**The Road to Total Knee Replacement - Utilisation of Knee Surgeries up to 10 Years Before TKR in England and Sweden**

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This study had no financial competing interests.

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**Abstract (249/250 words)**

**Objectives**

To compare the prevalence and timing of knee surgery (including meniscal, ligamentous, synovial and osteotomy) in the ten years prior to primary total knee replacement (TKR) between England and Sweden.

**Methods**

This was a population-based, case-control study within England and southern Sweden using electronic healthcare databases. Cases underwent primary TKR between 2015 and 2019. Risk-set sampling identified general population controls matched 1:1 by age, sex and practice/municipality. The annual prevalence and prevalence ratio (PR) of having at least one recorded surgery in each of the 10 years preceding TKR was estimated using Poisson regressions.

**Results**

We included 6,308 and 47,010 TKR cases in Sweden and England, respectively. Meniscal surgeries were the most frequent procedure prior to TKR in both countries - prevalence was higher in England across all time points. The prevalence of meniscal surgery increased in both countries in the years approaching TKR, reaching 33.2 (95% confidence interval 31.6-34.9) per 1,000 persons in England, and 9.83 (7.66, 12.61) in Sweden. In England, we observed a decrease from 2014 to 2018 in the utilisation of this procedure in the four years preceding a TKR. The prevalence of all analysed surgeries was consistently lower in controls.

**Conclusions**

There are comparable trends in the use of knee surgery in the years preceding TKR across England and Sweden. Of note, meniscal surgeries remain common, even within the year prior to TKR, highlighting that these patients may experience low-value care. Careful consideration of knee surgery in those with late-stage disease is required.

**Significance and Innovation**

* Our comparative study shows that the utilisation of knee surgery rises substantially one to two years prior to a primary total knee replacement (TKR) in both England and Sweden, two high-income countries with publicly funded healthcare systems.
* The trend showing higher utilisation of knee operations when nearing TKR was particularly evident for meniscus surgery which is not recommended for the treatment of people with OA or degenerative change. Stratified analyses showed a larger discrepancy in the prevalence of meniscus surgery between age groups in England with higher prevalence in people aged < 65 suggesting a strong referral pattern.
* We highlighted a period effect signifying a decrease in the utilisation of meniscal surgery in England from 2014 to 2018, exclusively in the two years prior to TKR. Despite this decrease, the trend of increased utilisation in the year preceding TKR is still observable and the prevalence in England is still higher than in Sweden.

**Background**

Primary total knee replacement (TKR) is one of the most common orthopaedic procedures in the world, performed in 95% of cases for end-stage osteoarthritis (OA)(1). In the UK alone, more than 100,000 TKR are performed each year (2). Despite being common, there are no definitive and shared recommendations for the timing at which patients should be considered for TKR, potentially resulting in differences in referral patterns, for instance by geographical area or the preferences of clinicians and patients (3-5). The National Institute for Health & Care Excellence (NICE) in England and the National Board of Health and Welfare (Socialstyrelsen) in Sweden describe a schematic care pathway commencing with a diagnosis of OA, and proceeding through a holistic approach and self-management to core non-surgical treatments (information, exercise, weight loss) and then a wide range of conservative and pharmacological treatments (including adjuncts) along with a referral for consideration of joint surgery (6, 7).

Studies have shown an underutilisation of first-line interventions such as exercise and education in favour of pharmacological and surgical management in the years preceding TKR (8, 9). Nevertheless, the use of arthroscopies in people with knee OA is not recommended due to a lack of evidence supporting its effectiveness in improving symptoms or reducing the rates of subsequent TKR (10, 11). In contrast, multiple studies have shown an increased risk of structural progression and TKR after arthroscopic partial meniscectomy (12-15). In addition, recent reports have suggested that arthroscopies may negatively influence the subsequent joint replacement including higher rates of complication, revision, and periprosthetic joint infection (16, 17). Overall, arthroscopies have a yearly rate of progression to TKR of 2.6%, with this figure nearly doubling in cohorts aged ≥65 years or in those with more severe OA (18). Considering this, the proportion of patients undergoing knee arthroplasty within a year of knee arthroscopy has previously been proposed as an indicator of potential overuse of knee arthroscopy in patients with OA (10). Thus, in light of the lack of shared decision rules guiding TKR referrals and evidence supporting the use of arthroscopies, more information regarding the management of people with OA is strongly needed. International comparative studies offer precious insights into how patients are managed in different healthcare systems, permitting opportunities to compare and contrast the care of patients. England and Sweden are two high-income countries with publicly funded healthcare systems where healthcare for OA including surgery, prescribed drugs and physiotherapy are free of charge or, as is the case in Sweden, requires a contribution from the patient that can reach up to a maximum of 1,200 Swedish Krona (equivalent to≈ 120$) a year(19). Previous literature suggests a lower rate of arthroscopies in Sweden than in other European countries including England (10, 20, 21), although it remains unclear whether this trend is also seen in patients that undergo TKR. Establishing aspects of management that differ between countries may suggest that change is not only required, but may be feasible to implement.

In this study, we aimed to investigate the prevalence pattern of common knee surgeries in the ten years prior to TKR, comparing England vs Sweden and also to the general population who do not undergo TKR.

**Patients and Methods**

*Study design and data source*

This was a multi-national, population-based, case-control study. The study was set within English and Swedish healthcare databases. Sweden and England are two European countries with similar health system structures - both countries provide free healthcare at the point of use, funded via taxation (Supplementary File 1). Furthermore, whilst both countries have subtle differences in the recording of information, both provide comprehensive data available for analysis and comparable rates of TKR and OA management strategies (22).

In Sweden, we used three registers comprising the entire population of Skåne, the southernmost region in Sweden with approximately 1.4 million inhabitants (13% of the total Swedish population as of December 2020)(23). From the Swedish Population Register, we retrieved data on age, sex, residential address, and deaths, whilst individual-level data on income, education, marital status, and country of birth were retrieved from the Longitudinal Integration Database for Health Insurance and Labour Market Studies (LISA by Swedish acronym). Lastly, from the Skåne Healthcare Register (SHR) we extracted information about diagnoses provided at healthcare visits to a physician. Data from the three registers were linked using patients’ pseudo-anonymised personal unique identification number, which is assigned to all residents in Sweden by the Swedish Tax Agency. In England, anonymised data of patients newly undergoing TKR and with linkage consent to Hospital Episode Statistics (HES) Admitted Patient Care (APC) were extracted from the Clinical Practice Research Datalink’s (CPRD) Aurum and HES APC data. The CPRD Aurum database includes routinely collected primary care data from general practices using the EMIS software system, and at time of extraction included data on 23.1 million patients, of which 2.5 million were active(24). Surgical procedures in the study period prior to TKR were identified using Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures (OPCS) codes, extracted from the HES APC database (25, 26).

The study was approved by the Regional Ethical Review Board in Lund, Sweden, and scientific and ethical approval was received for use of CPRD data in England from the Independent Scientific Advisory Committee (ISAC; Protocol 20\_000099). We reported the study according to the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines (27).

Case definition

ICD-10 codes and KVÅ codes in Sweden and Medcodes (coded using a combination of SNOMED CT (UK edition) and Read codes) in England were used to identify subjects aged 45 years and over who underwent primary TKR between 1st January 2015 and 31st December 2019 (code lists available in Supplementary File 2A-B). To be eligible for inclusion in both England and Sweden, subjects had to be registered in the healthcare database for a minimum of 10 years prior to their TKR (i.e. index date). To reduce the inclusion of subjects with prevalent TKR, those who received a TKR between 2000 and 2014 were excluded.

Control definition

Population controls were selected to establish the overall prevalence of surgery in the general population. One control for each case was randomly selected, matched by 5-year age strata (45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, 80-84 and ≥85 years), sex and general practice (in England) or residential area (in Sweden). We selected controls using risk set-sampling, resulting in controls having equivalent risk-free time compared to matched cases (28). Controls were assigned the same index date as their 1:1 matched cases (or the last day of the index year identical to that of corresponding cases in the UK) and, as cases, had no primary TKR within the 10-year lookback period.

Exposure definition

OPCS codes in England and ICD-10 codes in Sweden were used to identify meniscal, ligamentous (e.g. reconstruction, suture, transposition, incision) and synovial (i.e. synovectomy) knee surgeries as well as knee osteotomy (Supplementary File 3-7). Moreover, we analysed all knee surgeries in combination to explore the overall cumulative trend. Finally, we used total hip replacement as a control exposure, to assess possible differences in knee procedures prior to TKR explained by different attitudes and approaches to surgery between Sweden and England.

Patient characteristics / covariates

Besides the matched variables (age, sex and practice/region), index year, presence of common comorbidities (cardiovascular diseases, cancer, and diabetes), as well as lower back pain, and other musculoskeletal disorders (all musculoskeletal disorders except OA in the English data and knee OA in the Swedish data) were presented to allow comparisons between cases and controls. Comorbidities were defined by the presence of codes in patients’ health records throughout the 10-year study period. Codes for comorbidities had been previously developed and used in prior studies (22).

Statistical analysis

Contingency tables were generated for both populations to describe the frequency of cases and controls by sex, age-stratification, and index year. Yearly prevalence with 95% confidence intervals of having at least one recorded meniscal surgery, ligament surgery, synovial surgery, osteotomy, any knee surgery and THR overall and in each of the 10 years preceding TKR was estimated using Poisson regression models and presented as number of surgeries per 1,000 people. For single procedures with an overall prevalence >200 over the study time, we estimated the overall prevalence ratio (PR) between cases and controls (reference group: prevalence in the control group) and period effects on prevalence in cases and controls based on the year of TKR (2015 to 2019), age-group at time of index date and sex.

Results

We identified 6,308 and 47,010 subjects who received a TKR between 2015 and 2019 in southern Sweden and England, respectively (Table 1). In both countries, the age and gender distributions were similar and the annual number of new primary TKR cases remained stable throughout the study period. The comorbidity profile among cases and controls was also similar with the exception of musculoskeletal conditions, including back pain and OA in other joints, that were more common among cases. In Sweden, the prevalence of cardiovascular disease, cancer and depression in both cases and controls was higher than in England.

Overall, knee surgeries in the ten years prior to TKR among cases were more commonly performed in England (Prevalence 19.62 (95% confidence interval: 19.23, 20.03) per 1,000 persons) than in Sweden ( 10.1 (9.4, 10.9)) (Table 2). Meniscal surgeries were the most common knee procedure performed in cases in the 10 years prior to TKR in both countries, but overall proportion among cases was more than three times higher in England (18.4 (18.04, 18.81)) than in Sweden ( 5.8 (5.3, 6.5)). Among the case group, the prevalence of ligament surgery was similar in the two countries while synovial surgery and osteotomy were more common in Sweden. The prevalence of all analysed surgeries was consistently lower among controls. Nevertheless, knee surgeries were more common among controls in England than in Sweden. PRs were thus comparable between Sweden and England for all the analysed surgeries.

Among cases, temporal trends showed a similar prevalence of knee surgeries up to seven years before TKR when the prevalence in England began to increase (Figure 1, Supplementary File 8). In Sweden the prevalence of surgeries appeared stable throughout the study time only to increase in the last year before TKR. Similarly, meniscal surgery was more prevalent in England than in Sweden throughout the studied period, with a greater than two-fold increase in prevalence in the three years prior to TKR, increasing from 16.1 (15.0, 17.3) to 33.2 (31.6, 34.9) surgeries per 1,000 people. In Sweden, the prevalence of meniscal surgery fluctuated between 3.5 (2.3,5.3) and 6.3 (6.6, 8.6) surgeries per 1,000 people until the last year prior to TKR when the prevalence increased to 9.8 (7.7, 12.6) surgeries per 1,000 people. Among controls, no trend was detectable throughout the study time in England or Sweden, although the prevalence of meniscus surgery was higher in England at most timepoints.

Osteotomy, synovial and ligament surgeries were much less frequent than meniscal surgery. Due to the low number of procedures, we were not able to estimate the prevalence of osteotomy and ligament surgeries in the 10 years prior TKR. synovial surgery had a higher prevalence in Sweden. Nevertheless, a temporal trend with an increase in prevalence in the last year before TKR was detectable in both countries (Supplementary file 9). Due to the low number of procedures, we were not able to estimate the prevalence of osteotomy, ligament and synovium surgeries stratified by calendar year (2015-2018) age group or sex.

