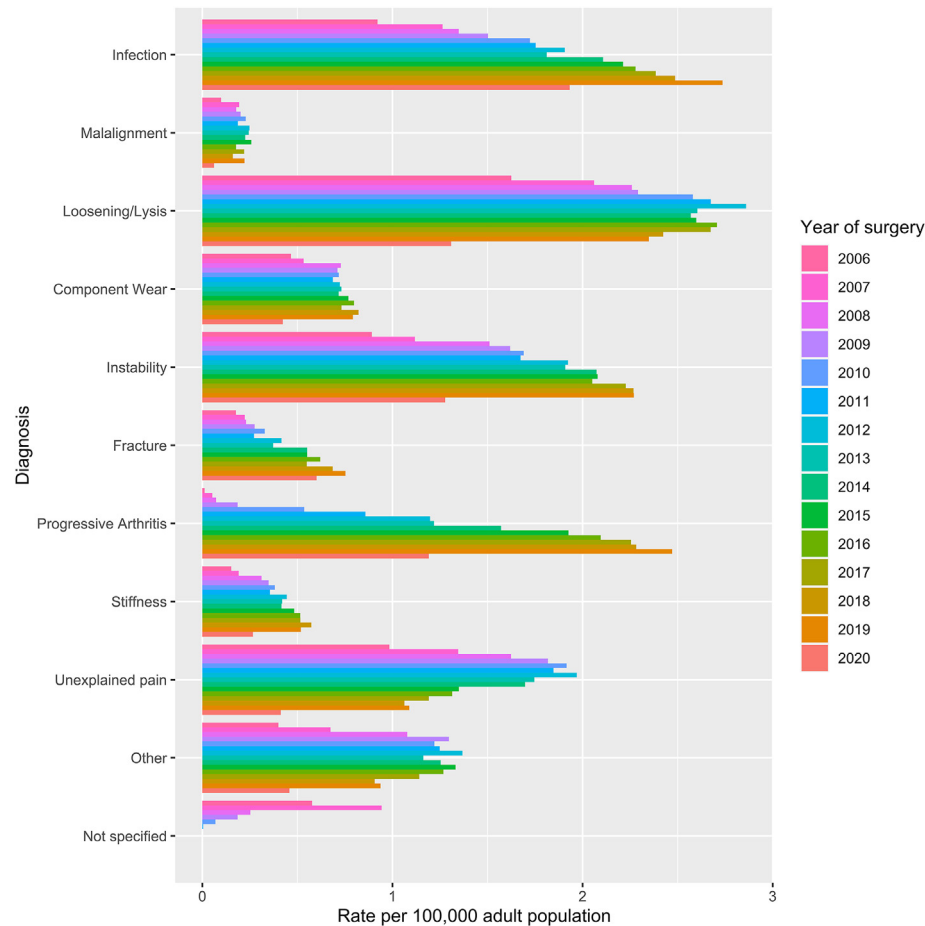


Fig. 4

Osteoarthritis and Cartilage

Grouped barplots demonstrating annual incidence rates for all rKR by indication for surgery from 2006 to 2020. Diagnoses are ranked in hierarchical order (greatest importance at the top). Note that arthroplasty services were severely disrupted by the Covid-19 pandemic in 2020.

data are best interpreted with reference to the total number of rKR in a given year. For example, whilst the *proportion* of rKR for aseptic loosening/lysis was lower in 2019 compared to 2006, the crude incidence rates was higher in 2019 compared to 2006.

For rKR procedures between 2014 and 2019 that could be linked to a pKR, infection was the most frequent diagnosis (Fig. 5). Infection accounted for 17.1% for *first linked rKR* ($n = 3,723/21,758$), 36.5% for *second linked rKR* ($n = 978/2,677$) and 49.4% for *third or more linked rKR* ($n = 343/694$). Aseptic loosening was the most frequent diagnosis (22.4%, $n = 3,115/13,937$) for rKR procedures that could not be linked to a pKR.

Discussion

From 2006 to 2019, annual total counts of rKR increased by 149% and the incidence rate of rKR increased by 124%. While the incidence of rKR is still increasing, the rate of this increase appears to be slowing down rather than increasing exponentially as previously projected^{7,29}. There was a 43.6% reduction in total rKR procedures in 2020 during the Covid-19 pandemic. This is similar to the reduction of ~50% reported for primary joint replacement³⁰. The

percentage of rKR procedures linked to a pKR on the NJR increased from 4.4% in 2006 to 71.3% in 2019.

