Temporal trends in comorbidity in adult elective hip and knee replacement patients in England: A national population-based cohort study from the National Joint Registry

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Keywords

Total hip replacement, knee replacement, comorbidity, cohort study

Declarations

Availability of data and materials

Access to the data analysed in this study required permission from the National Joint Registry for England, Wales and Northern Ireland Research Sub-committee. http://www.njrcentre.org.uk/njrcentre/Research/Researchrequests/tabid/305/Default.aspx contains information on research data access request to the National Joint Registry.

Competing interests

I have read the journal's policy and the authors of this manuscript have the following competing interests: MW (Stryker, Heraeus, DePuy), AB (Stryker) and JMW (Amgen) have received research and other financial support from companies or suppliers outside the submitted work. AJ declares advisory board positions with receipt of fees (Anthera Pharmaceuticals, INC.) and paid consultancy work (Freshfields Bruckhaus Deringer) for companies outside the submitted work. MRW (Hip International) and JMW (Bone and Joint Research, Journal of Orthopaedic Research) declare journal editorial positions. JMW is a board member for the British Orthopaedic Research Society. All other authors declare no competing interests.

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Authors' contributions

CP, AS, AB, AJ and MW designed the study. CP, AB, AS, JMW, AJ and MW reviewed the published work. CP conducted the statistical analysis and wrote the report. All contributors reviewed and agreed the final version before submission. CP had full access to all the data and AS is the guarantor.

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Abstract

Aims

Our main aim was to describe the trend in the comorbidities of patients undergoing elective THRs and KRs between 2005 and 2018 in England.

Patients and Methods

We combined data from the National Joint Registry (NJR) on primary elective hip and knee replacements performed between 2005-2018 with pre-existing conditions recorded at the time of their primary operation from Hospital Episodes Statistics. We described the temporal trend in the number of comorbidities identified using the Charlson comorbidity index, and how this varied by age, gender, ASA grade, index of multiple deprivation and type of KR.

Results

We included 696,504 and 833,745 elective primary THRs and KRs respectively, performed for any indication. Between 2005 and 2018 the proportion of elective THR and KR patients with ≥1 comorbidities at the time of their operation increased substantially (THR: 20% to 38%, KR: 22% to 41%). This was driven by increases in four conditions: COPD (2018: 16-17%), diabetes without complications (2018: THR 10%, KR 14%), myocardial infarction (2018: 4%), and renal disease (2018: 7-8%). Notably, renal disease prevalence increased from <1% in 2005 to 7-8% in 2018.

Conclusion

Between 2005 and 2018 there were significant changes in the number of comorbidities recorded in patients having elective primary THRs and KRs. Renal disease is now one of the most prevalent comorbidities in this patient population. Future research should explore whether this comorbidity trend has increased the burden on other medical specialities to optimise these patients before surgery and to provide additional aftercare.

Introduction

Elective knee (KR) and total hip (THR) replacements for osteoarthritis of the hip and knee joints are amongst the most commonly performed elective operations with over 200,000 performed in 2019 in the UK [1]. They are highly successful procedures with a typical 10-year revision rates of <5% [1] and postoperative mortality is very rare [2,3].

According to the National Institute for health and Care Excellence the presence of comorbidities (pre-existing health conditions that coexist with an index disease) should not be a barrier to referral for joint replacement surgery [4]. However, patients with end-stage osteoarthritis and comorbidities have longer waiting times until surgery [5] and have more severe joint problems at the time of their surgery compared with patients with fewer or no comorbidities [6]. The presence of comorbidities is associated with more complex clinical management of joint replacement patients and worse health outcomes [7,8]. It is a predictor of perioperative and in-hospital mortality [9], and a risk factor for 90-day postoperative mortality [10,11]. Several comorbidities have been associated with increased risk for early revision after THR and KR, including chronic pulmonary disease, renal disease, and rheumatologic disease [12–14].

