Geographic region, socioeconomic position and the utilisation of primary total joint replacement for hip or knee osteoarthritis across western Victoria: A cross-sectional multilevel study of the Australian Orthopaedic Association National Joint Replacement Registry

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Author contributions

SLB-O conceived the study and drafted the manuscript. SV undertook the analyses. All authors were involved in the study design and contributed to the interpretation of the background data; all authors provided critical appraisal of the manuscript for important intellectual content; and all authors approved the final manuscript.

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Mini abstract

Compared to urban residents, those in rural/regional areas often experience inequitable healthcare from specialist service-providers. Independent of small between-area differences in utilisation, socially advantaged groups had the greatest uptake of joint replacement. These data suggest low correlation between ‘need’ vs. ‘uptake’ of surgery in rural/regional areas.

Abstract

Background and purpose: Compared to urban residents, those in rural and regional areas often experience inequitable healthcare from specialist service-providers, often due to geographical issues. We investigated associations between socioeconomic position (SEP), region of residence and utilisation of primary total knee replacement (TKR) and/or total hip replacement (THR) for osteoarthritis.

Design and methods: As part of the Ageing, Chronic Disease and Injury study, we extracted data from the Australian Orthopaedic Association National Joint Replacement Registry (2011-2013) for adults that utilised primary TKR (n=4,179; 56% female) and/or THR (n=3,120; 54% female). Residential addresses were matched with the Australian Bureau of Statistics (ABS) 2011 census data: region of residence was defined according to Local Government Areas (LGAs), and area-level SEP (quintiles) defined using an ABS-derived composite index. The ABS-determined control population (n=591,265; 51% female) excluded individuals identified as cases. We performed multilevel logistic regression modelling using a stratified 2-stage cluster design.

Results: TKR was higher for those aged 70-79yr (AOR 1.4 95%CI 1.3-1.5; referent=60-69yr) and in the most advantaged SEP quintile (AOR 2.1, 95%CI 1.8-2.3; referent=SEP quintile 3); results were similar for THR (70-79yr=AOR 1.7, 95%CI 1.5-1.8; SEP quintile 5=AOR 2.5, 95%CI 2.2-2.8). Total variances contributed by the variance in LGAs were 2% (SD random effects±0.28) and 3% (SD±0.32), respectively.

Conclusion: Independent of small between-LGA differences in utilisation, and in contrast to the expected greater prevalence of osteoarthritis in disadvantaged populations, we report greater TKR and THR in more advantaged groups. Further research should investigate whether more advantaged populations may be over-serviced.

Significance for public health

The social and geographic patterning of primary total knee replacement (TKR) and total hip replacement (THR) surgery, and any relationships with age and sex, has not been described for this region. This study links data from Ageing, Chronic Disease and Injury (ACDI) study to the Australian Orthopaedic Association National Joint Replacement Registry, which is the most complete and extensive set of joint replacement data in Australia. This information is particularly important because the need for elective surgery, such as joint replacement for advanced osteoarthritis, may not correlate with the uptake of surgery for residents in these areas. Furthermore, osteoarthritis is more prevalent in rural and farming communities compared to the general population, due to risk factors specific to agricultural and farming activities, including biomechanical stress related to repetitive forceful activities.

Introduction

Aligned with the rapidly ageing Australian population, the predicted growth in populations of all ages in rural and regional areas will significantly contribute to the burden of chronic disease and demand for health service provision [1]. Compared to residents of urbanised areas, those in rural and regional areas of countries such as Australia, Canada and the United States are more likely to experience inequitable healthcare from specialist service providers [2-4], often due to geographical distance between patient and provider [5]. However, it is also suggested that inequities in specialist healthcare are exacerbated by the effect of out-of-pocket healthcare costs on rural and regional residents [6]. Thus, the need for elective surgery, such as joint replacement for advanced joint disease, may not correlate with the uptake of surgery for residents in rural and regional areas, particularly where access to financial resources may be lower. Joint diseases, such as osteoarthritis, are more prevalent in rural and farming communities compared to the general population, due to risk factors specific to agricultural and farming activities, including biomechanical stress related to repetitive forceful activities [7, 8].