The highest incidence rates for rKR were in patient groups aged 70 years and older. These older patient groups also experienced the greatest increase in the incidence rate of rKR over the study period. For the years 2006–2019 combined, aseptic loosening was the most frequent indication for rKR (20.7%), followed by infection (16%). However, in recent years, procedures for infection appear to be increasing and those for aseptic loosening reducing. In 2019, infection was the most frequent indication for rKR. For rKR procedures linked to a pKR, infection accounted for 17.1% for *first linked rKR*, 36.5% for *second linked rKR* and 49.4% for *third or more linked rKR*.

Lewis et al.¹⁵ recently reported incidence rates for rKR using registry data from Australia, Sweden and the United States. Their study provides an exemplar for international registry collaboration. Similar to our study, they observed slowing of the rate of increase of rKR procedures over a 15 year period. For the year 2017, they reported an incidence rate of rKR of 19.5 per 100,000 persons in Australia, 9.4 per 100,000 persons in Sweden and 11.8 per 100,000 (insured) persons in the United States (from the

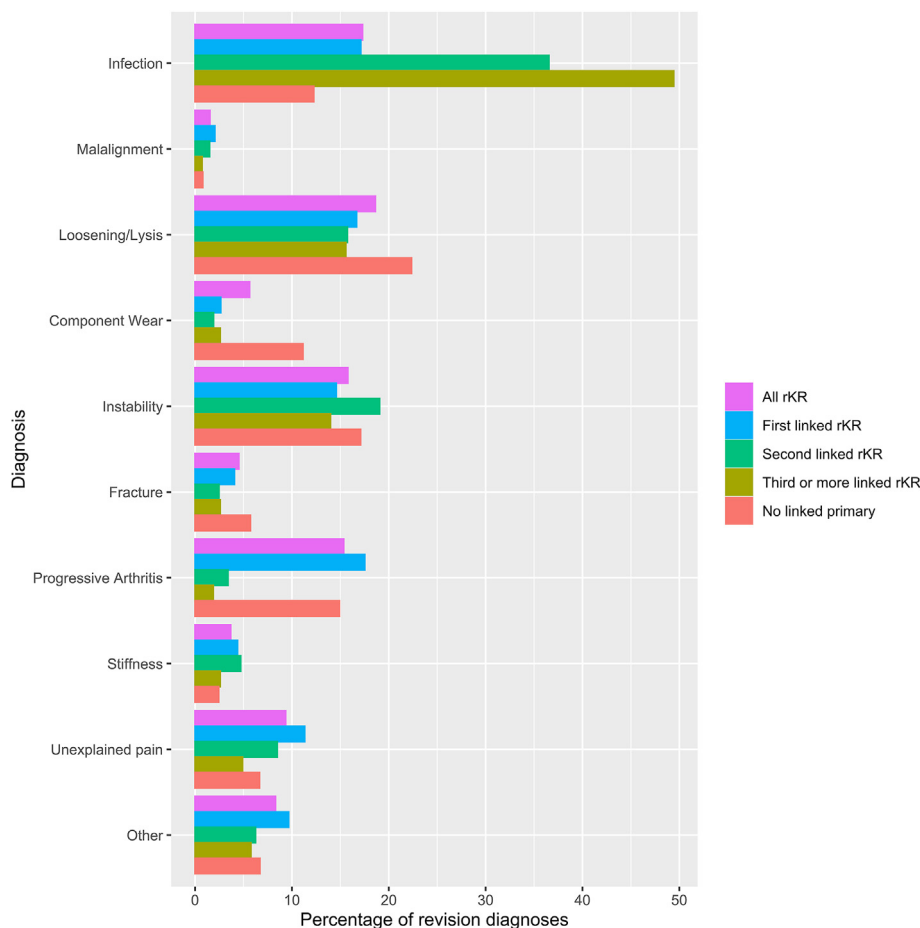


Fig. 5

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Percentage frequency of each revision diagnosis for first-, second- and third or more-linked rKR and unlinked rKR procedures for the period 1st Jan 2014 to 31st December 2019. Diagnoses are ranked in hierarchical order (greatest importance at the top). For a given procedure (e.g., First linked rKR), the sum of all diagnoses is 100%.

Kaiser Permanente Joint Replacement Registry). We have identified a rate of rKR of 14.1 per 100,000 adults in 2019. It is important to note our use of a different denominator, which we believe reflects the population of interest. However, in order to provide closer comparison to the aforementioned study (ignoring differences in population age structures), the incidence rate of rKR in the UK in 2019 was 11.1 per 100,000 total population (i.e., adults and children). More recently, a follow-up study from Lewis *et al.*¹⁹ reported trends in the indications for rKR. They found increases in the proportion of revisions for infection and decreases in the proportion of revisions for wear across the three registries they studied. We observed largely similar trends in the UK. To provide greater interpretation, our study has taken the approach of presenting crude incidence rates, as well as reporting changes in proportions of rKR for each diagnosis over time. We have also explored the indications for re-revision KR procedures, demonstrating the high prevalence of infection.