Despite the importance of comorbidities for the outcomes of joint replacement surgery only one study has described the temporal trend in comorbidity burden among THR patients in the UK [15]. No studies have compared trends between THR and KR patients in the UK or explored how the comorbidity burden of patients varies by demographic factors.

The aims of this study are:

1. To describe how the burden of comorbidity in patients receiving an elective hip or knee replacement has changed over time between 2005 and 2018
2. To describe how the trend in the burden of comorbidity varies by demographic factors
3. To identify which comorbidities have changed over this time-period

Patients and Methods

Data Source

The NJR, established in 2003, includes >2.5 million primary THRs and KRs in patients aged >18 years performed in public and private hospitals in England, Wales, Northern Ireland, the Isle of Man and the States of Guernsey [1]. Data are collected at the time of surgery on prosthesis and operative information, and patient information. We linked these records to Hospital Episodes Statistics (HES)

data at the time of their primary operation. For people who had more than one primary joint replacement we linked separate HES records for each operation.

Ethics approval and consent to participate

Patient consent was obtained for data collection by the NJR. According to the specifications of the NHS Health Research Authority, separate informed consent and ethical approval were not required for the present study.

Study sample

We included patients who received a primary elective THR or KR for any indication between 1st January 2005 and 31st December 2018. We included primary operations that could be linked to HES records. Privately funded operations were not included since these are not recorded in HES and hence comorbidity indices could not be derived. NHS funded patients treated in the private sector are included. Linkage excluded operations not performed in England, since HES data collection only covers England. We excluded people who had not given consent for recording of personal details for research purposes and primary operations performed for trauma (see Figures S1 & S2). We excluded primary hip resurfacings, since these operations are performed in very low numbers and not representative of current practice.

Comorbidities

The two main comorbidity indices relevant to joint replacement surgery are the Elixhauser Index (EHI) [16] and Charlson Comorbidity Index (CCI) [17]. We used the CCI for our main analyses and present EHI trends in our sensitivity analyses to determine whether findings are dependent on the specific comorbidity index used. We used conditions recorded at the time of the primary operation in HES using ICD-10 codes to identify comorbidities from the CCI (full list of codes Table S1) and EHI.

Statistical analyses

We described trends for primary THRs and KRs separately. We further separated KRs into total (TKR), unicompartmental (UKR) and patellofemoral (PFR) KRs (see sensitivity analyses).

We described temporal trends (per year) in:

1. The total number of CCI comorbidities
    a. 0, 1, 2, 3, 4+ comorbidities
2. The number of CCI comorbidities and the five most prevalent comorbidities by:
    a. ASA grade (‘I’, ‘II’, ‘III’, ‘IV & V’, recorded in the NJR)
    b. Patient demographics (recorded in the NJR and HES)
        i. NJR: Age (10-year bands <55 to ≥75), gender

ii. HES: Level of socioeconomic deprivation based on patient's home address using quintiles of the 2004 Index of Multiple Deprivation (IMD)

3. The 17 individual CCI conditions
    a. Grouped according to their CCI weighting to denote the severity of the condition with respect to mortality risk: Low (weight = 1), Moderate (weight = 2, 3), High (weight = 6)

We plotted the trends as line plots with the proportion of each CCI category per year and underlying proportions are reported as tables in the supplementary material. We used R version 4.0 [18], the 'tidyverse' suite of packages [19], the 'comorbidity' package [20], and the ICD10 catalogue from Stata (StataCorp).

Sensitivity analyses

1. We compared trends in ASA grade and patient demographics for our study sample with patients who met our inclusion criteria but for whom we were unable to link to HES
2. KRs can be sub-divided into types of replacements normally performed on younger patients (unicompartmental and patellofemoral knee replacements) [1]. We therefore repeated our description of comorbidity trends for TKRs, UKRs and PFRs separately.
3. We present temporal trends in the count of EHI conditions, another widely used comorbidity index, for THRs and KRs.