The pattern of primary total knee replacement (TKR) and total hip replacement (THR) surgery, and any relationships with age, sex, geographic location and socioeconomic position (SEP) has not been described for the region of western Victoria. These data will enhance the development of a comprehensive snapshot of health across Western Victoria, currently being compiled from various sources as part of the Ageing, Chronic Disease and Injury (ACDI) study [9]. The ACDI study was launched in 2015 to address the dearth of locally-generated health-specific data available from the rural and regional sub-populations resident in western Victoria. The value of these current data is imperative to contribute to locally-generated knowledge regarding any between- or within-area differences in the utilisation of disease-specific TKR and/or THR

Methods

Australian Orthopaedic Association National Joint Replacement Registry

The Australian Orthopaedic Association National Joint Replacement Registry (AOA NJRR) commenced documenting knee and hip joint replacement surgery in September 1999; since 2002, data collection has been undertaken in all States and Territories [10]. The AOA NJRR monitors the performance and outcome of joint replacements Australia-wide and receives voluntary cooperation from all public and private hospitals undertaking joint replacement surgery. Data are matched and verified by cross-linking registry data with government hospital separation data for all arthroplasty procedures. We have previously reported that this verification process has established that the Registry receives information on more than 99% of all joint replacement surgeries [11]. The AOA NJRR is the most complete and extensive set of joint replacement data in Australia, and has been validated against health department unit record data using a sequential multi-level matching process coupled with the retrieval of unreported procedures [10].

For this study, we investigated TKR and THR performed for a diagnosis of osteoarthritis during the period 2011-2013 inclusive: osteoarthritis is the most common reason for joint replacement, and this disease-specific focus is relevant to the aim of the ACDI study. An incident primary TKR was defined as a primary replacement of both tibiofemoral joint surfaces (and in some cases also the patellofemoral joint), and an incident primary THR was defined as primary replacement of the acetabulum and femoral articular surface: both conventional and resurfacing procedures were included. Primary partial joint replacements, revisions and joint replacement surgery performed for conditions other than osteoarthritis were excluded. Combined, there were a total of 9,652 primary joint replacement surgeries registered with the AOA NJRR as having been performed during 2003-2010; of those 4,179 were for knee OA and 3,120 were for hip OA, leaving 1,353 ‘other’ joint replacements excluded from analyses (4.4%=knee replacements for other diagnoses; 66.8%=hip replacements for other diagnoses; 16.0%=OA of joints other than the knee or hip; 12.8%=diagnoses other than OA on joints other than the knee or hip).

Cases and control population

As part of the ACDI study, adults residing in western Victoria and registered with the AOA NJRR as having utilised a primary TKR (n=4,179; 56% female) and/or THR (n=3,120; 54% female), regardless of geographic site of the operative procedure, were identified as cases. The full residential address of each patient that had undergone a TKR or THR was matched with the Australian Bureau of Statistics 2011 census data, whereby area-level SEP (quintiles) were defined using the Australian Bureau of Statistics derived composite index of Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD). The IRSAD is equivalised for both advantage and disadvantage, and thus values span the continuum from the most socially disadvantaged to the most socially advantaged. Quintile cut-points for IRSAD values were based on the Victorian population.

From the cross-referencing process of linking residential addresses to the Australian Bureau of Statistics census data, we also ascertained the region of residence according to Local Government Areas. Local Government Areas are administrative boundaries that cover incorporated areas that are legally designated parts of States and/or Territories over which incorporated local governing bodies have responsibility [12]. Western Victoria spans approximately one-third of the State of Victoria, includes 21 Local Government Areas [9] and large areas of agricultural production. Using Australian Bureau of Statistics concordance files, patient data were further mapped to Local Government Areas , so that the full age and sex population counts could be used. The control population (n=591,265; 51% female) was ascertained from Australian Bureau of Statistics data for 2011, excluding those individuals identified as cases, and making the assumption that population figures remained similar 2011-2013.

