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ORIGINAL ARTICLE

Lifetime Risk of Total Hip Replacement Surgery and Temporal Trends in Utilization: A Population-Based Analysis

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Objective. **To investigate lifetime risk of total hip replacement (THR) surgery in the state of Victoria, Australia and to describe temporal trends in THR incidence.**

Methods. **We analyzed a retrospective population-based longitudinal cohort of patients who received a primary THR in Victoria from 1998–2009. The factors potentially contributing to changes in lifetime risk were also examined, including temporal changes in THR incidence according to health care setting (public versus private), socioeconomic status, and geographic location (regional versus metropolitan).**

Results. **We identified 45,775 patients receiving THR over the time period. For a woman age 20–29 years, the mortality-adjusted lifetime risk rose significantly over time, from 8.49% (95% confidence interval [95% CI] 8.23–8.69%) in 1999–2000 to 10.30% (95% CI 10.07–10.49%) in 2007–2008. For a man age 20–29 years, the mortality-adjusted lifetime risk also increased significantly, from 9.29% (95% CI 8.97–9.58%) in 1999–2000 to 10.27% (95% CI 9.95–10.48%) in 2004–2005, but in contrast to the pattern observed for women, it decreased slightly in 2007–2008 (9.90% [95% CI 9.60–10.16%]). We also identified an increasing number of THRs in private hospitals, in people in middle and low socioeconomic groups, and in rural areas.**

Conclusion. **The lifetime risk of THR for women was similar to men, despite a higher burden of hip osteoarthritis, and this warrants further investigation. However, increases in the number of THR procedures performed for patients in regional areas and in lower socioeconomic groups suggest some reductions over time in known disparities.**

INTRODUCTION

Estimation of the lifetime risk of joint replacement surgery is an emerging field in musculoskeletal epidemiology. While global burden of disease data are valuable for understanding disease incidence and prevalence and the relative impact of a disease on patients' lives (1), lifetime risk provides an alternative method of quantifying population disease burden and associated health care utilization. Although a previous study has demonstrated that the lifetime risk of hip osteoarthritis (OA) may be as high as 25% (2), we identified only 1 study that examined the lifetime risk of total hip replacement (THR) surgery over an individual's lifetime. Culliford et al (3) found that the lifetime risk of THR in the UK has changed markedly over time, particularly for women. The lifetime risk of THR increased over a 15-year period (1991–2006), from 4.0–11.1% for women and from 2.2–6.6% for men.

Changes in lifetime risk of THR over time could be mediated by factors at the external environment (macro), health system (meso), and patient and clinician (micro) levels (Figure 1). Environmental factors, such as changes in population demographics due to the aging population and the social acceptability of THR, may play a role as the procedure becomes more common and educational attainment across the population increases (4). Inequitable access to joint replacement has been identified across a range of settings (5). Our earlier study involving the lifetime risk of total knee replacement (TKR) suggested that policy ini-

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Significance & Innovations

- Estimation of the lifetime risk of joint replacement surgery is an emerging field in musculoskeletal epidemiology. Lifetime risk provides an alternative method to burden of disease data for quantifying population disease burden and associated health care utilization. For this study, lifetime risk of total hip replacement (THR) was used to estimate the probability of having surgery over an individual's lifetime.
- Lifetime risk of THR increased over the 9-year study period to 9.90% (95% confidence interval [95% CI] 9.60–10.16%) for men and 10.27% (95% CI 10.07–10.49%) for women.
- The lifetime risk of THR for both sexes was similar, despite a higher burden of hip osteoarthritis for women, warranting further investigation on the barriers to accessing surgery. Increases in the number of procedures in regional areas and in lower socioeconomic groups suggested reductions in known disparities over time.

tiatives to reduce barriers to accessing TKR increased the overall utilization over the time period for some patient groups (6). We identified a steady increase in the incidence of TKR in Victoria, Australia over the 9-year study period for private hospitals (overall increase of 90%), which may have been related to private health insurance initiatives introduced over the same time period to encourage higher rates of private health insurance, allowing more patients to access surgery through the private system. However, disparities for patients in the public system were still evident. Health system factors are also likely to play a major role in THR utilization. We also found that individuals living in outer regional or remote areas demonstrated the greatest gains in access to TKR over the study period. This may have reflected local initiatives to improve the provision of orthopedic services in nonmetropolitan locations. Last, previous studies have demonstrated that patient-level factors, such as increasing rates of obesity and OA, may be driving increased use of THR. A recent Organisation for Economic Co-operation and Development study found that the rate of obesity increased by ~5% from 1995–2005 among Australian men and women ages 15–64 years, which is similar to the increase over the same time period in the UK (7). The most recent Global Burden of Disease Study showed a 60% increase in hip OA burden from 1990–2010 (2). Increasing acceptance of THR in younger people (8,9) might also contribute to a rise in overall lifetime risk.