The data we have presented here should be considered to complement that presented by the NJR in its annual reports. The NJR regularly present count data (i.e., totals) of procedures, which

can be used to understand overall surgical activity. This has useful applications - for example, for workforce planning and budget allocation. Our approach, calculating incidence rates, has shown that increases in annual totals of rKR reflects both an increase in the size of the adult population and an increase in the intervention rate. One of the strengths of this study is its reproducibility and openness. All results are derived directly from the underlying source data and the statistical code used to prepare the data is provided as a supplementary file. We believe that this is the first study using the NJR dataset to take this approach. However, there are a number of limitations to our study that should be noted. It is likely that some of the trends we have described represent changes in reporting practices, rather than operative activity. We have described changes in the definition of rKR over the course of the study, with a greater variety of procedures eligible to be reported in later years (including secondary patella resurfacing and DAIR procedures, for example). We also know that surgeon compliance for reporting of rKR procedures continued to improve over the study period^{16,24,25}. Latest figures from the NJR data quality audit suggested that ~5% of rKR procedures were not

reported to the NJR in 2018/19, and this proportion is expected to shrink further in coming years. We have used a diagnosis hierarchy to classify a single dominant diagnosis for rKR when the NJR allows multiple indications to be specified. We recognise that there is subjectivity in this process, and the hierarchy we have adopted may not reflect the *true* order of importance for all cases. We also wish to highlight a limitation relevant to the interpretation of our analysis of the main indication for *first-linked*, *second-linked*, and *third or more-linked* rKR. This analysis relies on the implicit assumption that linked procedures were representative of *first*, *second*, and *third or more* rKR more generally. Due to the relatively short existence of the NJR, we caution that there may be over-representation of revision diagnoses occurring during ‘early’ follow-up (such as infection) and under-representation of revision diagnoses more likely to occur in ‘late’ follow-up (such as component wear). We have mitigated against this effect to some extent by analysing data only from more recent years (2014–2019), but this question will benefit from re-examination using more mature registry data in the future.

Our study has shown the profound effect of the Covid-19 pandemic on rKR activity. Waiting lists for surgery are currently at record levels³¹ and operative activity will need to increase to treat the backlog of patients. The recent observation that many areas of the UK have struggled to return to pre-pandemic levels of primary joint replacement frames this challenge in stark terms³⁰. It is also important to recognise that, prior to the pandemic, annual increases in rKR activity were slowing. There may be positive reasons for this, such as improvements in the outcome following primary joint replacement³², or greater adoption of evidence-based indications for surgery. The observation that rates of surgery for ‘unexplained pain’ have reduced over time may support this, though it is possible that surgeons have simply changed their coding practices. Another possible explanation for the smaller than expected increase in the rate of rKR is a lag in time between increases in pKR and the need for revision surgery (though it is evident that increases in the incidence of pKR have also slowed). The trends we have observed may indicate difficulties increasing capacity for joint replacement procedures in the NHS, particularly for rKR which may be resource-intensive³³, and this requires further investigation. One important methodological consideration for future studies on the incidence rate of joint replacement is how to handle data generated around the time of the Covid-19 pandemic. In the immediate future, referencing this data is likely to be useful to measure the recovery of surgical provision. For studies investigating clinical outcomes following joint replacement, it will be important to consider whether data generated from procedures performed during the pandemic can be assumed to be representative of usual practice.

In conclusion, in the UK annual total counts of rKR increased by 149% and the incidence rate of rKR increased by 124% between 2006 and 2019. The trends we have observed suggest that, while the incidence of rKR is still increasing, the rate of increase appears to be slowing down rather than increasing exponentially. The provision of rKR reduced by 43.6% in 2020, during the Covid-19 pandemic. The rate of intervention will need to increase to treat the current long waiting lists of patients. The indications for rKR changed over the study period. Infection became the most common indication for rKR in 2019 and was found to be highly prevalent in re-revision KR procedures.

Author contributions

All authors made substantial contributions to the work. CRediT roles:

- SAS: Conceptualisation, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Software, Writing - original draft
- RK: Investigation, Methodology, Software, Supervision, Writing - review & editing
- AA: Investigation, Writing - review & editing
- DWM: Investigation, Writing - review & editing
- SP: Investigation, Methodology, Supervision, Writing - review & editing
- DJB: Conceptualisation, Funding acquisition, Investigation, Methodology, Supervision, Writing - review & editing
- AJP: Conceptualisation, Funding acquisition, Investigation, Methodology, Supervision, Writing - review & editing

Conflict of interest

None.

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Other contributors

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Statement of role of funding source in publication

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Data statement

All data for this study is available through research request to the NJR. Statistical code is provided with the manuscript.

Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.joca.2022.08.016>.

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