Overall, the PR for having received any knee surgery increased from 11.6 (5.0, 26.7) to 29.9 (9.4, 94.4), and from 6.7 (5.3, 8.4) to 26.8 (21.0, 34.2), between 10 and 1 year before index date, in Sweden and England, respectively (; Supplementary file 10, 11). The PR for having received meniscal surgery followed the same pattern as meniscal surgeries were the most common knee procedures reported prior to TKR. The PR of having received a THR increased from 1.2 (0.7, 2.0) to 2.9 (2.0, 4.2) in Sweden, whereas it increased from 1.5 (1.2, 1.9) to 4.3 (3.7, 5.0) in England (supplementary file 12). Analyses stratified by age, calendar year and sex were performed only for meniscal surgery (the most frequent type of surgery). In both countries age had a strong influence on prevalence of meniscal surgery prior to TKR (Figure 2). Among people aged <65 years, the prevalence of meniscal surgery in Sweden remained relatively stable over the study time (Supplementary File 13). In England, the prevalence at the beginning of the study time was similar to Sweden. However, over the 10-year leading up to TKR, the risk of meniscal surgery increased three-fold, peaking two years before TKR and remaining stable through the last year. Among people aged ≥65 years, similar trends characterised by an increase in prevalence in the last year prior to TKR were observed in both countries. The prevalence of meniscal surgery in men and women in Sweden was similar throughout the study time (Figure 3, (Supplementary File 14)). In England, men had a higher prevalence of meniscal surgeries 10 years before TKR (men: 14.05 (12.53, 15.75), women: 8.37 (7.33, 9.56)). This difference decreased up to five years before TKR from when differences in the prevalence of this procedure were no longer detectable. The pattern of surgery for each calendar year followed what was observed in the main analysis (Figure 4). Only in England, we could detect a period effect showing a decrease in the utilisation of meniscal surgery from 2014 to 2018, exclusively in the two years prior to TKR.

The prevalence of THR was similar in England and southern Sweden overall and at all time points, showing an increase most noticeable in the three years before TKR (Supplementary File 15). In both countries, THR was more commonly performed in people aged ≥65 years, within which the above temporal trend was more marked (Supplementary File 16). Prevalence of THR in men and women was similar throughout the follow up in both countries (Supplementary File 17, 18). Nevertheless, in England, women showed a higher prevalence of THR between four and two years prior to TKR.

**Discussion**

Our comparative study, set within two high-income countries with publicly funded healthcare systems, shows that the likelihood of undergoing a knee operation rises substantially one to two years prior to a primary TKR. This trend was particularly evident for meniscus surgery. Moreover, stratified analyses showed a larger discrepancy in the prevalence of meniscus surgery between age groups in England with higher prevalence in people aged < 65 and a period effect signifying a decrease in the utilisation of meniscal surgery in England from 2014 to 2018, exclusively in the two years prior to TKR.

These findings may have different interpretations depending on the type of surgery considered. Meniscus surgery was the most common knee procedure performed in both countries in the ten years prior to TKR. Knee arthroscopies have been shown to be unable to slow the progression of OA or delay joint replacement and may even have a negative impact (12-15, 29, 30). There is also considerable controversy regarding the utilisation of knee arthroscopy in patients with degenerative changes in the knee, as studies have shown no benefit compared to physical therapy, or placebo/sham procedures (11, 31). With prior studies demonstrating that close to 10% of patients undergoing arthroscopy underwent TKR within one year [10, 29], it is therefore reasonable to scrutinise the use of such procedures in patietnts with degenerative disease. Our findings further reinforce this.

It could be argued that the use of arthroscopic surgery in younger subjects may be advisable if able to postpone TKR, although evidence of the clinical benefits, even in these age groups, is scarce (32, 33). This may explain the higher prevalence of meniscal surgery in patients aged <65 years, a trend particularly noticeable in England. A further reason for meniscal surgery may be acute knee injury. Whilst previous reports have suggested that arthroscopies performed due to injury progress less often and more slowly to TKR than those performed due to OA (34, 35), we were not able to assess the reason for which the meniscus surgery was performed due to coding limitations. Nonetheless, we would expect that only a minority of subjects would undergo rapid joint degeneration progressing to TKR within a few years from an injury, in line with previous evidence (36). Finally, with advances in other diagnostic modalities, such as magnetic resonance imaging, it is unlikely that the arthroscopic procedures prior to TKR were performed for diagnostic purposes, particularly in recent years.

Interestingly, the pattern of meniscus surgery in England was strongly influenced by the calendar year in which the TKR was performed. The observed pattern shows a decrease from 2014 to 2018 in the utilisation of meniscus surgery in the four years preceding a TKR. The observed reduction may coincide with growing high-quality evidence showing a lack of clinical improvement and cost-effectiveness of arthroscopies performed to treat degenerative meniscal pathology (11, 31, 33, 37, 38). Whilst this decrease is reassuring, the use of meniscal surgery remains higher than in Sweden. This may suggest England is lagging behind Sweden where utilisation of meniscal surgery in OA patients has been shown to be lower than in other countries (21). In 2012, the Swedish Board of Health and Welfare issued the first national guideline containing recommendations against the use of arthroscopies in people with OA or degenerative meniscal lesions which resulted in a 29% and 35% reduction in knee arthroscopies, respectively(20). In addition, the observed differences may potentially reflect the efficacy of nationally-implemented management approaches focusing on exercise and education as first-line interventions for patients with OA in Sweden (39-41). Despite more conclusive evidence being needed, this exercise intervention has been found to be associated with a reduction in a person’s willingness to undergo surgery while a similar exercise programme has been shown to be able to delay TKR up to two years in people on a waiting list for the procedure (1, 42-44). This temporal trend seems to justify our hypothesis that many of the observed arthroscopies performed shortly before a TKR may have been inappropriate. Finally, the PRR between cases and control were similar in Sweden and England both overall and for each of the years preceding TKR. The large confidence intervals associated with the estimates from Sweden make interpretation of these findings challenging. Nevertheless, the similar PRR together with the higher prevalence of procedures in both cases and controls in England seem to suggest that the observed trend of utilisation of surgical procedure may not be specific for OA but rather reflect an overall higher use.

The prevalence of ligament and synovial surgeries, as well as osteotomy, was rare in the 10 years prior to a TKR. These findings suggest that these surgeries are not part of the management process of people with OA nearing TKR. This is not surprising for ligament surgery which is more often performed after an injury which we expect to be less common in people aged 45 or older. Synovial surgery was more common than osteotomy and ligament surgery, especially in Sweden. Conditions of the synovium (e.g. synovial plica syndrome, synovitis) can cause knee pain. Nevertheless, their surgical management is debated which may explain the relatively low prevalence. Osteotomy, on the other hand, is a major surgical procedure used to re-establish correct biomechanics in case of important deformities or misalignment of the lower limb (45). For this reason, osteotomy is also a relatively rare procedure and thus the observed prevalences appear compatible with its indication.

The comparable prevalence of THR between England and Sweden suggest a similar approach to OA surgery of the lower limb, and serve to reinforce the observed trends in knee procedures as being due to differences in management, rather than general attitudes to surgical intervention. OA is known to affect multiple joints, thus it is not surprising that people received a THR in the 10 years prior to TKR.

Other factors that may influence the observed prevalence of surgery are patient preference and expectations. Reports have shown a person's willingness to undergo surgery to be the strongest predictor of TKR, more so than pain or disability (46). Furthermore, people willing to undergo surgery appear to experience less improvement after undergoing exercise for OA (42, 47). In this context, it is possible that people undergoing surgery (either THR or meniscus surgery) become more familiar and comfortable with the process of undergoing surgical therapy and may be more inclined to undergo TKR, potentially influencing the referral process and explaining the close occurrence of surgeries. On the other hand, people that feel less ready to undergo a major surgery such as TKR may request arthroscopy in the hope of avoiding or delaying the replacement of the joint.

There are some notable limitations in the current study. In the English dataset we were unable

to restrict TKR cases to those being performed for knee OA, but such misclassification

would affect less than 3% of cases. Established codelists for TKR in England include joint resurfacing, but again this is unlikely to influence results. Similarly, we could not attribute the reason for the other surgeries analysed in this manuscript. Despite the extensive work done to match diagnostic and surgical codes between Sweden and England, differences in the way surgeries are coded and recorded may have influenced the results. Another important limitation was the inability to match the surgeries to the knee that underwent TKR. This implies that the prevalence of surgeries performed on the knee receiving TKR may be lower than estimated. Nevertheless, we expect most of the surgery to be performed in the most symptomatic knee which is the one receiving a primary TKR. Further, even the surgeries perfomed on the contralateral knee are part of the patient’s experience prior to TKR and contribute to the disease burden, especially when comparing with the controls from the general population. Limited by the study design, other individual-level confounders (such as injury or psychological disorders) were not further investigated in the study as the study was aimed to describe prevalence patterns at a population-level.

**Conclusions**

Overall, we observed a higher prevalence of meniscus surgery and THR when nearing a primary TKR while ligament and synovial surgeries, as well as osteotomy, were rare and stable over the study time. In both Sweden and England, the risk of meniscal surgery increases in the years leading up to TKR, particularly for patients aged < 65 years. Although decreasing over time, the prevalence of meniscal surgery within 12 months prior to TKR – a proposed indicator of low-value care - were higher in England than in Sweden. These differences in meniscus surgery were in stark contrast to the close similarities observed for patterns of THR prior to TKR. Our findings reinforce the need for continued efforts, particularly in England, to reduce low-value meniscus surgery, including providing access to cost-effective alternatives

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**Studies involving humans or animals**

No direct participant recruitment was done for the study. This study was approved by the

independent scientific advisory committee for CPRD research (ISAC reference: 20\_000099).

**Data sharing statement**

We used anonymised data on individual patients on which the analysis, results, and conclusions

reported in the paper are based. The CPRD data is not distributable under license. However, the

relevant data can be obtained directly from the agency (https:// [www.cprd.com/](http://www.cprd.com/)). Data from Sweden can be obtained directly from the agency (<https://www.skane.se>).

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**Table 1:** Basic demographic data and number of surgeries in cases and controls