Results

We included 696,504 elective primary THRs and 833,745 elective primary KRs performed in England between 2005 and 2018 that could be linked with HES (Table 1, Figures S1 & S2).

Comorbidity burden: 2005

In 2005 80.3% THR and 78.1% KR patients had no recorded comorbidities, 17.0% THR and 18.8% KR patients had one, and 2.7% THR and 3.1% KR patients had ≥2 comorbidities (Figure 1). A higher proportion of older compared with younger THR patients had more comorbidities (<55 years: 14%, ≥75 years: 22%), whereas there was little age difference for KR patients (<55 years: 23%, ≥75 years: 22%; Figures S3 and S4). The proportion of THR and KR patients who had ≥1 comorbidities increased with area deprivation (THR: least deprived 17%, most deprived 23%; KR: least deprived 19%, most deprived 27%) and ASA grade (THR: I 10%, IV/V 54%; KR: I 13%, IV/V 37%), but was very similar for men and women (THR: men 20%, women 19%; KR: men and women 22%).

Trend in comorbidity burden: 2005-2018

Between 2005 and 2018 the proportion of patients with ≥1 comorbidities increased (Figure 1). The main increases were in people with 1-2 comorbidities, increasing from 19% to 35% for THRs, and from 22% to 39% for KRs. The percentage of people with ≥3 comorbidities was small but increased substantially over time (THR: 0.3% to 2.3%, KR: 0.3% to 2.0%).

The comorbidity burden increased for THRs and KRs across all ages, both genders, and across IMD quintiles (Figures S3 and S4). The gap in comorbidity burden increased substantially between younger and older people and increased moderately between people living in less and more deprived areas. In 2018, 48% of THR and KR patients ≥75 years had ≥1 comorbidities, compared with 25% THR and 31% KR patients <55 years old. Thirty-four percent of THR and 37% of KR patients in the least deprived areas had ≥1 comorbidities compared with 44% of THR and 47% of KR patients in the most deprived areas.

In 2005 10% of THR and 13% of KR patients classified as ASA grade I had any comorbidities, which remained unchanged over time. The proportion of patients classified as grade II or III with 1-3 comorbidities increased over time and increased more for grade III than for grade II. The trend for people classified as grade IV/V generally followed a trend towards a higher proportion having more comorbidities.

Trend in specific comorbidities: 2005-2018

In 2018, the five main comorbidities were the same for THR and KR patients (Figure 2): 1) Chronic obstructive pulmonary disease (COPD), 2) diabetes without complications, 3) renal disease, 4) rheumatoid disease, and 5) myocardial infarction (MI). Rheumatoid disease may be an indication for joint replacement surgery rather than a comorbidity for this patient group, and its prevalence remained largely unchanged over time. The substantial increase in prevalence of the other four comorbidities underpins the entire increase in comorbidity burden. Aside from renal disease (moderate CCI weight), these comorbidities have a low weighting and are therefore considered to have only a low impact on a patient's predicted risk of postoperative mortality.

The temporal trends in the four most common comorbidities (excluding rheumatoid disease) were very similar for THR and KR patients (Figures S5 and S6). There was a marked rise in prevalence of myocardial infarction (MI) from 2012 onwards, particularly for older patients and those with high ASA grades. Diabetes prevalence increased with age, IMD and ASA grade, and was higher for men than women. This pattern persisted over time. The prevalence of renal disease did not differ by gender or IMD. There was little difference in prevalence by age or ASA grade in 2005 but prevalence increased over time much more for older patients and those with high ASA grade. The prevalence of

COPD was higher in 2005 for people from more deprived areas, those with higher ASA grades and women compared with men. Prevalence increased more over time with increased deprivation and higher ASA grade but differed minimally by gender. Initial prevalence and trend over time did not differ by age.