Ethical approval

The AOA NJRR Data Review Committee approved access to AOA NJRR data for this study, and the Barwon Health Human Research Ethics Committee approved the ACDI study.

Statistical analyses

Cases and controls were categorised into 10 year age groupings for analyses. Multilevel modelling was used to estimate the effect of age, sex, area-level SEP and Local Government Areas on the utilisation of a TKR and/or THR. Given the structure of population data from the Australian Bureau of Statistics, age and sex groupings were aggregated at the Local Government Areas level, and the number of TKR and THR in each sex, age group and Local Government Areas were aggregated over the study period. Separate mixed effects logistic regression with Local Government Areas as a random effect was conducted for each joint and results are presented as odds ratios (OR) and 95% confidence intervals (CI). For easier representation of the socio-economic effect on joint replacement uptake, predicted probabilities of joint replacement for each age group and SEP quintile were calculated, assuming random effect being 0 (denoted in the text as an "average Local Government Areas"). Analyses were performed using Stata 13.0 [13].

Results

Descriptive characteristics of patients that were registered with the AOA NJRR as having utilised a primary TKR (n=4,179) and/or THR (n=3,120) during the period 2011-2013 are presented in Table 1. The greatest proportions of TKR and THR, respectively, were observed in women (56% and 54%), those aged 60-69 years (38% and 32%) and 70-79 years (31% and 31%), and in the second most disadvantaged SEP quintile (28% and 27%).

Table 2 presents results from the multilevel modelling for both TKR and THR using a stratified 2-stage cluster design. Results for the null model show that the likelihood of TKR and THR utilisation differed minimally across the Local Government Areas; differences were 4% (SD of random effects ±0.38) and 5% (SD ±0.41), respectively. These differences were slightly reduced in fully-adjusted multilevel models (adjusted for sex, age groups and SEP), whereby the total variance in TKR and THR contributed by the variance of Local Government Areas was 2% (SD ±0.28) and 3% (SD ±0.32), respectively. In fully-adjusted multilevel models, men were less likely than women to utilise TKR (OR 0.89, 95%CI 0.84-0.94), and, holding the age group of 60-69 years as referent, TKR utilisation increased monotonically with age (groups); rates were lowest for the younger age groups of 0-39, 40-49, and 50-59 years, and greatest for those aged 70-79 years (OR 1.4, 95%CI 1.3-1.5). In this same multilevel model, monotonic increases in the effect of SEP on TKR utilisation were also observed, whereby, holding the mid-SEP quintile 3 as referent, significantly greater rates of TKR were observed in the two most advantaged SEP quintiles (quintile 4=OR 1.14, 95%CI 1.04-1.25, and quintile 5=OR 2.1, 95%CI 1.8-2.3). For THR utilisation, and noting that sex had no effect in fully-adjusted multilevel modelling, a similar relationship was observed for the effect of advancing age (groups) on THR; compared to the referent group of 60-69 years, the peak was observed in those aged 70-79 years (OR 1.65, 95%CI 1.51-1.80). In the same multilevel model, the effect of SEP quintiles on THR utilisation also increased with increasing advantage, whereby, compared to the referent group of the mid-SEP quintile 3, the most disadvantaged quintile was least likely to utilise THR (OR 0.82, 95%CI 0.74-0.90), whilst the two most advantaged SEP quintiles were significantly more likely (quintile 4=OR 1.27, 95%CI 1.16-1.40, and quintile 5=OR 2.46, 95%CI 2.17-2.80).