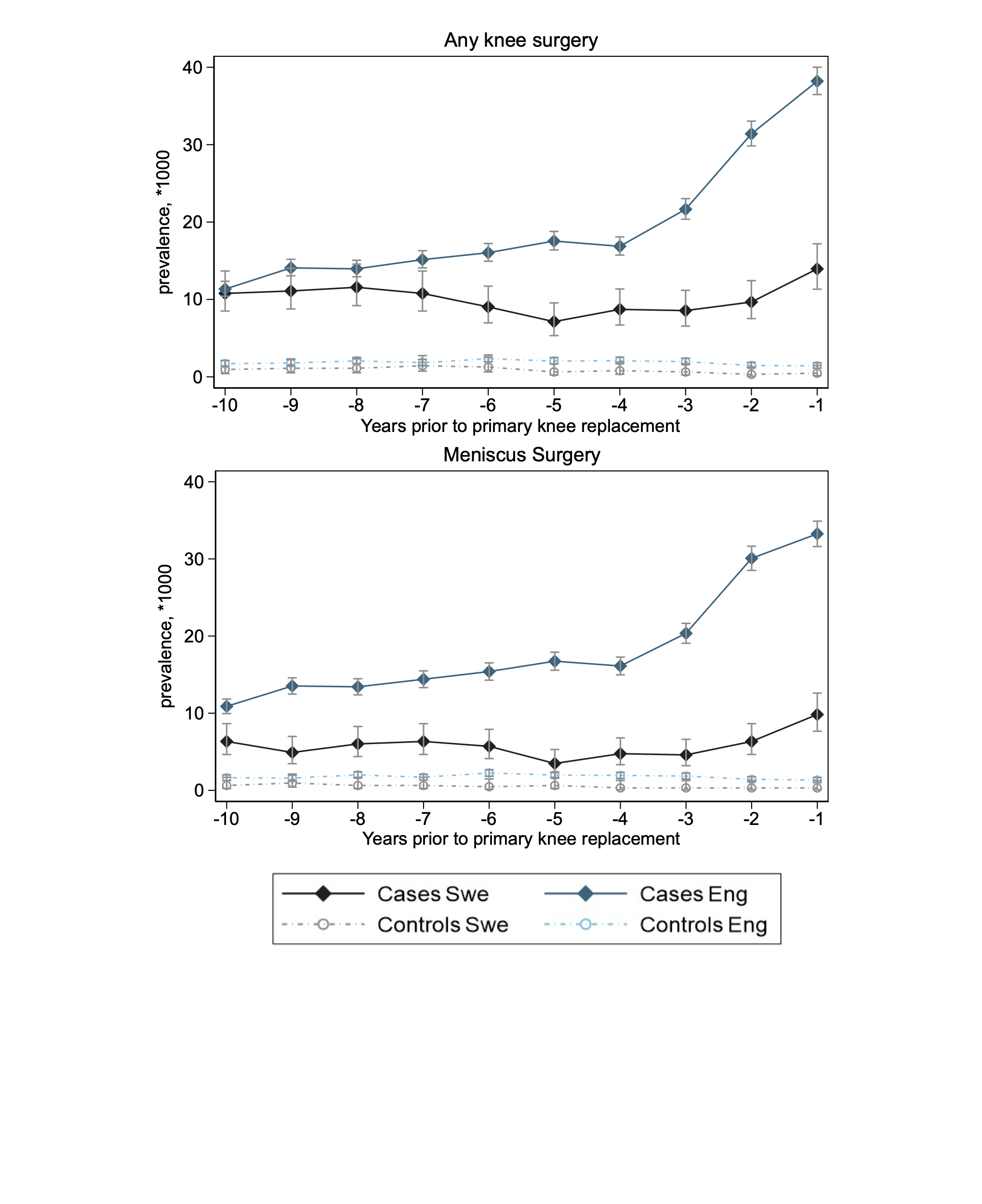
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Sweden** | | **England** | |
| **Variables** | **Cases**  (n=6,308) | **Controls**  (n=6,308) | **Cases**  (n=47,010) | **Controls**  (n=47,010) |
| **Age,** mean (SD) | 69.0 (8.9) | 68.9 (9.1) | 69.6 (9.6) | 69.6 (9.6) |
| <65 years, n (%) | 1,993 (31.6%) | 1,978 (31.4%) | 19,954 (42.4%) | 19,954 (42.4%) |
| ≥65 years, n (%) | 4,315 (68.4%) | 4,330 (68.6%) | 27,091 (57.6%) | 27,091 (57.6%) |
| **Females,** n (%) | 3,618 (57.3%) | 3,618 (57.3%) | 26,154 (55.6%) | 26,154 (55.6%) |
| **TKR performed by year,** n (%) |  |  |  |  |
| 2015 | 1,165 (18.5%) | - | 9,160 (19.5%) | - |
| 2016 | 1,254 (19.9%) | - | 9,442 (20.0%) | - |
| 2017 | 1,306 (20.7%) | - | 9,751 (20.7%) | - |
| 2018 | 1,273 (20.2%) | - | 9,189 (19.5%) | - |
| 2019 | 1,310 (20.8%) | - | 9,468 (20.1%) | - |
| **Surgeries,** n\* |  |  |  |  |
| Any knee surgery | 639 (10.1%) | 55 (0.9) | 9,225 (19.6%) | 879 (1.9%) |
| Meniscus | 368 (5.8%) | 33 (0.5%) | 8,659 (18.0%) | 833 (1.8%) |
| Ligaments | 17 (0.3%) | 2 (<0.1%) | 90 (0.1%) | 11 (<0.1%) |
| Synovial | 158 (2.5%) | 11 (0.2%) | 369 (0.8%) | 30 (0.00%) |
| Osteotomy | 96 (1.5%) | 9 (0.1%) | 107 (0.2%) | 5 (<0.1%) |
| Hip replacement | 553 (8.8%) | 303 (4.8%) | 3,933 (8.4%) | 1,889 (4.0%) |
| **Comorbidities,** |  |  |  |  |
| Cancer | 1,183 (18.8%) | 1,159 (18.7%) | 4,514 (9.6%) | 5,148 (10.9%) |
| Cardiovascular | 1,315 (20.8%) | 1,400 (22.6%) | 5,022 (10.2%) | 5,738 (11.7%) |
| Diabetes | 897 (14.2%) | 883 (14.3%) | 6,710 (14.3%) | 6,828 (14.5%) |
| Depression | 1,016 (16.1%) | 907 (14.7%) | 5,365 (11.4%) | 4,505 (9.6%) |
| Other OA | 2,776 (44.0%) | 1,141 (18.5%) | 20,543 (43.7%) | 5,849 (12.4%) |
| Back pain | 2,176 (34.5%) | 1,581 (25.6%) | 18,321 (38.9%) | 14,498 (30.8%) |
| Other MSK conditions | 5,463 (86.6%) | 4,192 (67.8%) | 37,922 (80.6%) | 29,264 (62.2%) |
| \* Total number of surgeries per group during the whole study period, an individual may have received more than one surgery of the same type.  n: number; SD: standard deviation; TKR: Total Knee Replacement | | | | |

**Table 2:** Overall prevalence of surgeries per 1,000 people over 10 years preceding TKR.

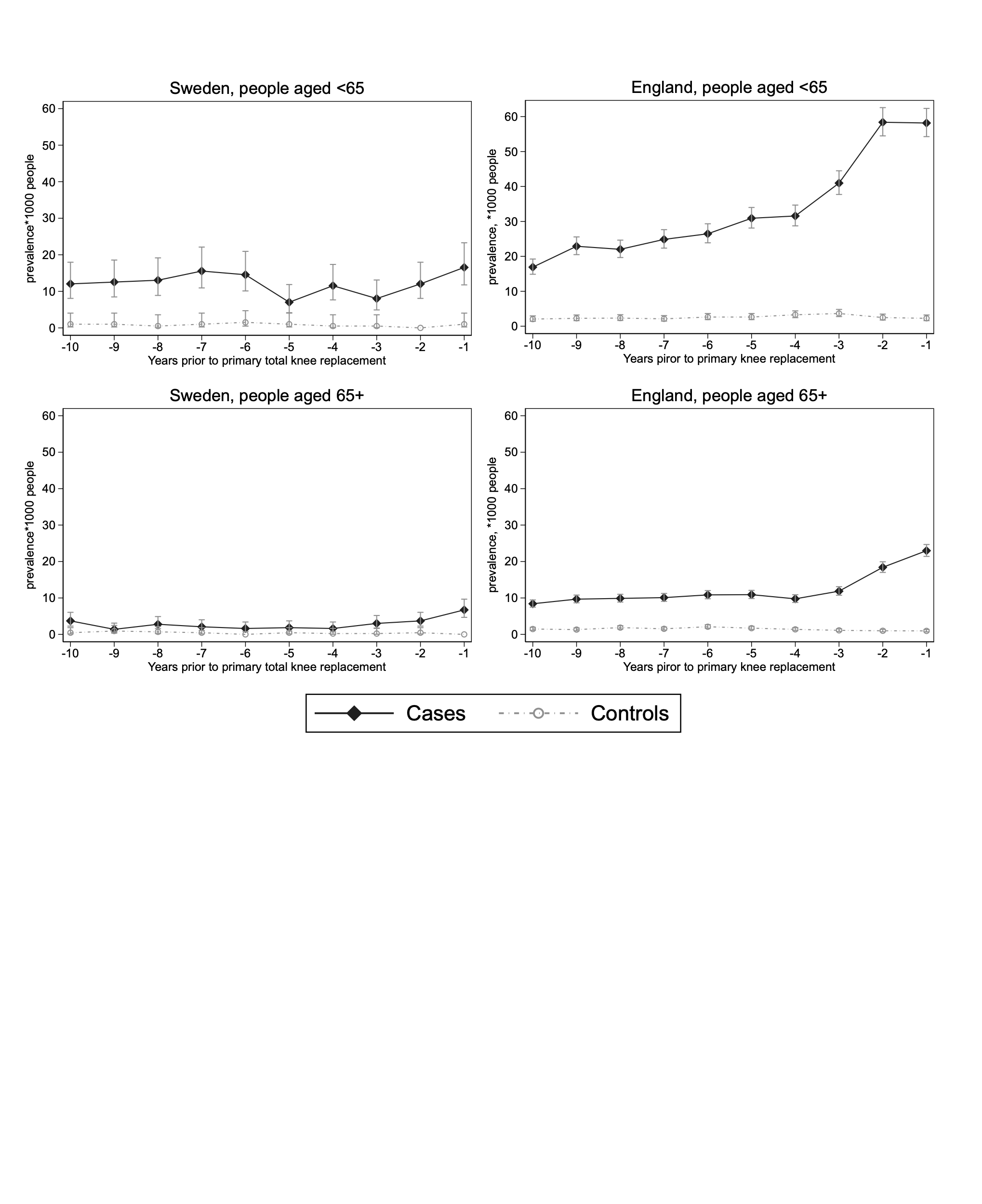
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Sweden** | | | **England** | | |
| **Surgery** | **Cases**  Prevalence (95%CI) | **Controls**  Prevalence (95%CI) | **Prevalence ratio**  Ratio\* (95%CI) | **Cases**  Prevalence (95%CI) | **Controls**  Prevalence (95%CI) | **Prevalence ratio**  Ratio\* (95%CI) |
| **Any knee surgery** | 10.13  (9.37, 10.95) | 0.87  (0.67, 1.14) | 11.6  (8.8,15.3) | 19.62  (19.23, 20.03) | 1.87  (1.75, 2.00) | 11.7  (10.9, 12.5) |
| **Meniscus** | 5.83  (5.27, 6.46) | 0.52  (0.37, 0.74) | 11.2  (7.8,15.9) | 18.42  (18.04, 18.81) | 1.77  (1.66, 1.90) | 11.4  (10.7, 12.2) |
| **Ligaments** | 0.27  (0.17, 0.43) | 0.03  (0.01, 0.13) | 8.5  (2.0, 36.8) | 0.19  (0.16, 0.24) | 0.02  (0.01, 0.04) | 11.6  (6.3, 21.5) |
| **Synovial** | 2.50  (2.14, 2.93) | 0.17  (0.10, 0.31) | 14.4  (7.8, 26.5) | 0.78  (0.71, 0.87) | 0.06  (0.04, 0.09) | 16.9  (11.9, 24.0) |
| **Osteotomy** | 1.52  (1.25, 1.86) | 0.14  (0.07, 0.27) | 10.7  (5.4, 21.1) | 0.23  (0.19, 0.28) | 0.01  (0.00, 0.03) | 19.7  (8.7, 44.7) |
| **THR** | 8.77  (8.07, 9.53) | 4.80  (4.29, 5.38) | 1.8  (1.6, 2.1) | 8.37  (8.11, 8.63) | 4.02  (3.84, 4.20) | 2.3  (2.2, 2.4) |
| CI: Confidence Interval, THR: Total hip replacement, \* controls are used as reference with numbers > 1 indicating a higher prevalence among the cases | | | | | | |