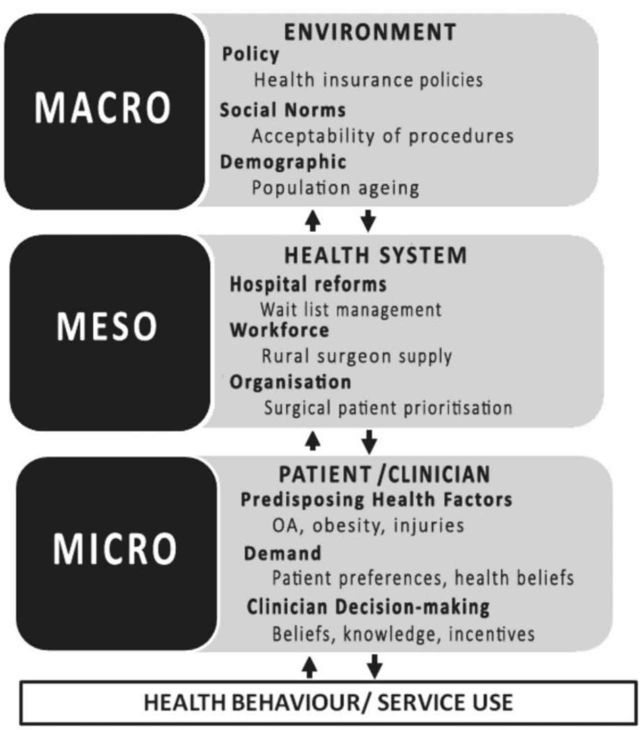

Figure 1. Health service utilization model. This model provides a theoretical framework to demonstrate potential drivers of health care use at the external environment (macro), health system (meso), and patient and clinician (micro) levels. It has been informed by the Andersen health services utilization model (27). OA = osteoarthritis.

Whether similar patterns exist in relation to THR utilization in Australia is unclear because only cross-sectional data have been reported to date (10). Longitudinal investigation of THR incidence according to different system-level factors is fundamental for interpreting temporal changes in the lifetime risk of THR.

The present study aimed to investigate lifetime risk of THR in Victoria, Australia and temporal changes in risk and to describe temporal changes in the incidence of THR according to the health care setting (public versus private), socioeconomic status (SES), and the geographic location of residence and hospital that could contribute to changes in lifetime risk.

PATIENTS AND METHODS

Data sources. Data on THR were obtained from the Victorian Admitted Episodes Data Set (VAED), a hospital admissions data set maintained by the Victorian State Department of Health to provide case mix funding to hospitals and support health service planning (11). The data set includes information on all admitted episodes to public or private hospitals within the state of Victoria. Hospital episodes relating to a single person are linked longitudinally using stepwise deterministic linkage methods developed by the Department of Health. Diagnoses and procedures are coded according to the International Statistical Classification of Disease and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM).

Data on the population of Victoria according to age, sex, SES, and area of residence were obtained from the Australian Bureau of Statistics (ABS). Life-table data for 3 time periods (1999–2000, 2004–2005, and 2007–2008) were also obtained from the ABS and used to calculate mortality-adjusted lifetime risk. Life-table data simulate a hypothetical cohort of 100,000 people in Victoria and report the number of years of life lived by sex at each year of age, which has been estimated using all-cause mortality rates for the Victorian population.

Participant inclusion criteria. The numerator for our study included patients with a hospital admission from July 1, 1998 to June 30, 2009 and an operative procedure code indicating a primary or bilateral THR (Table 1). Because we did not have data on the laterality of procedures, we excluded second primary THR procedures, if identified, over the time period (n = 7,188), because these were assumed to involve the contralateral hip. Patient transfers to other hospitals (n = 434) and admissions including codes to indicate fractures to the neck of the femur (n = 1,527) were also excluded.