Sensitivity analyses

We found slight differences in the demographics and clinical characteristics of patients in the NJR who met our inclusion criteria but without linked HES records compared with those with linked HES records (Table S2). Patients with linked HES records were more obese and had higher ASA grades, although these differences did not remain when restricted to people having publicly funded operations (results not reported).

Our KR study sample consisted of 91.5% TKRs, 7.6% UKRs and 1.0% PFRs (Table S3). Within these KR sub-groups, a temporal trend of increasing comorbidity burden was consistent with that observed for TKRs (Figure S7).

The trend in EHI comorbidities shows a more significant increase in the comorbidity burden for THR and KR patients over time (Figures S8 and S9). The comparable trends towards increasing comorbidity burden defined using either the CCI or the EHI supports our main findings, however differences in the included conditions and the ICD10 codes used in their definitions change the magnitude of the comorbidity trend.

Discussion

Between 2005 and 2018 the proportion of people in England having elective primary THRs and KRs with comorbidities at the time of their operation increased from approximately 20% to 40%. The comorbidity burden increase was larger for older people and people from more deprived areas. The increased comorbidity burden was driven by increases in four conditions: COPD, diabetes without complications, myocardial infarction, and renal disease. The prevalence of renal disease increased from a negligible proportion to become the third most frequently recorded condition. We speculate that the increased comorbidity burden would lead to an increase in demands on other medical specialties to ensure patients are ready for surgery and that they receive appropriate aftercare.

The increase in the comorbidity burden we observed may reflect a true and significant change in the patients receiving publicly funded elective hip and knee replacements. Surgeons may be less risk averse and treating sicker patients or patients with more comorbidities may be filtered away from private provision. Regardless of the cause, this change may have significant implications for the cost

of delivering care due to increased management of comorbid conditions and increased risks of adverse surgical outcomes. The performance and efficiency of NHS Trusts will also be adversely affected by treating patients who require more resources.

However, the increased recording of comorbidities may not reflect an actual increase in their underlying prevalence. Surgeons may be more incentivised than previously to report comorbidities, for example through the Best Practice Tariff (BPT) for hip and knee replacements, introduced in 2014/15 [21]. Additional funding is available to hospitals which meet the BPT criteria. One criterion is having sufficient patients with improvements in Oxford Hip or Knee Score, adjusted for casemix including comorbidities [22]. This change to remuneration arrangements might have increased the recording of comorbidities, but the trend we observed towards more comorbidities is evident throughout our study period, including before the introduction of BPT. We are not aware of any other initiatives which could have incentivised recording of comorbidities above population trends but cannot exclude this as an explanation.

The most comparable previous study, by Partridge et al., describes the comorbidity burden among THR patients 2005-2014 and the prevalence of some conditions in 2005 and 2014 [15]. We found a similar trend in comorbidity burden and prevalence of diabetes. However, we reported a markedly higher prevalence of COPD in 2005 (6% versus 2%) and 2014 (13% versus 4%). This may reflect differences in the codes used to define conditions, particularly COPD, or the use of different versions of the Charlson Index [23] which limits comparisons between studies of prevalence estimates, particularly when underlying code lists are not reported.

Comorbidity trends were consistent between THR and KR patients, including KR sub-types, and between men and women. We found the increasing comorbidity burden was more pronounced for older patients and those with a high ASA grade. We observed widening gaps in the comorbidity burden of older compared with younger patients, and patients from more compared with less deprived areas. These trends may indicate improved access to elective joint replacement surgery for more clinically vulnerable or socioeconomically deprived patients.