**Figure Legends**

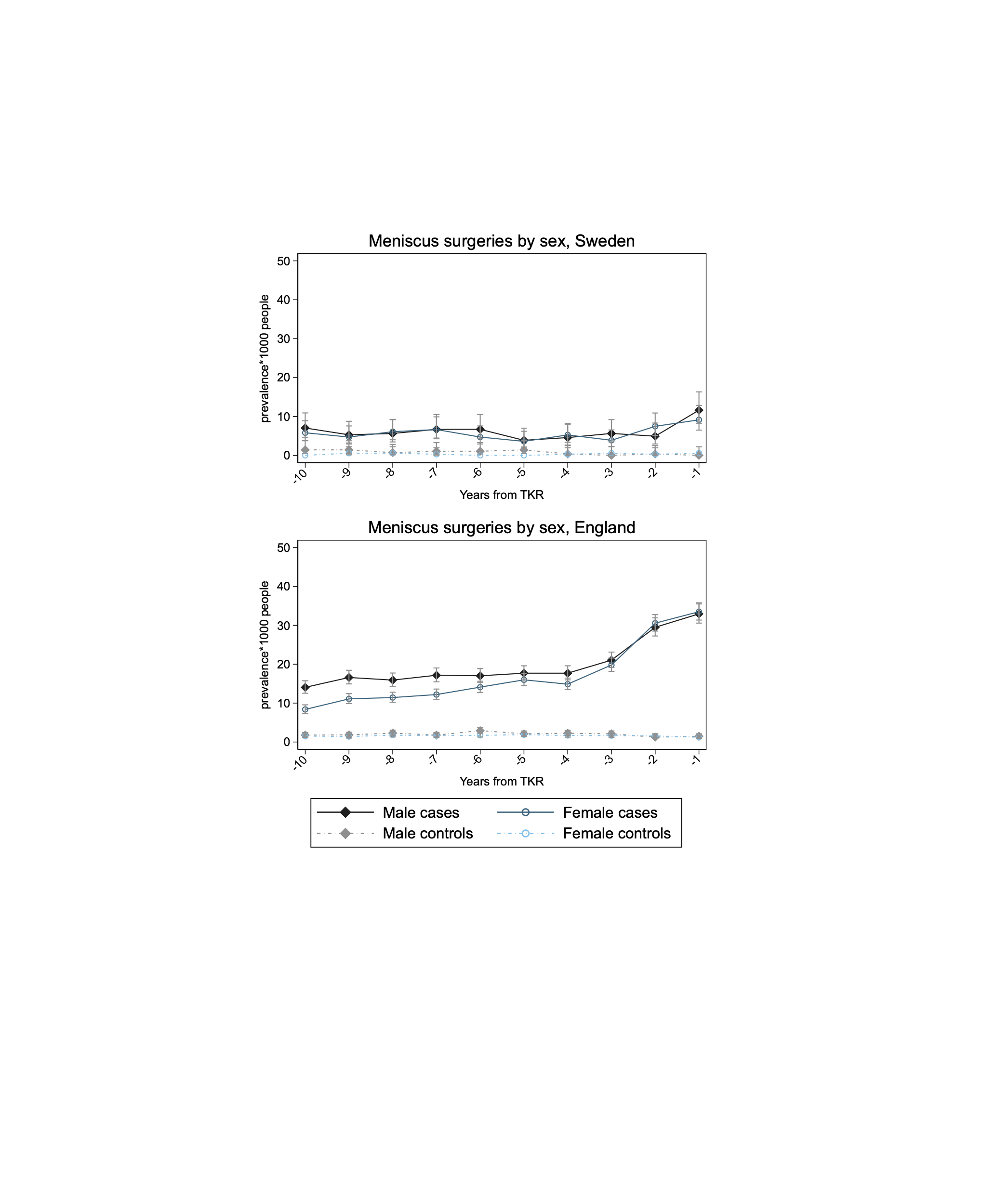
**Figure 1**: Prevalence of knee surgeries in the ten years prior to total knee replacement.



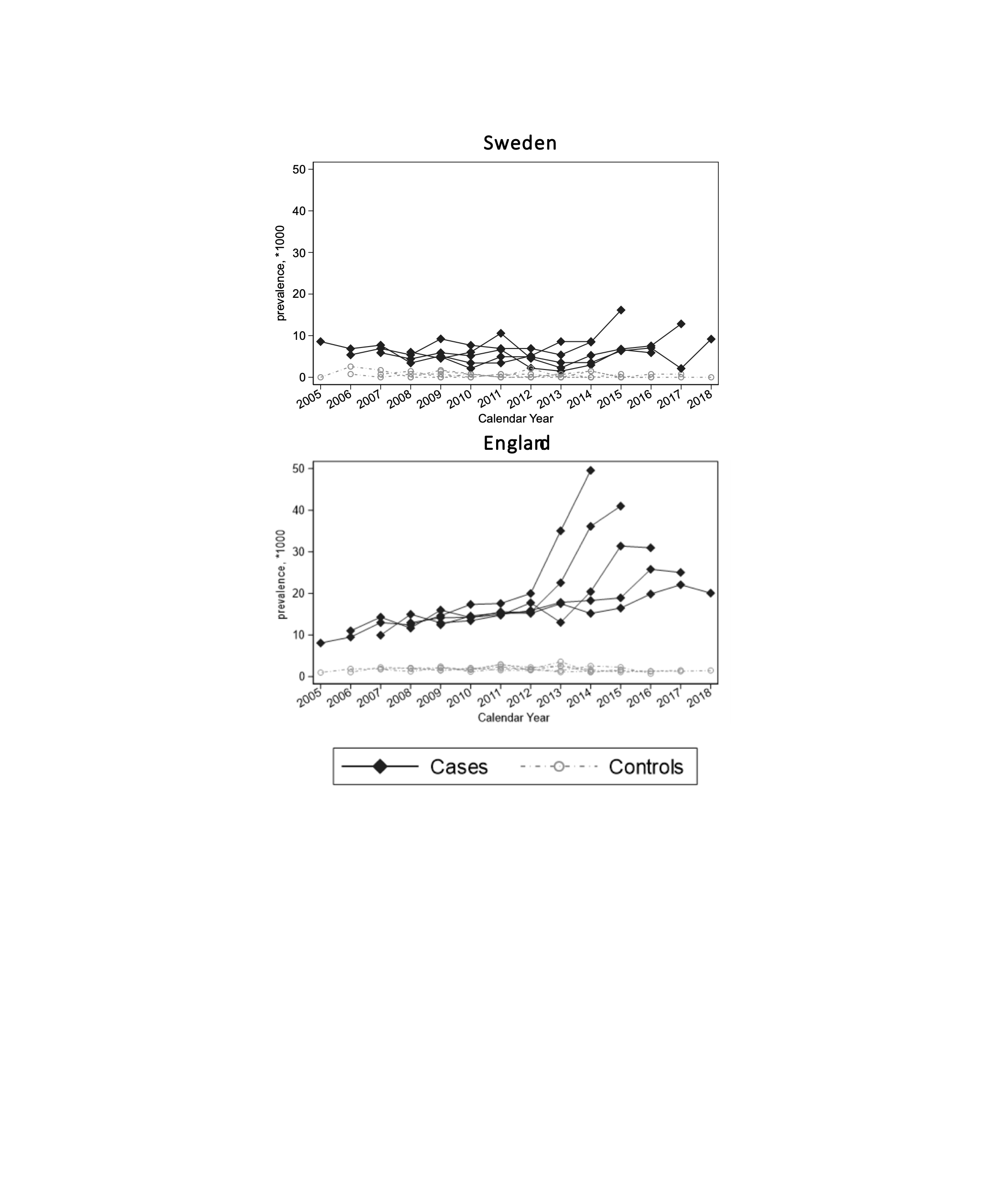
**Figure 2**: Prevalence of meniscus surgery in the ten years prior to primary total knee replacement in Sweden and England, stratified by age group



**Figure 3**: Prevalence of meniscus surgery in the ten years prior to total knee replacement, stratified by sex.



**Figure 4**: Prevalence of meniscus surgery for each calendar year by index year (year of primary total knee replacement) in Sweden and England



**Supplementary file 1:** Comparison of selected characteristics of population and healthcare in England and Sweden

|  |  |  |  |
| --- | --- | --- | --- |
|  | England (UK) | Sweden | Source |
| Population (millions) - 2019 | 56.3 | 10.3 | Office for National Statistics; Statistics Sweden |
| Population over 65 years, % | 19% | 20% | Office for National Statistics; Statistics Sweden |
| Life expectancy at birth (2016): male/female | 79.4/83.0 | 80.6/84.1 | [Trends in life expectancy and healthy life years at birth and age 65 in the UK, 2008–2016, and other countries of the EU28: An observational cross-sectional study - The Lancet Regional Health – Europe](https://www.thelancet.com/journals/lanepe/article/PIIS2666-7762(20)30023-5/fulltext) |
| Healthy life expectancy at birth (2016): male/female | 63.1/63.1 | 73.1/73.4 | [Trends in life expectancy and healthy life years at birth and age 65 in the UK, 2008–2016, and other countries of the EU28: An observational cross-sectional study - The Lancet Regional Health – Europe](https://www.thelancet.com/journals/lanepe/article/PIIS2666-7762(20)30023-5/fulltext) |
| Healthcare spending (%GDP), 2017 | 9.6 | 11.0 | Commonwealth Fund https://www.commonwealthfund.org/international-health-policy-center/system-stats/percentage-gdp-spent-health-care |
| Type of public coverage | National health service | National health service | [The social care and health systems of nine countries (kingsfund.org.uk)](https://www.kingsfund.org.uk/sites/default/files/media/commission-background-paper-social-care-health-system-other-countries.pdf) |
| Universal? | Yes | Yes | [The social care and health systems of nine countries (kingsfund.org.uk)](https://www.kingsfund.org.uk/sites/default/files/media/commission-background-paper-social-care-health-system-other-countries.pdf) |
| Main funding source | General taxation (inc employment-based national insurance contributions) | General taxation | [The social care and health systems of nine countries (kingsfund.org.uk)](https://www.kingsfund.org.uk/sites/default/files/media/commission-background-paper-social-care-health-system-other-countries.pdf) |
| Spending on pharmaceuticals per capita ($), 2017 | 469 | 515 | [Spending on Pharmaceuticals per Capita | Commonwealth Fund](https://www.commonwealthfund.org/international-health-policy-center/system-stats/spending-pharmaceuticals-capita) |
| Prevalence of obesity (%), 2017 | 28.7 | 13.0\* | [Prevalence of Obesity (BMI>30) | Commonwealth Fund](https://www.commonwealthfund.org/international-health-policy-center/system-stats/prevalence-obesity) |
| Waited 4 months or more for elective surgery (%), 2016 | 12 | 12 | [Waited Four Months or More for Elective Surgery | Commonwealth Fund](https://www.commonwealthfund.org/international-health-policy-center/system-stats/wait-for-elective-surgery) |
| Availability of analgesic opioids (S-DDD per million inhabitants per day), 2014-2016 | 8771 | 9174 | [Health at a Glance 2019 : OECD Indicators | OECD iLibrary (oecd-ilibrary.org)](https://www.oecd-ilibrary.org/sites/4dd50c09-en/1/3/4/3/index.html?itemId=/content/publication/4dd50c09-en&_csp_=82587932df7c06a6a3f9dab95304095d&itemIGO=oecd&itemContentType=book) |
| Knee replacement surgery (per 1000 population), 2017 | 145 | 132 | [Health at a Glance 2019 : OECD Indicators | OECD iLibrary (oecd-ilibrary.org)](https://www.oecd-ilibrary.org/sites/4dd50c09-en/1/3/4/3/index.html?itemId=/content/publication/4dd50c09-en&_csp_=82587932df7c06a6a3f9dab95304095d&itemIGO=oecd&itemContentType=book) |
| Annual primary care consultation prevalence for osteoarthritis (per 10000 registered population, all ages), 2010 | 176 | 196 | [Extended report: International comparisons of the consultation prevalence of musculoskeletal conditions using population-based healthcare data from England and Sweden (nih.gov)](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3888586/) |
| \* Self-reported, rather than measured | | | |

**Supplementary file 2A**: codes used to identify **knee replacement** in Sweden

|  |  |
| --- | --- |
| Sweden | |
| KVÅ Code |  |
| NGB39 | Primary total prosthetic replacement with hybrid technique |
| NGB49 | Primary total prosthetic replacement with cement |
| NGB29 | Primary total prosthetic replacement without cement |
| NGB53 | Primary prosthetic replacement of the patella |
| NGB59 | Primary prosthetic replacement of the patella with primary total knee replacement |
| NGB99 | Other primary total prosthetic replacement of the knee |