Covariates of interest. Our methods have been described previously (6). In summary, age, sex, hospital type (public or private), and hospital region (metropolitan or rural) were extracted from the VAED. Age at the time of hospital admission for THR was categorized into 10-year groups. Patient comorbidities were defined using ICD-10-AM codes (12) (see Supplementary Appendix A, available in the online version of this article at http://onlinelibrary.wiley.com/doi/10.1002/acr.22279/abstract) and the primary diagnosis on admission was identified. We were not able to include obesity among the comorbidities of interest because the coding of this variable was considered to be incomplete. We found that only 1.52% of people receiving THR were obese, compared with Australian population data demonstrating that 20.5% of the general population are obese (13).

The hospital type was included as an indication of health insurance status. In Australia, THR is performed in both the public and private health systems. The public system is funded by the government and provides universal health care, but commonly has long waiting lists for surgery. The private health system is accessible to individuals with private health insurance and those who are able to pay the costs associated with treatment. In the context of THR, the private health system offers 2 main advantages for patients: the choice of surgeon and avoidance of longer wait times for consultation and surgery.

Each patient's Statistical Local Area (SLA) of residence was linked to the Victorian Department of Health region that services the geographic area to provide an indication of the patients' residential rurality. Rural was defined as residing in nonmetropolitan health regions of Melbourne, as classified by the Victorian Department of Health (14). In Australia, rural residence has been linked to poorer health outcomes because access to care can be more limited and rates of risk factors may be higher (15). In contrast to our previous methods (6), we utilized this method of classifying the patients' rurality to allow us to determine whether patients who lived in rural areas were also receiving care at rural hospitals.

Each patient's SLA at the time of hospital admission was linked to the Australian Socio-Economic Indexes for Areas (SEIFA) (16). The SEIFA measure is an Australia-wide area-based index of SES based on census data for each SLA. The Index of Economic Resources, one of 4 measures of SES, was utilized for this study. This composite index includes measures of income, employment, and housing status within each geographic area. We selected this index of SES because it was thought to most closely reflect economic capacity to purchase private health insurance, which allows faster access to THR surgery in Australia.

Table 1. Descriptive characteristics of the cohort*

	Total hip replacement (n = 45,775)
Financial year of procedure	
1998–1999	3,523 (7.70)
1999–2000	3,491 (7.63)
2000–2001	3,694 (8.07)
2001–2002	4,120 (9.00)
2002–2003	4,407 (9.63)
2003–2004	4,543 (9.92)
2004–2005	4,287 (9.37)
2005–2006	4,270 (9.33)
2006–2007	4,171 (9.11)
2007–2008	4,594 (10.04)
2008–2009	4,675 (10.21)
Age group, years	
<30	165 (0.36)
30–39	671 (1.46)
40–49	2,457 (5.37)
50–59	7,101 (15.51)
60–69	13,276 (29.00)
70–79	15,348 (33.52)
≥80	6,757 (14.76)
Sex	
Men	20,404 (44.57)
Women	25,371 (55.43)
Country of birth	
Australian born	33,247 (72.63)
Non–Australian born	12,528 (27.37)
Geographic region	
Metropolitan	28,915 (63.58)
Regional	16,564 (36.42)
Socioeconomic status tertile†	
High	12,842 (28.10)
Middle	18,788 (41.12)
Low	14,065 (30.78)
Comorbid conditions‡	
Hypertension	6,071 (13.26)
Current smoker	3,808 (8.32)
Diabetes mellitus (uncomplicated)	2,173 (4.67)
Chronic lung disease	1,103 (2.41)
Hyperlipidemia	825 (1.80)
Connective tissue disease	765 (1.67)
Chronic heart failure	566 (1.24)
Chronic renal disease	563 (1.23)
Musculoskeletal conditions	
OA	41,663 (91.02)
RA	648 (1.42)

* Values are the number (percentage). OA = osteoarthritis; RA = rheumatoid arthritis.
† Socio-Economic Indexes for Areas Index of Economic Resources.
‡ Comorbidities with frequency >1%.