Figure 1 presents the predicted probabilities (%) of differences in TKR and THR utilisation across SEP quintiles and age groups for persons residing in an ‘average’ Local Government Area. Although differences between SEP quintiles 1-4 were small, the predicted probabilities of TKR and THR for those in SEP quintile 5 were significantly greater. Supplementary Online Table 1 presents the predicted probabilities in each age group and SEP quintile for utilisation of a TKR or THR by persons residing in an ‘average’ Local Government Area: individuals in SEP 5 (most socially advantaged) were more likely to utilise a joint replacement compared to individuals in SEP quintiles 1-4.

Discussion

Whilst we report low differences in TKR and THR across Local Government Areas, large differences were observed between SEP quintiles whereby, compared to the most disadvantaged SEP groups, the most socially advantaged groups were twice as likely to utilise TKR and two-and-a-half times more likely to utilise THR. Utilisation of joint replacement surgery increased with age, peaking in those aged 70-79 years. Few between-sex differences were observed, although men were slightly less likely to utilise a TKR compared to women.

A greater utilisation of TKR and THR in more advantaged SEP populations contrasts sharply with the expectation of higher rates of knee and hip osteoarthritis in socially disadvantaged populations [14]. However, as we have previously reported [15], utilisation is linked to health-seeking behaviour. Thus, whilst we may expect the greater need of TKR and THR to be in the more socially disadvantaged groups, it is these groups that are likely to have lower health literacy [16]. The notion of health literacy encompasses a constellation of health-related cognitive and social skills including interpretative, listening and self-efficacy abilities. Thus, health literacy has strong influences on interaction with healthcare professionals and the healthcare system in general [17]. Indeed, one study reported that ~60% of Australians aged 15-74 years in 2008 had suboptimal health literacy skills [17]. Furthermore, we have previously speculated that those of greater social disadvantage are least likely to have: wealth on which to draw to utilise elective surgery, flexibility with regards to work and social responsibilities, and social support on which to rely during the recovery period post-surgery

[15]. We are unable to determine whether the discrepancy between observed and expected joint replacements in lower SEP groups correlates with differences in patient referral, or with differences in waiting lists for TKR or THR which may have greater representation of disadvantaged individuals. Compounding this issue is the limited information regarding whether SEP-related discrepancies in patient referral originate from lower expectations of the practitioner for the disadvantaged patient to do well post-surgery, and thus a reduced rate of referral [18, 19], the willingness and/or preferences of the patient [20, 21], other individual factors such as culture or work or home-based responsibilities, or perhaps whether local/regional hospitals are both resourced and able to provide the necessary surgery and rehabilitation, or may be over-servicing patients that are more socially advantaged.

Our findings of minimal between- Local Government Areas differences, but clear within- Local Government Areas differences due to SEP, contrasts to regional differences reported in other countries. For instance, in the USA, a large study of sex, geographic, socioeconomic, and racial/ethnic differences in 430,726 TKR performed during the period 1998-2000 reported that any differences in TKR between groups (including racial/ethnic groups) were attributable in part to both geographic differences and income levels [22]. However, our findings of few between- Local Government Areas differences are aligned with those we have previously reported for primary total joint replacement of the shoulder in Australia 2007-2011 [23]. In that multilevel analysis, we observed only minor geographical differences in the uptake of shoulder joint replacement (for men but not women), whereby men in New South Wales were least likely to utilise this surgery compared to men in other States or Territories [23]. It is interesting that our observations in this study of lower TKR and THR utilisation in the most socially disadvantaged populations in western Victoria, contrasts with our observations across Australia 2003-2010. In that previous study, TKR was greater for the most socially disadvantaged groups compared to the least disadvantaged groups [15]. This discrepancy may be reconciled by referring to the 2014 submission to the Senate Inquiry into the extent of income inequality in Australia, which was focused on populations in rural and remote Australia [6]. In particular, that report also highlighted that any inequities in healthcare related to social disadvantage *per se* would be exacerbated by the effect of out-of-pocket healthcare costs on rural and regional residents [6]. Given this, it may be likely that socially disadvantaged persons in rural and regional regions may be the least able to afford TKR or THR, and thus not utilise these surgeries, thereby potentially explaining our findings of lower utilisation than expected in lower SEP groups.