**Supplementary file 2B**: codes used to identify **knee replacement** in England

|  |  |
| --- | --- |
| England | |
| OPCS Code |  |
| O181 | Primary hybrid prosthetic replacement of knee joint using cement |
| O188 | Other specified hybrid prosthetic replacement of knee joint using cement |
| O189 | Unspecified hybrid prosthetic replacement of knee joint using cement |
| W401 | Primary total prosthetic replacement of knee joint using cement |
| W408 | Other specified total prosthetic replacement of knee joint using cement |
| W409 | Unspecified total prosthetic replacement of knee joint using cement |
| W411 | Primary total prosthetic replacement of knee joint not using cement |
| W418 | Other specified total prosthetic replacement of knee joint not using cement |
| W419 | Unspecified total prosthetic replacement of knee joint not using cement |
| W421 | Primary total prosthetic replacement of knee joint NEC |
| W428 | Other specified other total prosthetic replacement of knee joint |
| W429 | Unspecified other total prosthetic replacement of knee joint |
| W431 | Primary total prosthetic replacement of joint using cement NEC |
| W438 | Other specified total prosthetic replacement of other joint using cement |
| W439 | Unspecified total prosthetic replacement of other joint using cement |
| W441 | Primary total prosthetic replacement of joint not using cement NEC |
| W448 | Other specified total prosthetic replacement of other joint not using cement |
| W449 | Unspecified total prosthetic replacement of other joint not using cement |
| W451 | Primary total prosthetic replacement of joint NEC |
| W458 | Other specified other total prosthetic replacement of other joint |
| W459 | Unspecified other total prosthetic replacement of other joint |
| W521 | Primary prosthetic replacement of articulation of bone using cement NEC |
| W528 | Other specified prosthetic replacement of articulation of other bone using cement |
| W529 | Unspecified prosthetic replacement of articulation of other bone using cement |
| W531 | Primary prosthetic replacement of articulation of bone not using cement NEC |
| W538 | Other specified prosthetic replacement of articulation of other bone not using cement |
| W539 | Unspecified prosthetic replacement of articulation of other bone not using cement |
| W541 | Primary prosthetic replacement of articulation of bone NEC |
| W548 | Other specified other prosthetic replacement of articulation of other bone |
| W549 | Unspecified other prosthetic replacement of articulation of other bone |
| W581 | Primary resurfacing arthroplasty of joint |

|  |  |
| --- | --- |
| Sweden | |
| KVÅ Code |  |
| NGD0 | Total excision of the meniscus |
| NGD1 | Partial excision of the meniscus |
| NGD2 | Suture and replantation of the knee meniscus |
| NGD9 | Other operations on the meniscus |

**Supplementary file 3A**: codes used to identify **meniscus surgeries** in Sweden

**Supplementary file 3B**: codes used to identify **meniscus surgeries** in England

|  |  |
| --- | --- |
| England | |
| OPCS Code |  |
| W701 | Open total excision of semilunar cartilage |
| W702 | Open excision of semilunar cartilage NEC |
| W821 | Endoscopic total excision of semilunar cartilage |
| W822 | Endoscopic resection of semilunar cartilage NEC |
| W703 | Open repair of semilunar cartilage |
| W823 | Endoscopic repair of semilunar cartilage |
| W828 | Other specified therapeutic endoscopic operations on semilunar cartilage |
| W829 | Unspecified therapeutic endoscopic operations on semilunar cartilage |

**Supplementary file 4A**: codes used to identify **ligament surgeries** in Sweden

|  |  |
| --- | --- |
| Sweden | |
| KVÅ Code |  |
| NGE4 | Reconstruction of knee ligaments with foreign material |
| NGE2 | Suture or replantation of knee ligaments |
| NGE3 | Transposition of knee ligaments |
| NGE9 | Other operation on knee ligaments |
| MGE0 | Incision or suture of the joint capsule |
| MGE1 | Transection or incision of knee joint ligaments |

**Supplementary file 4B**: codes used to identify **ligament surgeries** in England

|  |  |
| --- | --- |
| England | |
| OPCS Code |  |
| W723 | Primary prosthetic replacement of intra-articular ligament |
| W724 | Prosthetic replacement of intra-articular ligament NEC |
| W731 | Primary extra-articular prosthetic augmentation of intra-articular ligament NEC |
| W732 | Extra-articular prosthetic augmentation of intra-articular ligament NEC |
| W733 | Primary prosthetic reinforcement of intra-articular ligament NEC |
| W734 | Prosthetic reinforcement of intra-articular ligament NEC |
| W742 | Reconstruction of intra-articular ligament |
| W752 | Open repair of intra-articular ligament NEC |
| W841 | Endoscopic repair of intra-articular ligament |
| W842 | Endoscopic reattachment of intra-articular ligament |
| O271 | Extra-articular ligament reconstruction for stabilisation of joint |
| W725 | Primary prosthetic replacement of extra-articular ligament |
| W726 | Prosthetic replacement of extra-articular ligament NEC |
| W743 | Reconstruction of extra-articular ligament NEC |
| W753 | Open repair of extra-articular ligament NEC |
| W721 | Primary prosthetic replacement of multiple ligaments |
| W722 | Prosthetic replacement of multiple ligaments NEC |
| W728 | Other specified prosthetic replacement of ligament |
| W729 | Unspecified prosthetic replacement of ligament |
| W738 | Other specified prosthetic reinforcement of ligament |
| W739 | Unspecified prosthetic reinforcement of ligament |
| W741 | Reconstruction of multiple ligaments NEC |
| W748 | Other specified other reconstruction of ligament |
| W749 | Unspecified other reconstruction of ligament |
| W751 | Open repair of multiple ligaments NEC |
| W777 | Transposition of ligament for stabilisation of joint |
| W778 | Other specified stabilising operations on joint |

**Supplementary file 5A**: codes used to identify **osteotomy** in Sweden

|  |  |
| --- | --- |
| Sweden | |
| KVÅ Code |  |
| NGK59 | Angle, rotational or displacement osteotomy of the knee or lower leg |
| NGK69 | Shortening or lengthening osteotomy of the knee or lower leg |

**Supplementary file 5B**: codes used to identify **osteotomy** in England

|  |  |
| --- | --- |
| England | |
| OPCS Code |  |
| W121 | Biosseus angulation periarticular osteotomy and internal fixation HFQ |
| W122 | Angulation periarticular osteotomy and internal fixation NEC |
| W123 | Biosseus angulation periarticular osteotomy and external fixation HFQ |
| W124 | Angulation periarticular osteotomy and external fixation NEC |
| W125 | Biosseus angulation periarticular osteotomy NEC |
| W131 | Rotation periarticular osteotomy |
| W132 | Displacement osteotomy |
| W134 | Relocation and derotation osteotomy |
| W161 | Multiple osteotomy and internal fixation HFQ |
| W162 | Multiple osteotomy and external fixation HFQ |
| W163 | Multiple osteotomy NEC |
| W164 | Osteotomy and internal fixation NEC |
| W165 | Osteotomy and external fixation NEC |
| W775 | Periarticular osteotomy for stabilisation of joint |

**Supplementary file 6A**: codes used to identify **synovial surgery** in Sweden

|  |  |
| --- | --- |
| Sweden | |
| KVÅ Code |  |
| NGF0 | Total Synovectomy |
| NGF1 | Partial synovectomy |
| NGF9 | Other operation to the synovial capsule or joint surface |

**Supplementary file 6B**: codes used to identify **synovial surgery** in England

|  |  |
| --- | --- |
| Sweden | |
| OPCS Code |  |
| W691 | Total synovectomy |
| W692 | Subtotal synovectomy |
| W693 | Partial synovectomy (includes Synovectomy NEC) |
| W698 | Other specified open operations on synovial membrane of joint |
| W699 | Unspecified open operations on synovial membrane of joint |

**Supplementary file 7A**: codes used to identify **hip replacement** in Sweden

|  |  |
| --- | --- |
| Sweden | |
| KVÅ Code |  |
| NFB09 | Primary hip semi- or partial prosthesis without cement |
| NFB19 | Primary hip semi- or partial prosthesis with cement |
| NFB29 | Primary total hip replacement without cement |
| NFB39 | Primary total hip replacement with hybrid technique |
| NFB49 | Primary total hip replacement with cement |
| NFB99 | Other primary hip replacement |

**Supplementary file 7B**: codes used to identify **hip replacement** in England

|  |  |
| --- | --- |
| England | |
| OPCS Code |  |
| W371 | Primary total prosthetic replacement of hip joint using cement |
| W378 | Total prosthetic replacement of hip joint using cement, Other specified |
| W379 | Total prosthetic replacement of hip joint using cement, Unspecified |
| W381 | Primary total prosthetic replacement of hip joint not using cement |
| W388 | Total prosthetic replacement of hip joint not using cement, Other specified |
| W389 | Total prosthetic replacement of hip joint not using cement, Unspecified |
| W391 | Primary total prosthetic replacement of hip joint NE |
| W398 | Other specified hybrid prosthetic replacement of hip joint using cemented acetabular component |
| W399 | Unspecified hybrid prosthetic replacement of hip joint using cemented acetabular component |
| W521 | Primary prosthetic replacement of articulation of bone using cement NEC |
| W531 | Primary prosthetic replacement of articulation of bone not using cement NEC |
| W541 | Primary prosthetic replacement of articulation of bone NEC |
| W581 | Primary resurfacing arthroplasty of joint |
| W931 | Primary hybrid prosthetic replacement of hip joint using cemented acetabular component |
| W938 | Other specified hybrid prosthetic replacement of hip joint using cemented acetabular component |
| W939 | Unspecified hybrid prosthetic replacement of hip joint using cemented acetabular component |
| W941 | Primary hybrid prosthetic replacement of hip joint using cemented femoral component |
| W948 | Other specified hybrid prosthetic replacement of hip joint using cemented femoral component |
| W949 | Unspecified hybrid prosthetic replacement of hip joint using cemented femoral component |
| W951 | Primary hybrid prosthetic replacement of hip joint using cement NEC |
| W958 | Other specified hybrid prosthetic replacement of hip joint using cement |
| W959 | Unspecified hybrid prosthetic replacement of hip joint using cement |

**Supplementary file 8**: prevalence of surgeries per 1,000 people in the ten years prior to primary total knee replacement

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Sweden** | | **England** | |
| Years prior TKR | **Cases**;n=6,337  Prevalence (95%CI) | **Controls**;n=6,337 Prevalence (95%CI) | **Cases**;n=47,010 Prevalence (95%CI) | **Controls**; n=47,010 Prevalence (95%CI) |
|  | **Any knee surgery** | | | |
| **-10** | 10.78 (8.50, 13.67) | 0.95 (0.43, 2.12) | 11.34 (10.42, 12.34) | 1.70 (1.37, 2.12) |
| **-9** | 11.10 (8.78, 14.03) | 1.11 (0.53, 2.33) | 14.08 (13.05, 15.20) | 1.79 (1.44, 2.21) |
| **-8** | 11.57 (9.20, 14.56) | 1.11 (0.53, 2.33) | 13.95 (12.93, 15.06) | 2.06 (1.69, 2.52) |
| **-7** | 10.78 (8.50, 13.67) | 1.43 (0.74, 2.74) | 15.15 (14.07, 16.30) | 1.83 (1.48, 2.26) |
| **-6** | 9.04 (6.97, 11.71) | 1.27 (0.63, 2.54) | 16.04 (14.93, 17.23) | 2.34 (1.94, 2.82) |
| **-5** | 7.13 (5.33, 9.55) | 0.63 (0.24, 1.69) | 17.55 (16.39, 18.79) | 2.04 (1.67, 2.49) |
| **-4** | 8.72 (6.69, 11.36) | 0.79 (0.33, 1.90) | 16.87 (15.73, 18.08) | 2.08 (1.71, 2.54) |
| **-3** | 8.56 (6.56, 11.18) | 0.63 (0.24, 1.69) | 21.65 (20.36, 23.03) | 1.96 (1.60, 2.40) |
| **-2** | 9.67 (7.52, 12.43) | 0.32 (0.08, 1.27) | 31.40 (29.84, 33.04) | 1.47 (1.16, 1.86) |
| **-1** | 13.95 (11.32, 17.19) | 0.48 (0.15, 1.47) | 38.20 (36.48, 40.01) | 1.43 (1.12, 1.81) |
|  | **Meniscus surgery** | | | |
| **-10** | 6.34 (4.65, 8.64) | 0.63 (0.24, 1.69) | 10.89 (9.95, 11.83) | 1.64 (1.27, 2) |
| **-9** | 4.91 (3.46, 6.99) | 0.95 (0.43, 2.12) | 13.53 (12.48, 14.58) | 1.6 (1.23, 1.96) |
| **-8** | 6.02 (4.38, 8.28) | 0.63 (0.24, 1.69) | 13.42 (12.38, 14.47) | 2 (1.6, 2.4) |
| **-7** | 6.34 (4.65, 8.64) | 0.63 (0.24, 1.69) | 14.4 (13.32, 15.49) | 1.7 (1.33, 2.07) |
| **-6** | 5.71 (4.12, 7.91) | 0.48 (0.15, 1.47) | 15.4 (14.28, 16.52) | 2.25 (1.83, 2.68) |
| **-5** | 3.49 (2.30, 5.30) | 0.63 (0.24, 1.69) | 16.74 (15.57, 17.91) | 1.98 (1.58, 2.38) |
| **-4** | 4.76 (3.33, 6.80) | 0.32 (0.08, 1.27) | 16.12 (14.98, 17.27) | 1.94 (1.54, 2.33) |
| **-3** | 4.60 (3.19, 6.62) | 0.32 (0.08, 1.27) | 20.36 (19.07, 21.65) | 1.85 (1.46, 2.24) |
| **-2** | 6.34 (4.65, 8.64) | 0.32 (0.08, 1.27) | 30.08 (28.51, 31.65) | 1.43 (1.08, 1.77) |
| **-1** | 9.83 (7.66, 12.61) | 0.32 (0.08, 1.27) | 33.25 (31.6, 34.9) | 1.34 (1.01, 1.67) |
| TKR: total knee replacement | | | | |