Table 2. Lifetime risk of future primary hip replacement in 1999–2000, 2004–2005, and 2007–2008, according to age*

	1999–2000						2004–2005						2007–2008					
Current age, years	30–39 years	40–49 years	50–59 years	60–69 years	70–79 years	Ever	30–39 years	40–49 years	50–59 years	60–69 years	70–79 years	Ever	30–39 years	40–49 years	50–59 years	60–69 years	70–79 years	Ever
Women																		
20–29	0.14	0.39	1.18	2.85	5.61	8.49	0.09	0.41	1.46	3.59	6.68	10.11	0.10	0.45	1.60	3.97	7.01	10.30
30–39		0.26	1.05	2.70	5.45	8.27		0.31	1.36	3.48	6.56	9.95		0.35	1.50	3.85	6.88	10.14
40–49			0.78	2.43	5.15	7.91			1.04	3.15	6.21	9.52			1.15	3.49	6.50	9.67
50–59				1.62	4.28	6.82				2.08	5.06	8.12				2.32	5.24	8.15
60–69					2.53	4.62					2.83	5.38					2.77	5.16
70–79						1.46						1.90						1.80
Men																		
20–29	0.12	0.41	1.31	3.09	5.59	9.29	0.12	0.50	1.55	3.62	6.37	10.27	0.12	0.50	1.54	3.6	6.33	9.90
30–39		0.29	1.18	2.95	5.42	9.03		0.38	1.42	3.48	6.21	10.03		0.48	1.40	3.45	6.16	9.65
40–49			0.88	2.64	5.06	8.49			1.04	3.08	5.76	9.39			1.02	3.05	5.71	9.04
50–59				1.72	4.00	6.89				1.99	4.54	7.65				1.99	4.52	7.41
60–69					2.01	3.90					2.29	4.47					2.30	4.36
70–79						0.89						1.23						1.20

* Values are the percentage. Lifetime risk calculations have been undertaken separately for men and women based on the sex-specific values for survival (S) and risk of undergoing a total hip replacement (R) at age X, using the formula $\sum_{x}^{80} S_x \times R_x$.

Where the SLA was missing (n = 197 patients and n = 34 SLAs), we imputed the Index of Economic Resources from SLAs within the closest geographic proximity. Where adjacent SLAs differed in their indices of economic resources, we chose the closest SLA with the largest population.

Statistical analysis. Chi-square analyses were undertaken for comparisons between all categorical variables. The lifetime risk of THR was calculated for each age group by dividing the total number of incident THRs by the total number of people expected to be alive at the beginning of the time period based on the ABS all-cause mortality rates for the Victorian population; these methods have been described elsewhere (6,17). Lifetime risk within each 10-year age group and overall lifetime risk were calculated at 3 time periods (1999–2000, 2004–2005, and 2007–2008) and stratified by sex. 95% confidence intervals (95% CIs) were calculated using a Poisson model, as recommended for rate-based analyses (18).

We calculated the incidence of THR for each financial year (July 1 to June 30) within the study period according to health care setting (public versus private), SES, and residential and hospital location (metropolitan versus rural). The population data used for SES have been previously described (6). All statistical analyses were performed using Microsoft Excel 2010 and Stata, version 12. This study received approval from the Monash University Ethics Committee, and the approval was registered at the University of Melbourne.

RESULTS

Characteristics of the cohort. We identified 45,775 patients with a hospital episode including a primary THR procedure over the study period (Table 1). There was a 33% increase in the number of primary THR procedures over this time period. THR surgery was most common among women (55.43%), people ages 70–79 years (33.52%), people residing in metropolitan areas (63.58%), those in the middle socioeconomic tertile (41.12%), and those with a concomitant diagnosis of OA (91.02%). People residing in metropolitan Melbourne (the capital city of Victoria) were more likely to be treated in private hospitals than people from regional areas (68.62% versus 51.92%; $P \leq 0.01$). This is consistent with the geographic distribution of public and private hospitals in Australia.