The increased comorbidity burden we observed is almost entirely explained by the increased prevalence of four comorbidities: COPD, uncomplicated diabetes, renal disease, and MI. The prevalence of renal disease and COPD were still increasing at the end of our study period. We do not have comparable trends in comorbidities defined using the CCI for the general population or other patient groups. For diabetes, a close comparison is the Health Survey for England (HSE), which records the prevalence of 'doctor-diagnosed diabetes' in adults. The HSE reported an increase from 12% in 2006 to 16% in 2018 in adults aged >65 years old with a diabetes diagnosis [24], slightly higher

than the 6% to 10% increase we found between 2005 and 2018 for diabetes without complications (prevalence of diabetes with complications: <0.5%). The proportion of people with a COPD diagnosis increased between 2004 and 2012 from ~1.6% to ~2% [25], equivalent to a ~50% increase over our longer study period. We found the prevalence of COPD doubled. As discussed previously, direct comparisons between populations of the prevalence of specific conditions can be influenced significantly by how conditions are defined, particularly COPD. The closest population trend to CCI defined 'renal disease' is the prevalence of chronic kidney disease in the UK. This was decreasing 2003-2009 and stabilised between 2009 and 2016 [26], which contrasts with the substantial increase in renal disease prevalence in our study. The eGFR threshold for normal renal function was raised in 2012[27]. This may have led to an increased recording in HES of people with mild kidney disease and an increase in the number of people classified as having CCI defined 'renal disease'. Although the trend towards higher prevalence of renal disease is evident earlier than 2012. The increasing prevalence of obesity, hypertension and diabetes in the general population may further increase the prevalence of renal disease. The trends of renal disease and COPD prevalence in joint replacement patients above the trends of these conditions in the general population suggest that joint replacement surgeons have become more willing to operate on patients with potentially complex comorbidities.

Strengths and weaknesses

The size and completeness of the NJR dataset, and HES linkage are strengths of this study. An NJR audit of procedure recording compliance found high capture rates for primary procedures (95.7%) [28]. Linkage of the NJR with HES data enabled us to derive CCI scores for patients over a 14-year timeframe and could facilitate the identification of other conditions of relevance to joint replacement patients in future. HES linkage is also an important limitation of this study. We could not derive comorbidity scores for patients who funded their operation privately or for those operations performed outside England. Patients who funded their operation privately may have had fewer comorbidities [29], so the trends we observed may relate only to publicly funded patients. We do not know whether all pre-existing conditions are recorded in HES. A comparison of comorbidities recorded through primary care records with those recorded through HES found that primary care records recorded more comorbidity than HES, but this did not adversely affect their models of mortality risk [30]. This suggests that our HES records are likely to be missing comorbidities but these missing comorbidities are unrelated to mortality risk. Some conditions recorded at the time of the primary operation may have been conditions which were not present on admission, i.e. complications [31]. Temporal changes in the diagnostic threshold for diseases (e.g., raising the threshold for normal renal function) may also account for some of the observed trends.

Future research

We do not know whether other medical specialities are under an increased burden due to additional preoperative and postoperative needs of hip and knee replacement patients with comorbidities. However, the comparable rates of perioperative complications in octogenarian compared with younger hip replacement patients, despite having more comorbidities, indicates postoperative needs may not be higher [32]. We have identified four comorbidities which have become much more prevalent in these patients. There may be a need for more personalised care of hip and knee replacement patients with these comorbidities.

Conclusions

Between 2005 and 2018 the comorbidity burden of patients who had elective THRs and KRs in England increased. Other medical specialities may be under increased burden to optimise these patients before their surgery and to provide additional aftercare. The significant increase in prevalence of renal disease is likely to continue and should be monitored closely to ensure no commensurate increase in post-operative complications.

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Figure captions

Figure 1: The proportion of THRs and KRs by number of Charlson comorbidities, 2005 to 2018