The AOA NJRR encapsulates the most complete and extensive set of joint replacement data in Australia, and, combined with our data extraction that encompassed an entire geographic region, we provide a comprehensive picture of primary total joint replacement utilisation for knee and hip osteoarthritis across western Victoria. We have previously reported that residents in the western Victoria study region span the full continuum of SEP from the most socially disadvantaged to the most advantaged [9]; this wide variation in SEP provides a robust opportunity to investigate inequalities in the uptake of joint replacement. Our study also has some limitations. We are unable to comment on whether the variation in TKR and THR across SEP may be explained by differences in rates of advanced osteoarthritis disease, although data suggest that the rates of osteoarthritis in Australia are greater for socially disadvantaged compared to more advantaged individuals (7.3% vs. 5.7%) [14]. Furthermore, we are unable to determine if the length of time between diagnosis and utilisation of surgery differs between SEP groups. We are also unable to comment on whether surgery was performed in the private vs. public healthcare system. It may be possible that the low variance in TKR and THR contributed by the variance of Local Government Areas (2%, and 3%, respectively) may be related to the rural and/or regional homogeneity of western Victoria. There is an uneven age distribution across Local Government Areas in the region, and whilst this may impact on unadjusted rates of surgery, especially THR, the patterns persisted after adjustment for age. Finally, patients that utilised TKR or THR may not be mutually exclusive.

These are the first data from western Victoria pertaining to social and geographic factors associated with TKR and THR utilisation, and, to the best of our knowledge, the first ever multilevel data investigating this question. We report small differences in TKR and THR utilisation across Local Government Areas, although greater utilisation in socially advantaged compared to disadvantaged groups. These findings contrast with the expectation of greater utilisation in socially disadvantaged groups that would correlate with the higher prevalence of osteoarthritis; further work is necessary to investigate reasons for this, including whether any difference is due to over-servicing in more advantaged groups of the population. In addition, investigations of revision rates of joint replacements would complement the findings of our current study.

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Table 1: Characteristics of patients residing in western Victoria that had utilised a primary TKR and/or THR for a diagnosis of osteoarthritis 2011-2013

	TKR (n=4,179)	*THR (n=3,120)*
Female	2,348 (56%)	1,673 (54%)
Age (years)		
0-39	11 (0.3%)	35 (1%)
40-49	110 (3%)	160 (5%)
50-59	649 (16%)	515 (17%)
60-69	1,571 (38%)	998 (32%)
70-79	1,313 (31%)	967 (31%)
≥80	527 (13%)	445 (14%)
SEP		
Quintile 1[a]	1,118 (27%)	730 (23%)
Quintile 2	1,190 (28%)	838 (27%)
Quintile 3	1,006 (24%)	798 (26%)
Quintile 4	661 (16%)	569 (18%)
Quintile 5[b]	204 (5%)	185 (6%)