Lifetime risk of primary THR. We examined the lifetime risk of THR at 3 time points (1999–2000, 2004–2005, and 2007–2008) across all age groups, stratified by sex (Table 2). For a woman age 20–29 years, the mortality-adjusted lifetime risk rose significantly over time, from 8.49% (95% CI 8.23–8.69%) in 1999–2000 to 10.11% (95% CI 9.85–10.31%) in 2004–2005 and to 10.30% (95% CI 10.07–10.49%) in 2007–2008. The observed trend in lifetime risk was noted to differ by age groups for women. The lifetime risk of undergoing THR at age 30–39 years among those currently ages 20–29 years was found to decrease significantly from 1999–2000 to 2004–2005 (0.14–0.09, $P < 0.01$) but then remained stable to 2007–2008 (0.09–0.10, $P = 0.46$). While some decreasing trends were noted for other age groups from 2004–2005 to 2007–2008, none of these were found to be significant.

For a man age 20–29 years, the mortality-adjusted lifetime risk also increased significantly, from 9.29% (95% CI 8.97–9.58%) in 1999–2000 to 10.27% (95% CI 9.95–10.48%) in 2004–2005, but in contrast to the pattern observed for women, there was a trend toward a decrease in lifetime risk in 2007–2008 (9.90% [95% CI 9.60–10.16%]). The decreasing trend did not reach significance ($P = 0.06$). While the decrease in lifetime risk from 2004–2005 to

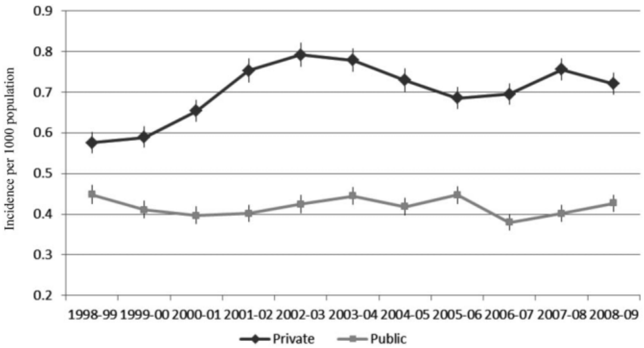

Figure 2. Incidence of total hip replacement by hospital setting. Nonoverlapping confidence limits represent significant differences in incidence ($P < 0.05$).

2007–2008 was consistent across the majority of age groups for men, no significant differences were evident.

Temporal changes in the incidence of primary THR. The incidence of THRs was higher in private hospitals than in public hospitals for much of the study period (Figure 2). The incidence of THRs in private hospitals increased significantly over the study period, from 0.58 per 1,000 population (95% CI 0.56–0.60) in 1998–1999 to 0.72 per 1,000 population (95% CI 0.69–0.75) in 2008–2009, while the incidence in public hospitals remained relatively stable at 0.45 per 1,000 population (95% CI 0.43–0.47) in 1998–1999 and 0.43 (95% CI 0.41–0.45) in 2008–2009.

From 1999–2000 to 2001–2002, all 3 SES tertiles demonstrated growth in the incidence of THRs (Figure 3). Notably, the incidence of THR in the highest socioeconomic tertile dropped from 0.84 per 1,000 population (95% CI 0.79–0.89) in 2001–2002 to 0.75 per 1,000 population (95% CI 0.71–0.79) in 2002–2003, where it remained relatively constant until 2008–2009. Conversely, the incidence in both the middle and lower socioeconomic tertiles continued to increase from 2001–2002 onward, although this was not significant for the middle tertile (from 1.17 per 1,000 population [95% CI 1.11–1.22] in 2001–2002 to 1.28 per 1,000 population [95% CI 1.22–1.34] in 2008–2009; $P = 0.05$). For the lowest tertile, THR incidence increased significantly, from 0.83 per 1,000 population (95% CI 0.79–0.88) in 2001–2002 to 1.02 per 1,000 population (95% CI 0.96–1.07) in 2008–2009.

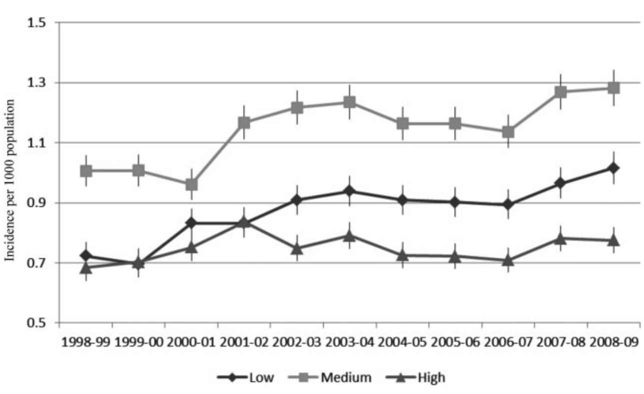

Figure 3. Incidence of total hip replacement by socioeconomic status tertile. Nonoverlapping confidence limits represent significant differences in incidence ($P < 0.05$).