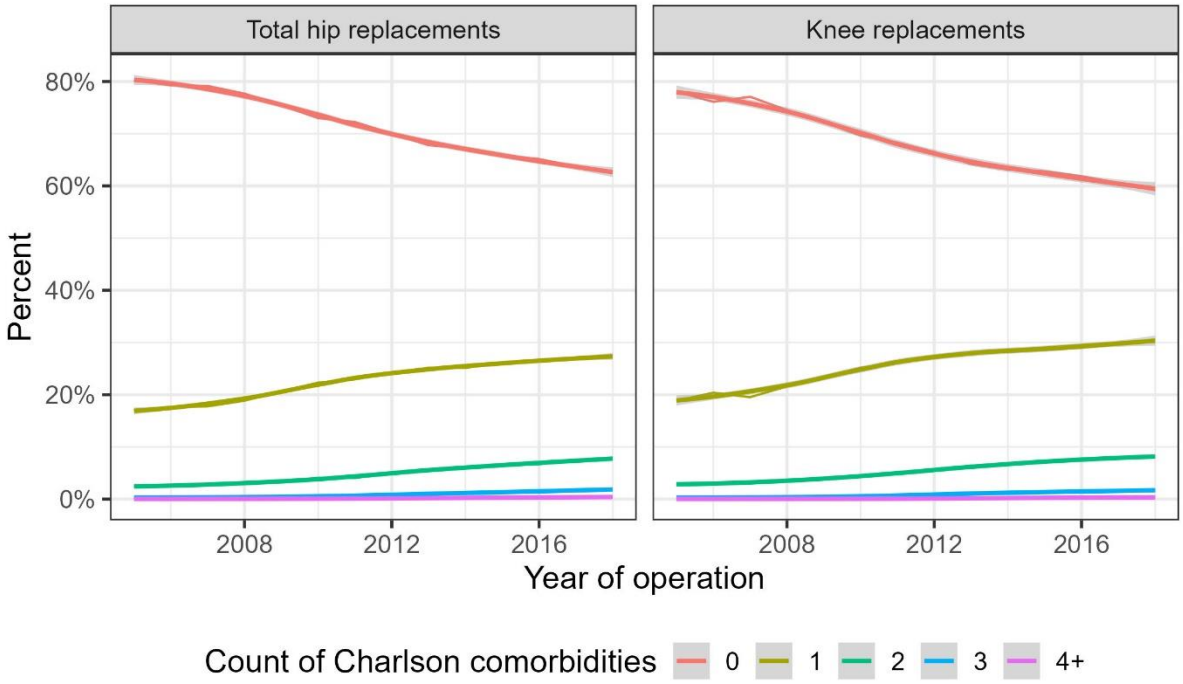

Figure 2: The trend in the proportion of THRs and KRs by CCI condition between 2005 and 2018, grouped by CCI weighting. The five most prevalent conditions for THRs and KRs in 2018 are identified.