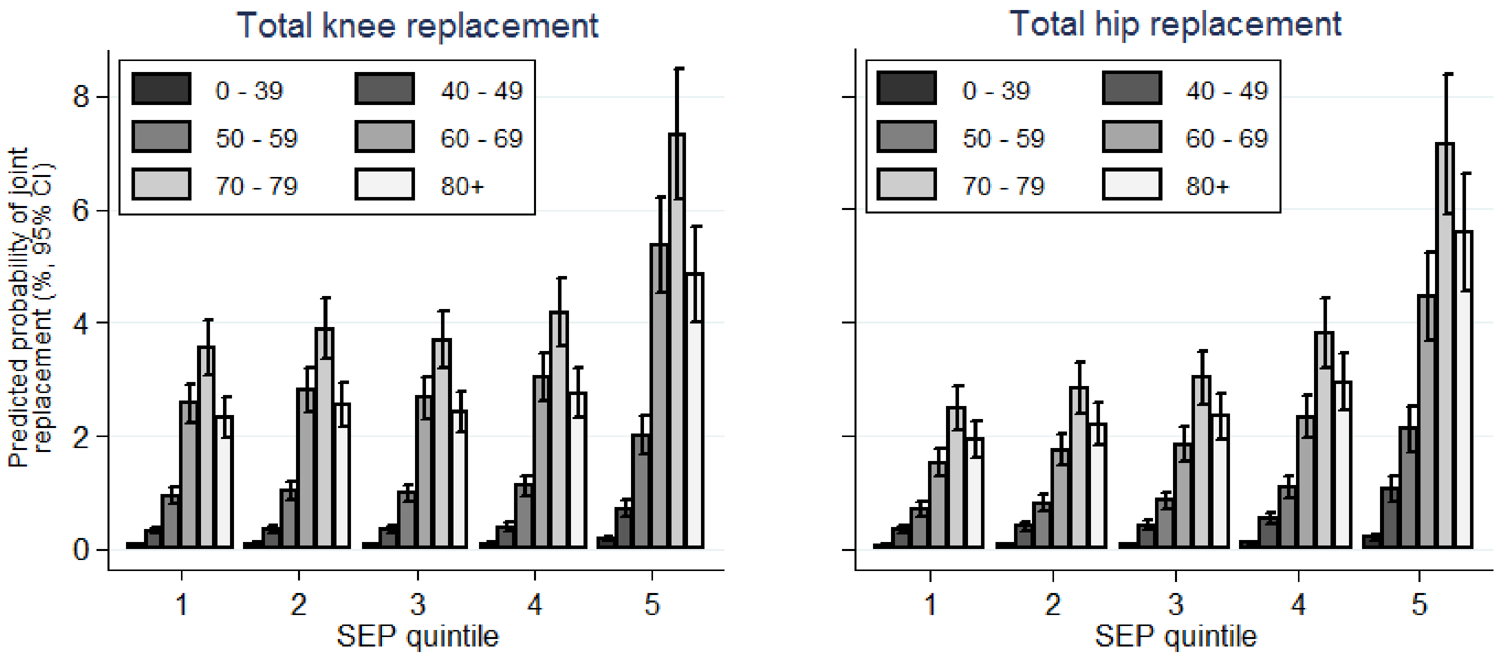
Abbreviations: SEP = socioeconomic position ([a] most disadvantaged; [b] most advantaged); THR = total hip replacement; TKR = total knee replacement

Table 2: Adjusted multilevel logistic regression models showing random effects of sex, age, and SEP on the utilisation of TKR and THR for osteoarthritis; values are the odds ratios (95% confidence intervals) unless otherwise indicated

	Primary total knee replacements (TKR)	*P value*	*Primary total hip replacements (THR)*	*P value*
Sex				
Female (referent)	1.00	-	1.00	-
Male	**0.89 (0.84-0.94)**	**≤0.001**	0.96 (0.90-1.02)	0.26
Age (years)				
0-39	**0.03 (0.03-0.04)**	**≤0.001**	**0.05 (0.42-0.06)**	**≤0.001**
40-49	**0.13 (0.11-0.14)**	**≤0.001**	**0.23 (0.20-0.26)**	**≤0.001**
50-59	**0.36 (0.33-0.39)**	**≤0.001**	**0.46 (0.42-0.51)**	**≤0.001**
60-69 (referent)	1.00	-	1.00	-
70-79	**1.39 (1.30-1.50)**	**≤0.001**	**1.65 (1.51-1.80)**	**≤0.001**
≥80	**0.93 (0.81-0.98)**	**0.02**	**1.26 (1.14-1.41)**	**≤0.001**
Socioeconomic position (SEP)				
Quintile 1 [a]	0.96 (0.88-1.04)	0.32	**0.82 (0.74-0.90)**	**≤0.001**
Quintile 2	1.05 (0.97-1.14)	0.24	0.94 (0.86-1.03)	0.21
Quintile 3 (referent)	1.00	-	1.00	-
Quintile 4	**1.14 (1.04-1.25)**	**0.006**	**1.27 (1.16-1.40)**	**≤0.001**
Quintile 5[b]	**2.07 (1.83-2.33)**	**≤0.001**	**2.46 (2.17-2.80)**	**≤0.001**
Random effects of LGAs[c]	**0.28 (0.20-0.39)**		**0.32 (0.23-0.44)**	
% total variance contributed by LGAs [d]	2%		3%	
P value [e]	**≤0.001**		**≤0.001**	