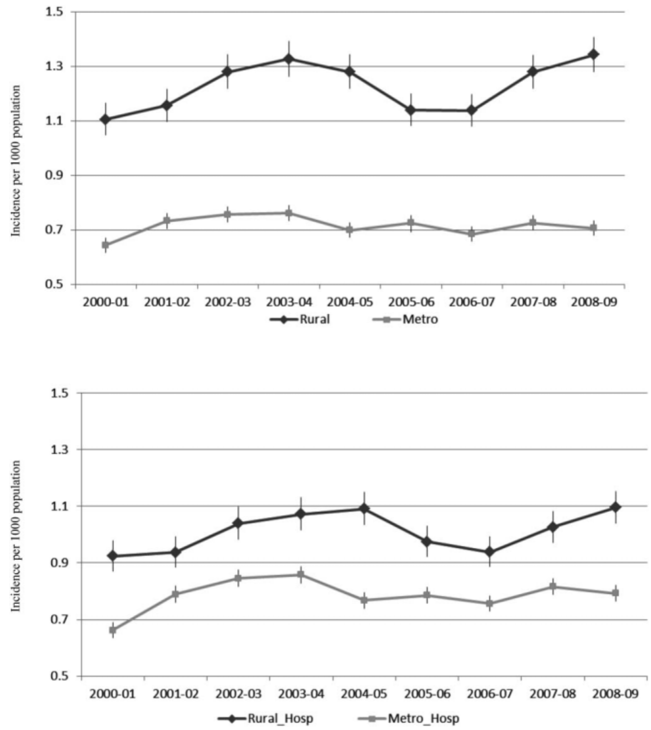

Figure 4. Incidence of total hip replacement by residential rurality and hospital (Hosp) rurality. Nonoverlapping confidence limits represent significant differences in incidence ($P < 0.05$).

The incidence of THR for patients residing in metropolitan locations showed a slight increase over the study period (from 0.64 per 1,000 population [95% CI 0.62–0.67] to 0.71 per 1,000 population [95% CI 0.68–0.73]; $P = 0.03$). However, there was a sharper increase in incidence over this period for patients residing in regional locations (from 1.10 per 1,000 population [95% CI 1.05–1.16] to 1.34 per 1,000 population [95% CI 1.28–1.41]) (Figure 4). While a proportion of patients residing in regional areas received their care at metropolitan hospitals (n = 3,145 [19.0%]), a small but significant increase in the incidence of THR in regional hospitals was evident over the study period (from 0.92 per 1,000 population [95% CI 0.87–0.98] to 1.10 per 1,000 population [95% CI 1.03–1.15]; $P < 0.001$) (Figure 4).

DISCUSSION

Over the 11-year period examined in this study, we quantified the lifetime risk of THR in the second largest state in Australia (accounting for 20% of the population) (19). We also characterized changes in THR utilization according to different system-level factors that could theoretically impact lifetime risk of surgery. There was a significant increase in the lifetime risk of THR for both sexes, although this trend was sharper for women. Despite this trend, our overall lifetime risk estimates were relatively similar for both sexes. Because the prevalence of hip OA is known to be higher in women compared with men in Australia (20), this difference may indicate underutilization of surgery by women and warrants further investigation. We also noted increasing utilization in private hospitals and for patients both residing in rural areas and being treated in rural areas. THR incidence increased in the middle and lowest socioeconomic groups, while the highest group remained steady, suggesting improved access to surgery over time for the lower 2 groups.