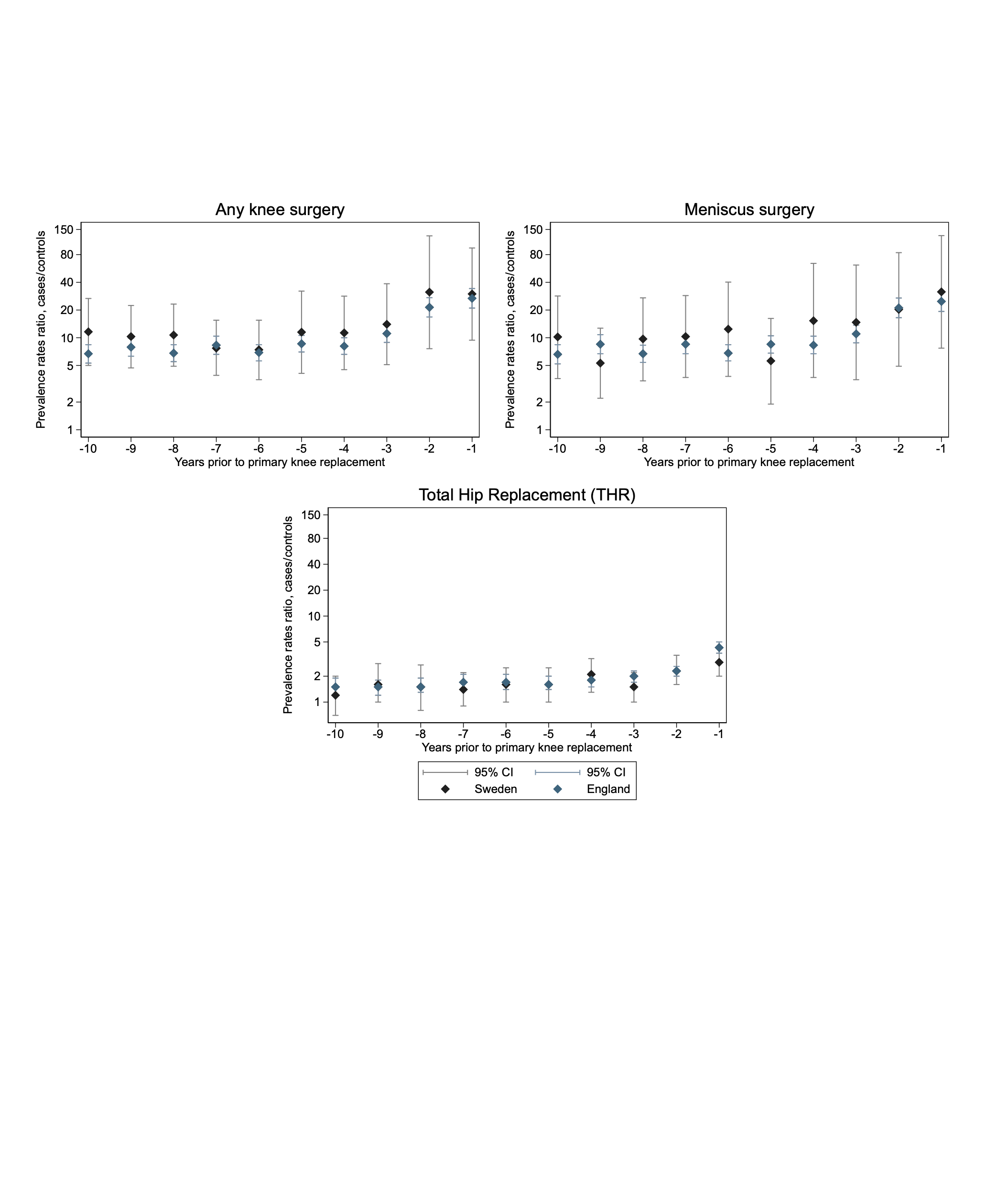
**Supplementary file 9**: prevalence of surgeries per 1,000 people in the ten years prior to primary total knee replacement

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Sweden** | | **England** | |
| Years prior TKR | **Cases**;n=6,337  Prevalence (95%CI) | **Controls**;n=6,337 Prevalence (95%CI) | **Cases**;n=47,010 Prevalence (95%CI) | **Controls**; n=47,010 Prevalence (95%CI) |
|  | **Synovium surgery** | | | |
| **-10** | 1.27 (0.63, 2.54) | 0.00 (0.00, .) | 0.19 (0.07, 0.32) | 0.04 (-0.02, 0.1) |
| **-9** | 3.80 (2.55, 5.68) | 0.00 (0.00, .) | 0.34 (0.17, 0.51) | 0.09 (0, 0.17) |
| **-8** | 2.85 (1.80, 4.53) | 0.16 (0.02, 1.13) | 0.26 (0.11, 0.4) | 0.04 (-0.02, 0.1) |
| **-7** | 2.54 (1.55, 4.14) | 0.32 (0.08, 1.27) | 0.28 (0.13, 0.43) | 0.06 (-0.01, 0.14) |
| **-6** | 1.90 (1.08, 3.35) | 0.63 (0.24, 1.69) | 0.34 (0.17, 0.51) | 0.09 (0, 0.17) |
| **-5** | 1.90 (1.08, 3.35) | 0.00 (0.00, .) | 0.47 (0.27, 0.66) | 0.06 (-0.01, 0.14) |
| **-4** | 1.59 (0.85, 2.95) | 0.32 (0.08, 1.27) | 0.21 (0.08, 0.34) | 0.09 (0, 0.17) |
| **-3** | 3.01 (1.92, 4.72) | 0.16 (0.02, 1.13) | 0.87 (0.61, 1.14) | 0.09 (0, 0.17) |
| **-2** | 2.22 (1.31, 3.75) | 0.00 (0.00, .) | 0.98 (0.7, 1.26) | 0.02 (-0.02, 0.06) |
| **-1** | 3.96 (2.68, 5.87) | 0.16 (0.02, 1.13) | 3.91 (3.35, 4.48) | 0.06 (-0.01, 0.14) |
|  | **Hip replacement** | | | |
| **-10** | 5.38 (4.19, 6.90) | 3.64 (2.69, 4.93) | 4.19 (3.61, 4.78) | 2.74 (2.27, 3.22) |
| **-9** | 5.99 (4.73, 7.58) | 5.90 (4.65, 7.48) | 4.7 (4.08, 5.32) | 3.15 (2.64, 3.66) |
| **-8** | 5.81 (4.58, 7.39) | 4.34 (3.29, 5.72) | 5.59 (4.92, 6.27) | 3.62 (3.07, 4.16) |
| **-7** | 6.85 (5.50, 8.55) | 4.77 (3.66, 6.22) | 6.08 (5.38, 6.79) | 3.53 (2.99, 4.07) |
| **-6** | 6.94 (5.58, 8.64) | 3.73 (2.77, 5.03) | 6.64 (5.9, 7.37) | 3.83 (3.27, 4.39) |
| **-5** | 7.72 (6.27, 9.51) | 5.47 (4.27, 7.00) | 6.66 (5.92, 7.4) | 4.04 (3.47, 4.62) |
| **-4** | 9.37 (7.76, 11.32) | 5.47 (4.27, 7.00) | 7.91 (7.11, 8.72) | 4.49 (3.88, 5.09) |
| **-3** | 9.20 (7.60, 11.13) | 5.38 (4.19, 6.90) | 9.15 (8.28, 10.01) | 4.66 (4.04, 5.28) |
| **-2** | 13.36 (11.41, 15.65) | 6.94 (5.58, 8.64) | 12.08 (11.09, 13.08) | 5.32 (4.66, 5.98) |
| **-1** | 16.92 (14.70, 19.47) | 6.42 (5.11, 8.06) | 20.66 (19.36, 21.95) | 4.81 (4.18, 5.43) |
| TKR: total knee replacement | | | | |

**Supplementary file 10**: prevalence ratio of **any surgery**  and **meniscus surgery** between cases and controls (reference group: prevalence in control group) in the ten years prior to primary total knee replacement

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Sweden** | | **England** | |
| Years prior primary  TKR | **Any knee surgery**  Prevalence Ratio (95%CI) | **Meniscus**  Prevalence Ratio (95%CI) | **Any knee surgery**  Prevalence Ratio (95%CI) | **Meniscus**  Prevalence Ratio (95%CI) |
| **-10** | 11.6 (5.0, 26.7) | 10.2 (3.6, 28.4) | 6.7 (5.3, 8.4) | 6.6 (5.2, 8.4) |
| **-9** | 10.3 (4.7, 22.4) | 5.3 (2.2, 12.7) | 7.9 (6.3, 9.9) | 8.5 (6.7, 10.8) |
| **-8** | 10.7 (4.9, 23.2) | 9.7 (3.4, 27.1) | 6.8 (5.5, 8.4) | 6.7 (5.4, 8.3) |
| **-7** | 7.7 (3.9, 15.5) | 10.3 (3.7, 28.7) | 8.3 (6.6, 10.4) | 8.5 (6.7, 10.7) |
| **-6** | 7.4 (3.5, 15.5) | 12.4 (3.8, 40.2) | 6.9 (5.6, 8.4) | 6.8 (5.6, 8.4) |
| **-5** | 11.5 (4.1, 32.1) | 5.6 (1.9, 16.2) | 8.6 (7.0, 10.6) | 8.5 (6.8, 10.5) |
| **-4** | 11.3 (4.5, 28.3) | 15.3 (3.7, 64.2) | 8.1 (6.6, 10.0) | 8.3 (6.7, 10.4) |
| **-3** | 14 (5.1, 38.6) | 14.7 (3.5, 61.6) | 11.1 (8.9, 13.7) | 11.0 (8.8, 13.7) |
| **-2** | 31.3 (7.6, 127.9) | 20.3 (4.9, 84) | 21.4 (16.8, 27.2) | 21.1 (16.5, 27.0) |
| **-1** | 29.9 (9.4, 94.4) | 31.5 (7.7, 128.6) | 26.8 (21.0, 34.2) | 24.8 (19.3, 31.9) |

TKR: total knee replacement

**Supplementary file 11**: Prevalence rates ratio (PRR) between cases and controls (reference category) of **any knee surgery, meniscus surgery** and **total hip replacement** in the ten years prior to primary total knee replacement.