[a] most disadvantaged socioeconomic quintile; [b] most advantaged socioeconomic quintile; [c] standard deviation of the random effects of Local Government Areas (LGAs); [d] percentage of the total variance contributed by the variance of the LGAs; [e] P value for a likelihood ratio test. Bolded text indicates statistical significance at p value ≤0.05

Figure 1: Predicted probabilities for the utilisation of total knee replacement (TKR) and total hip replacement (THR) across quintiles of SEP (socioeconomic position) in an 'average' Local Government Area (LGA) for each age group.



Supplementary Online Table 1: Predicted probabilities (95%CIs) in each age group and SEP quintile for utilising a TKR or THR: assuming an 'average' Local Government Area (LGA)

SEP quintiles	0-39 years	40-49 years	50-59 years	60-69 years	70-79 years	80 years and older
Total knee replacement (TKR)						
1*	0.08 (0.06-0.09)	0.36 (0.29-0.42)	0.72 (0.59-0.84)	1.53 (1.28-1.77)	2.49 (2.10-2.89)	1.93 (1.61-2.26)
2	0.09 (0.07-0.11)	0.41 (0.33-0.49)	0.82 (0.68-0.96)	1.75 (1.48-2.03)	2.86 (2.41-3.30)	2.22 (1.85-2.58)
3	0.09 (0.07-0.11)	0.44 (0.35-0.52)	0.87 (0.73-1.02)	1.86 (1.57-2.15)	3.03 (2.55-3.51)	2.35 (1.95-2.75)
4	0.12 (0.09-0.14)	0.55 (0.45-0.66)	1.10 (0.92-1.29)	2.35 (1.97-2.73)	3.81 (3.20-4.42)	2.96 (2.45-3.47)
5**	0.23 (0.18-0.28)	1.07 (0.85-1.28)	2.12 (1.73-2.52)	4.46 (3.68-5.24)	7.14 (5.91-8.37)	5.59 (4.55-6.62)
Total hip replacement (THR)						
1*	0.08 (0.07-0.10)	0.33 (0.27-0.39)	0.94 (0.80-1.08)	2.57 (2.22-2.92)	3.56 (3.07-4.04)	2.33 (1.98-2.68)
2	0.09 (0.07-0.11)	0.36 (0.30-0.43)	1.03 (0.88-1.19)	2.81 (2.43-3.20)	3.89 (3.36-4.42)	2.56 (2.18-2.93)
3	0.08 (0.07-0.10)	0.34 (0.28-0.41)	0.98 (0.84-1.13)	2.68 (2.31-3.04)	3.70 (3.19-4.21)	2.42 (2.06-2.79)
4	0.10 (0.08-0.12)	0.39 (0.32-0.46)	1.12 (0.95-1.29)	3.04 (2.60-3.47)	4.19 (3.59-4.79)	2.75 (2.32-3.19)
5**	0.18 (0.14-0.21)	0.71 (0.57-0.85)	2.01 (1.67-2.35)	5.37 (4.53-6.21)	7.33 (6.18-8.47)	4.86 (4.02-5.69)

* most disadvantaged; ** most advantaged