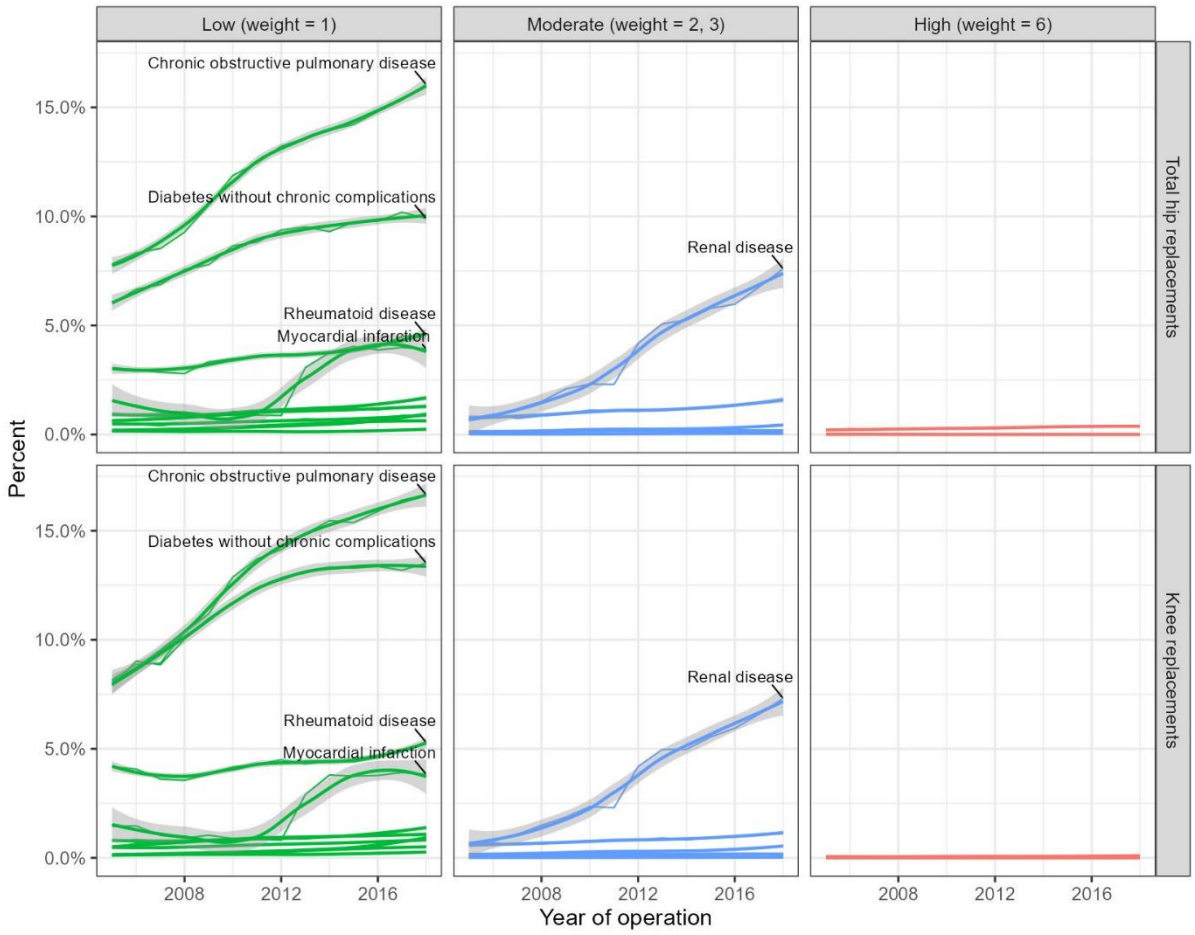

Table 1: A description of the study sample for THRs and KRs

	THRs	KRs
Characteristic	**N = 696,504[1]**	**N = 833,745[1]**
Patient Age at Surgery (years)	70 (62, 76)	70 (63, 76)
Age at operation		
<50 years	76,070 (11%)	61,245 (7.3%)
50-64 years	147,039 (21%)	193,273 (23%)
65-74 years	251,943 (36%)	324,440 (39%)
≥75 years	221,452 (32%)	254,787 (31%)
Gender		
Female	421,648 (61%)	474,969 (57%)
Male	274,856 (39%)	358,776 (43%)
WHO BMI classification		
Underweight	8,012 (1.7%)	2,791 (0.5%)
Normal weight	87,637 (19%)	53,247 (9.6%)
Overweight	183,618 (39%)	189,641 (34%)
Class I obesity	123,317 (26%)	182,552 (33%)
Class II obesity	47,264 (10%)	91,685 (16%)
Class III obesity	15,812 (3.4%)	37,355 (6.7%)
Unknown	230,844	276,474
Quintiles of IMD		
Most deprived	84,945 (12%)	121,002 (15%)
More deprived	117,052 (17%)	151,189 (18%)
Middle	153,384 (22%)	181,601 (22%)
Less deprived	168,835 (25%)	190,154 (23%)
Least deprived	162,428 (24%)	178,738 (22%)
Unknown	9,860	11,061
ASA Grade		
I	93,250 (13%)	83,955 (10%)
II	482,024 (69%)	606,943 (73%)
III	117,380 (17%)	140,045 (17%)
IV +V	3,850 (0.6%)	2,802 (0.3%)

[1]Statistics presented: Median (IQR); n (%)