**Supplementary file 12**: prevalence ratio of **total hip replacement** between cases and controls (reference group: prevalence in control group) in the ten years prior a primary knee replacement

|  |  |  |
| --- | --- | --- |
|  | **Sweden** | **England** |
| Years prior TKR | **Hip replacement**  Prevalence Ratio (95%CI) | **Hip replacement**  Prevalence Ratio (95%CI) |
| **-10** | 1.2 (0.7, 2.0) | 1.5 (1.2, 1.9) |
| **-9** | 1.6 (1, 2.8) | 1.5 (1.2, 1.8) |
| **-8** | 1.5 (0.8, 2.7) | 1.5 (1.3, 1.9) |
| **-7** | 1.4 (0.9, 2.2) | 1.7 (1.4, 2.1) |
| **-6** | 1.6 (1, 2.5) | 1.7 (1.4, 2.1) |
| **-5** | 1.6 (1, 2.5) | 1.6 (1.4, 2.0) |
| **-4** | 2.1 (1.3, 3.2) | 1.8 (1.5, 2.1) |
| **-3** | 1.5 (1, 2.2) | 2.0 (1.7, 2.3) |
| **-2** | 2.3 (1.6, 3.5) | 2.3 (2.0, 2.6) |
| **-1** | 2.9 (2.0, 4.2) | 4.3 (3.7, 5.0) |
| TKR: total knee replacement | | |

**Supplementary file 13**: prevalence of **meniscus surgery** in the ten years prior to primary total knee replacement by age group

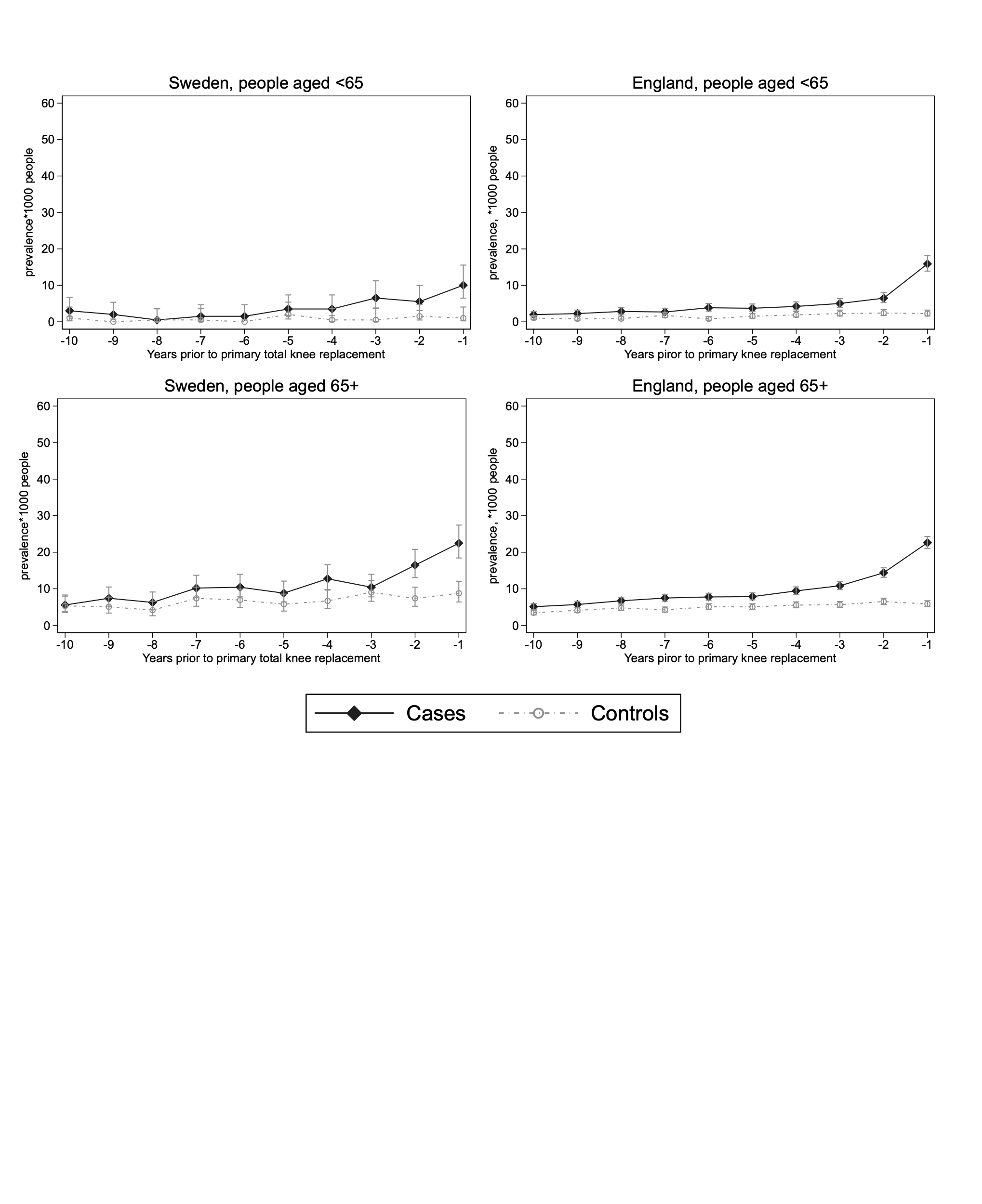
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Sweden** | | **England** | |
| Years prior TKT | **Cases**  Prevalence (95%CI) | **Controls**  Prevalence (95%CI) | **Cases**  Prevalence (95%CI) | **Controls**  Prevalence (95%CI) |
|  | **< 65 years** | | | |
| **-10** | 12.04 (8.07, 17.97) | 1.01 (0.25, 4.04) | 16.91 (14.87, 19.23) | 2.04 (1.41, 2.96) |
| **-9** | 12.54 (8.48, 18.56) | 1.01 (0.25, 4.04) | 22.89 (20.49, 25.56) | 2.26 (1.59, 3.21) |
| **-8** | 13.05 (8.88, 19.16) | 0.51 (0.07, 3.59) | 22.01 (19.67, 24.64) | 2.33 (1.65, 3.30) |
| **-7** | 15.55 (10.94, 22.12) | 1.01 (0.25, 4.04) | 24.86 (22.35, 27.64) | 2.11 (1.47, 3.04) |
| **-6** | 14.55 (10.11, 20.94) | 1.52 (0.49, 4.70) | 26.46 (23.87, 29.33) | 2.62 (1.89, 3.64) |
| **-5** | 7.02 (4.16, 11.86) | 1.01 (0.25, 4.04) | 30.91 (28.10, 33.99) | 2.62 (1.89, 3.64) |
| **-4** | 11.54 (7.67, 17.37) | 0.51 (0.07, 3.59) | 31.56 (28.72, 34.68) | 3.28 (2.45, 4.39) |
| **-3** | 8.03 (4.92, 13.10) | 0.51 (0.07, 3.59) | 40.97 (37.71, 44.50) | 3.64 (2.76, 4.81) |
| **-2** | 12.04 (8.07, 17.97) | 0.00 (0.00, .) | 58.39 (54.48, 62.57) | 2.48 (1.77, 3.47) |
| **-1** | 16.56 (11.77, 23.29) | 1.01 (0.25, 4.04) | 58.17 (54.27, 62.35) | 2.26 (1.59, 3.21) |
|  | **≥ 65 years** | | | |
| **-10** | 3.71 (2.27, 6.05) | 0.46 (0.12, 1.85) | 8.41 (7.48, 9.46) | 1.47 (1.11, 1.95) |
| **-9** | 1.39 (0.62, 3.10) | 0.92 (0.35, 2.46) | 9.67 (8.67, 10.79) | 1.32 (0.98, 1.78) |
| **-8** | 2.78 (1.58, 4.90) | 0.69 (0.22, 2.15) | 9.88 (8.87, 11.01) | 1.86 (1.45, 2.39) |
| **-7** | 2.09 (1.09, 4.01) | 0.46 (0.12, 1.85) | 10.09 (9.07, 11.23) | 1.53 (1.16, 2.02) |
| **-6** | 1.62 (0.77, 3.40) | 0.00 (0.00, .) | 10.84 (9.78, 12.02) | 2.10 (1.66, 2.66) |
| **-5** | 1.85 (0.93, 3.71) | 0.46 (0.12, 1.85) | 10.90 (9.84, 12.09) | 1.71 (1.32, 2.22) |
| **-4** | 1.62 (0.77, 3.40) | 0.23 (0.03, 1.64) | 9.76 (8.76, 10.88) | 1.38 (1.03, 1.84) |
| **-3** | 3.01 (1.75, 5.19) | 0.23 (0.03, 1.64) | 11.87 (10.75, 13.09) | 1.11 (0.81, 1.53) |
| **-2** | 3.71 (2.27, 6.05) | 0.46 (0.12, 1.85) | 18.41 (17.01, 19.93) | 0.99 (0.70, 1.39) |
| **-1** | 6.72 (4.67, 9.67) | 0.00 (0.00, .) | 22.98 (21.41, 24.67) | 0.96 (0.68, 1.36) |
| \* Total number of surgeries per group, an individual may have received more than one surgery of the same type  TKR: total knee replacement | | | | |

**Supplementary file 14**: prevalence of **meniscus surgery in** the ten years prior to primary total knee replacement in men and women

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Sweden** | | **England** | |
| Years prior TKR | **Cases**  (n=6,337) | **Controls**  (n=6,337) | **Cases**  (n=47,010) | **Controls**  (n=47,010) |
|  | **Men** | | | |
| **-10** | 7.06 (4.51, 11.07) | 1.49 (0.56, 3.96) | 14.05 (12.53, 15.75) | 1.77 (1.29, 2.45) |
| **-9** | 5.20 (3.08, 8.79) | 1.49 (0.56, 3.96) | 16.59 (14.93, 18.43) | 1.82 (1.33, 2.50) |
| **-8** | 5.95 (3.64, 9.71) | 0.74 (0.19, 2.97) | 15.92 (14.30, 17.73) | 2.30 (1.73, 3.05) |
| **-7** | 5.95 (3.64, 9.71) | 1.12 (0.36, 3.46) | 17.17 (15.48, 19.04) | 1.77 (1.29, 2.45) |
| **-6** | 7.06 (4.51, 11.07) | 1.12 (0.36, 3.46) | 17.02 (15.34, 18.89) | 2.92 (2.28, 3.76) |
| **-5** | 3.35 (1.74, 6.43) | 1.49 (0.56, 3.96) | 17.69 (15.98, 19.59) | 2.11 (1.57, 2.83) |
| **-4** | 4.09 (2.26, 7.38) | 0.37 (0.05, 2.64) | 17.69 (15.98, 19.59) | 2.25 (1.69, 3.00) |
| **-3** | 5.58 (3.36, 9.25) | 0.00 (0.00, .) | 21.05 (19.17, 23.11) | 2.11 (1.57, 2.83) |
| **-2** | 4.83 (2.81, 8.32) | 0.37 (0.05, 2.64) | 29.49 (27.25, 31.91) | 1.25 (0.85, 1.83) |
| **-1** | 10.78 (7.49, 15.51) | 0.00 (0.00, .) | 32.94 (30.57, 35.50) | 1.49 (1.05, 2.11) |
|  | **Women** | | | |
| **-10** | 5.80 (3.78, 8.90) | 0.00 (0.00, .) | 8.37 (7.33, 9.56) | 1.53 (1.12, 2.09) |
| **-9** | 4.70 (2.92, 7.56) | 0.55 (0.14, 2.21) | 11.09 (9.88, 12.44) | 1.41 (1.03, 1.95) |
| **-8** | 6.08 (4.00, 9.23) | 0.55 (0.14, 2.21) | 11.43 (10.21, 12.80) | 1.76 (1.32, 2.35) |
| **-7** | 6.63 (4.45, 9.90) | 0.28 (0.04, 1.96) | 12.20 (10.93, 13.61) | 1.64 (1.22, 2.22) |
| **-6** | 4.70 (2.92, 7.56) | 0.00 (0.00, .) | 14.11 (12.74, 15.62) | 1.72 (1.28, 2.30) |
| **-5** | 3.59 (2.09, 6.19) | 0.00 (0.00, .) | 15.98 (14.52, 17.59) | 1.87 (1.42, 2.48) |
| **-4** | 5.25 (3.35, 8.23) | 0.28 (0.04, 1.96) | 14.87 (13.47, 16.43) | 1.68 (1.25, 2.26) |
| **-3** | 3.87 (2.29, 6.53) | 0.55 (0.14, 2.21) | 19.81 (18.17, 21.59) | 1.64 (1.22, 2.22) |
| **-2** | 7.46 (5.12, 10.88) | 0.28 (0.04, 1.96) | 30.55 (28.50, 32.74) | 1.57 (1.15, 2.13) |
| **-1** | 9.12 (6.48, 12.83) | 0.55 (0.14, 2.21) | 33.49 (31.35, 35.79) | 1.22 (0.87, 1.73) |
| \* Total number of surgeries per group, an individual may have received more than one surgery of the same type  TKR: total knee replacement | | | | |