Our lifetime risk estimates for THR for men ages 50–59 were relatively consistent with estimates reported by Culliford et al (3) in the UK but significantly lower for women in this age group. When considering overall lifetime risk from ages 20–29 years, our estimates for women are comparable with the UK data, suggesting women may be receiving THR at younger ages in Australia. This may relate to sex- and age-related differences in the diagnosis and uptake of THR between countries (21). Exploring the international patterns of lifetime THR risk could help to identify the contribution of patient-level factors, such as OA and obesity burden, and differences in health policies and surgical practices (Figure 1). The increased trends in the lifetime risk of THR identified in this study were similar to those identified in our previous study examining the lifetime risk of TKR (6); however, TKR utilization patterns demonstrated a greater increase than THR over the time period. In the previous study, we also noted an increase in TKRs in regional settings, suggesting this may relate to system-wide changes. Encouragingly, we observed an increasing trend in THRs for the lowest SES group; this is in contrast to the reducing incidence of TKRs for this group over a similar time period. The difference in temporal trends in THR and TKR utilization may reflect a mismatch between greater potential need for TKR among people in lower SES groups (due to manual occupations or workplace injury) and the ability of the health system to meet this demand. A recent cross-sectional Australian study demonstrated higher rates of TKR for Australians living in the most disadvantaged areas compared with those living in the least disadvantaged areas and cited greater occupational risk factors as a possible explanation for the increased demand in this group (10).

At the environmental level, health insurance reforms were introduced in Australia in 1999–2000, which may have contributed to the observed rise in THR incidence in private hospitals and the observed increases in lifetime risk between 1999–2000 and 2004–2005 for both sexes. The initiatives, including substantial rebates and incremental loadings on insurance premiums according to age, saw the proportion of Australians with private health insurance increase from 38% in 1998 to 51% in 2001 (22). At the health system level, the Elective Surgery Access Service was introduced in 2002 to fast-track patients facing lengthy waits for THR or TKR by transferring their care to hospitals with the capacity to provide surgery more quickly (23). Another major health system initiative was the Osteoarthritis Hip and Knee Service, which was piloted at 4 major public hospital sites in 2006–2007 and implemented at an additional 10 sites in 2008–2009. This service included the introduction of a new patient monitoring and surgical prioritization system to reduce waiting times for orthopedic assessment and surgery and to facilitate faster access to care for people with the greatest need (24). It is now part of routine standard care in Victorian public hospitals. The increase in the number of THRs performed in rural patients may be related to workforce initiatives to increase the number of orthopedic surgeons in regional areas; however, this trend was also seen among rural patients receiving care in metropolitan hospitals, so it may reflect greater need among rural patients. Variation in the rates of orthopedic procedures in different geographic areas has been documented elsewhere, which may be related to differences in indications and clinical decision making for surgery in different settings (10,25).

There are several limitations to this study that should be acknowledged. This study relied primarily on health system administrative data. These data were collected primarily for hospital reimbursement purposes; therefore, detailed clinical information, such as the laterality of the procedures, was not available. While this would not change our estimates of overall lifetime risk, we may have overestimated the patient's age at the first primary THR if a prior procedure had been conducted on the contralateral hip. Because ages were provided to us in groupings (with ≥80 years being the highest category), we were not able to examine the lifetime risk for patients ages 80–89 years. We also excluded procedures conducted for fractured neck of femurs; however, these accounted for only 3.3% of total THR procedures. The proportion of cases with missing SLA data was 0.4%, wherein we imputed SES using nearest neighbor imputation methods (26). Given the small number of cases, these were unlikely to change our estimates. Data on some patient comorbidities, such as obesity, were well below population averages and believed to be underreported in our data, so we were unable to use these data in our analyses. Finally, we based this study on data from a single Australian state. Because the population of Victoria accounts for 20% of the Australian population, it is reasonable to expect the Victorian data to be representative of other large Australian states. However, the state-based policy initiatives we described to improve access to THR during the study period may have produced local trends.

In conclusion, we identified an increase in the lifetime risk of THR for both men and women over the 11-year study period. The observed increases in the number of procedures performed for patients in regional areas and in lower socioeconomic groups are encouraging and suggest some reductions over time in known disparities. However, the lifetime risk of THR performed in women was similar to men, despite a higher burden of hip OA, and warrants further investigation.

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AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be published. Dr. Bohensky had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. Bohensky, Ackerman, de Steiger, Brand.

Acquisition of data. Bohensky.

Analysis and interpretation of data. Bohensky, Ackerman, de Steiger, Gorelik, Brand.

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