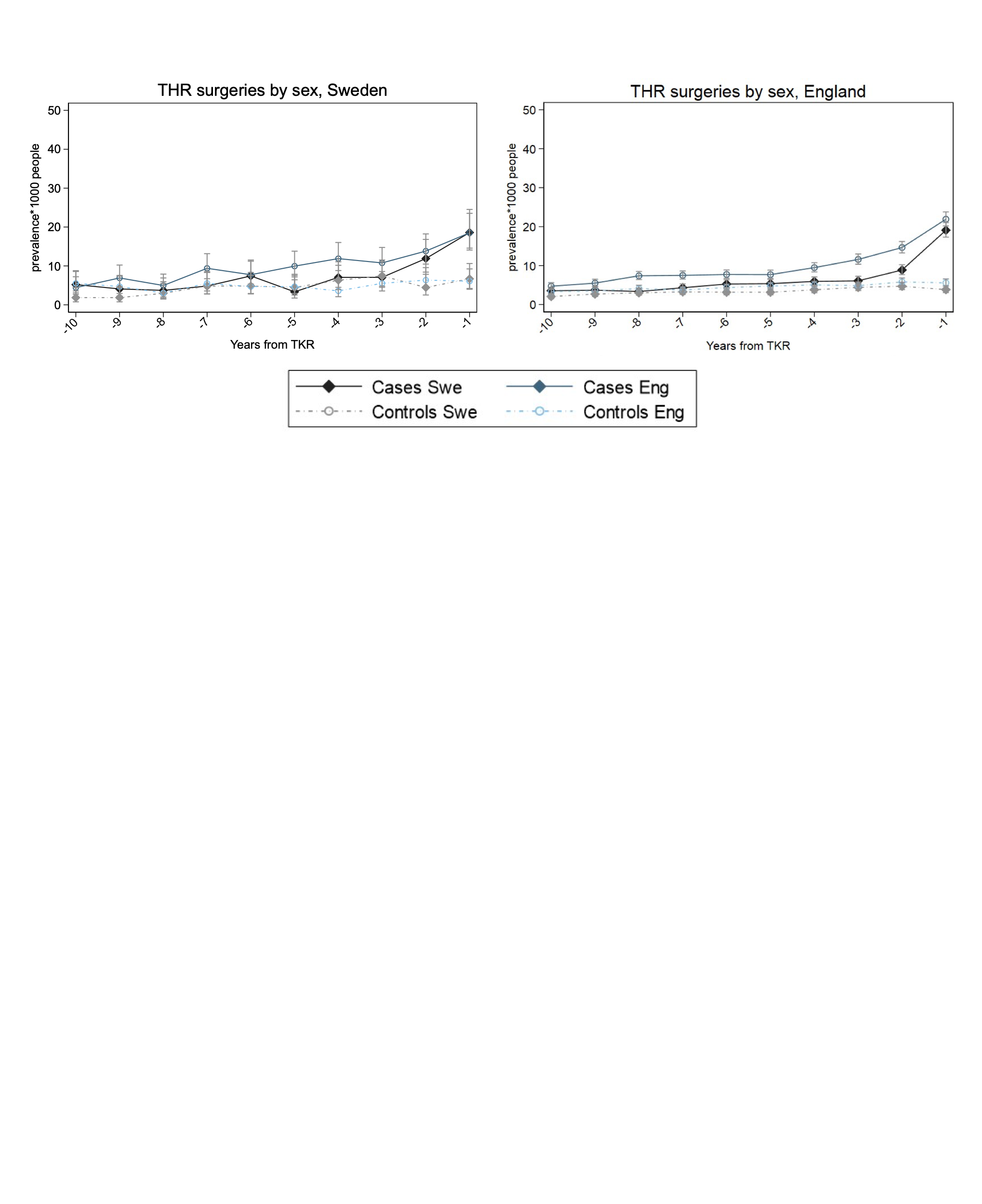
**Supplementary file 15**: prevalence of **total hip replacement (THR)** in the ten years prior a primary knee replacement by age group

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | **Sweden** | | **England** | |
| Years prior TKR | **Cases**  (n=6,337) | | **Controls**  (n=6,337) | **Cases**  (n=47,010) | **Controls**  (n=47,010) |
|  | **< 65 years** | | | | |
| **-10** | 3.01 (1.35, 6.70) | | 1.01 (0.25, 4.04) | 1.97 (1.35, 2.87) | 1.02 (0.60, 1.72) |
| **-9** | 2.01 (0.75, 5.35) | | 0.00 (0.00, .) | 2.26 (1.59, 3.21) | 0.80 (0.44, 1.45) |
| **-8** | 0.50 (0.07, 3.56) | | 0.51 (0.07, 3.59) | 2.84 (2.08, 3.89) | 0.87 (0.50, 1.54) |
| **-7** | 1.51 (0.49, 4.67) | | 0.51 (0.07, 3.59) | 2.70 (1.95, 3.72) | 1.75 (1.17, 2.61) |
| **-6** | 1.51 (0.49, 4.67) | | 0.00 (0.00, .) | 3.86 (2.95, 5.06) | 0.80 (0.44, 1.45) |
| **-5** | 3.51 (1.67, 7.37) | | 2.02 (0.76, 5.39) | 3.72 (2.83, 4.89) | 1.53 (1.00, 2.35) |
| **-4** | 3.51 (1.67, 7.37) | | 0.51 (0.07, 3.59) | 4.23 (3.27, 5.47) | 1.90 (1.29, 2.78) |
| **-3** | 6.52 (3.79, 11.23) | | 0.51 (0.07, 3.59) | 5.03 (3.97, 6.37) | 2.26 (1.59, 3.21) |
| **-2** | 5.52 (3.06, 9.97) | | 1.52 (0.49, 4.70) | 6.49 (5.27, 7.99) | 2.41 (1.71, 3.38) |
| **-1** | 10.04 (6.47, 15.55) | | 1.01 (0.25, 4.04) | 15.89 (13.92, 18.15) | 2.26 (1.59, 3.21) |
|  | **≥ 65 years** | | | | |
| **-10** | 5.56 (3.73, 8.30) | | 5.31 (3.53, 7.99) | 5.11 (4.39, 5.93) | 3.45 (2.88, 4.15) |
| **-9** | 7.42 (5.24, 10.49) | | 5.08 (3.35, 7.72) | 5.71 (4.95, 6.58) | 4.12 (3.48, 4.87) |
| **-8** | 6.26 (4.29, 9.12) | | 4.16 (2.62, 6.60) | 6.73 (5.90, 7.67) | 4.75 (4.06, 5.55) |
| **-7** | 10.20 (7.59, 13.70) | | 7.39 (5.23, 10.45) | 7.48 (6.61, 8.47) | 4.27 (3.62, 5.03) |
| **-6** | 10.43 (7.79, 13.97) | | 6.93 (4.84, 9.91) | 7.78 (6.89, 8.79) | 5.08 (4.37, 5.90) |
| **-5** | 8.81 (6.41, 12.10) | | 5.77 (3.90, 8.54) | 7.87 (6.97, 8.88) | 5.08 (4.37, 5.90) |
| **-4** | 12.75 (9.79, 16.60) | | 6.70 (4.65, 9.64) | 9.43 (8.44, 10.54) | 5.56 (4.81, 6.42) |
| **-3** | 10.43 (7.79, 13.97) | | 9.01 (6.58, 12.33) | 10.84 (9.78, 12.02) | 5.65 (4.89, 6.51) |
| **-2** | 16.45 (13.04, 20.76) | | 7.39 (5.23, 10.45) | 14.39 (13.16, 15.74) | 6.52 (5.71, 7.45) |
| **-1** | 22.48 (18.42, 27.43) | | 8.78 (6.39, 12.06) | 22.62 (21.06, 24.29) | 5.86 (5.09, 6.74) |
| \* Total number of surgeries per group, an individual may have received more than one surgery of the same type  TKR: total knee replacement | | | | | |

**Supplementary file 16**: prevalence of **total hip replacement (THR)** in the ten years prior a primary knee replacement by age group

**Supplementary file 17**: prevalence of **total hip replacement** **(THR)** in the ten years prior a primary knee replacement in men and women

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Sweden** | | **England** | |
| Years prior TKR | **Cases**  (n=6,337) | **Controls**  (n=6,337) | **Cases**  (n=47,010) | **Controls**  (n=47,010) |
|  | **Men** | | | |
| **-10** | 5.20 (3.08, 8.79) | 1.86 (0.77, 4.47) | 3.55 (2.83, 4.46) | 2.06 (1.53, 2.78) |
| **-9** | 4.09 (2.26, 7.38) | 1.86 (0.77, 4.47) | 3.69 (2.95, 4.62) | 2.69 (2.07, 3.49) |
| **-8** | 3.72 (2.00, 6.91) | 2.97 (1.49, 5.95) | 3.36 (2.66, 4.24) | 3.02 (2.36, 3.87) |
| **-7** | 4.83 (2.81, 8.32) | 4.83 (2.81, 8.32) | 4.32 (3.51, 5.31) | 3.26 (2.57, 4.14) |
| **-6** | 7.43 (4.80, 11.52) | 4.83 (2.81, 8.32) | 5.27 (4.38, 6.36) | 3.16 (2.49, 4.03) |
| **-5** | 3.35 (1.74, 6.43) | 4.46 (2.53, 7.86) | 5.37 (4.46, 6.46) | 3.16 (2.49, 4.03) |
| **-4** | 7.06 (4.51, 11.07) | 6.32 (3.93, 10.17) | 5.95 (4.99, 7.09) | 3.79 (3.04, 4.72) |
| **-3** | 7.06 (4.51, 11.07) | 7.43 (4.80, 11.52) | 6.09 (5.12, 7.25) | 4.41 (3.60, 5.41) |
| **-2** | 11.90 (8.41, 16.82) | 4.46 (2.53, 7.86) | 8.87 (7.68, 10.25) | 4.70 (3.85, 5.73) |
| **-1** | 18.59 (14.09, 24.52) | 6.69 (4.22, 10.62) | 19.08 (17.30, 21.05) | 3.84 (3.08, 4.78) |
|  | **Women** | | | |
| **-10** | 4.42 (2.71, 7.22) | 5.53 (3.57, 8.57) | 4.70 (3.94, 5.61) | 3.29 (2.66, 4.06) |
| **-9** | 6.91 (4.67, 10.23) | 4.70 (2.92, 7.56) | 5.51 (4.68, 6.48) | 3.52 (2.87, 4.32) |
| **-8** | 4.98 (3.13, 7.90) | 3.04 (1.68, 5.49) | 7.38 (6.41, 8.50) | 4.09 (3.38, 4.94) |
| **-7** | 9.40 (6.71, 13.15) | 5.53 (3.57, 8.57) | 7.49 (6.52, 8.62) | 3.75 (3.07, 4.57) |
| **-6** | 7.74 (5.34, 11.21) | 4.70 (2.92, 7.56) | 7.72 (6.73, 8.87) | 4.36 (3.63, 5.24) |
| **-5** | 9.95 (7.18, 13.79) | 4.70 (2.92, 7.56) | 7.69 (6.69, 8.82) | 4.74 (3.98, 5.65) |
| **-4** | 11.89 (8.81, 16.03) | 3.59 (2.09, 6.19) | 9.48 (8.37, 10.74) | 5.05 (4.26, 5.99) |
| **-3** | 10.78 (7.88, 14.75) | 5.53 (3.57, 8.57) | 11.59 (10.35, 12.97) | 4.86 (4.08, 5.78) |
| **-2** | 13.82 (10.47, 18.23) | 6.36 (4.22, 9.57) | 14.64 (13.25, 16.19) | 5.81 (4.96, 6.81) |
| **-1** | 18.52 (14.58, 23.53) | 6.08 (4.00, 9.23) | 21.91 (20.19, 23.78) | 5.58 (4.75, 6.57) |
| \* Total number of surgeries per group, an individual may have received more than one surgery of the same type  TKR: total knee replacement | | | | |



**Supplementary file 18**: prevalence of **total hip replacement** **(THR)** in the ten years prior to primary total knee replacement in men and women