University Library

MINERVA ACCESS

A gateway to Melbourne's research publications

Minerva Access is the Institutional Repository of The University of Melbourne

Author/s:
Trieu, J;Dowsey, MM;Schilling, C;Spelman, T;Choong, PF

Title:
Population growth, ageing and obesity do not sufficiently explain the increased utilization of total knee replacement in Australia

Date:
2020-07-01

Citation:
Trieu, J., Dowsey, M. M., Schilling, C., Spelman, T. & Choong, P. F. (2020). Population growth, ageing and obesity do not sufficiently explain the increased utilization of total knee replacement in Australia. ANZ Journal of Surgery, 90 (7-8), pp.1283-1288. https://doi.org/10.1111/ans.16120.

Persistent Link:
https://hdl.handle.net/11343/276016

Trieu Jason (Orcid ID: 0000-0003-0146-3085)

Population growth, ageing, and obesity do not sufficiently explain the increased utilisation of total knee replacement in Australia

Dr Jason Trieu BBiomed MD

PhD candidate

University of Melbourne Department of Surgery, St Vincent's Hospital

Level 2, Clinical Sciences Building, 29 Regent Street, Fitzroy VIC 3065, Australia

trieu@student.unimelb.edu.au

University of Melbourne Research Training Program Scholarship Recipient (APP1116325)

Associate Professor Michelle M. Dowsey BHealthSci(Nursing) MEpi PhD

NHMRC Career Development Fellow, Deputy Academic Head

University of Melbourne Department of Surgery, St Vincent's Hospital

Level 2, Clinical Sciences Building, 29 Regent Street, Fitzroy VIC 3065, Australia

Department of Orthopaedic Surgery, St Vincent's Hospital

41 Victoria Parade, Fitzroy VIC 3065, Australia

mmdowsey@unimelb.edu.au

NHMRC Career Development Fellowship Recipient (APP1122526)

Dr Chris Schilling BEng(Hons) BCom(Hons) MSc PhD

Senior Research Fellow

University of Melbourne Department of Surgery, St Vincent's Hospital

Level 2, Clinical Sciences Building, 29 Regent Street, Fitzroy VIC 3065, Australia

chris.schilling@unimelb.edu.au

Dr Tim Spelman MBBS PhD

Senior Statistician

University of Melbourne Department of Surgery, St Vincent's Hospital

Level 2, Clinical Sciences Building, 29 Regent Street, Fitzroy VIC 3065, Australia

tim@burnet.edu.au

NHMRC Early Career Fellowship Recipient (APP1130685)

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/ans.16120

This article is protected by copyright. All rights reserved.

Author Manuscript

Professor Peter F. Choong MBBS MD FRACS FAOrthA FAAHMS
Sir Hugh Devine Chair of Surgery, NHMRC Practitioner Fellow
University of Melbourne Department of Surgery, St Vincent's Hospital
Level 2, Clinical Sciences Building, 29 Regent Street, Fitzroy VIC 3065, Australia
Director of Orthopaedic Surgery
Department of Orthopaedic Surgery, St Vincent's Hospital
41 Victoria Parade, Fitzroy VIC 3065, Australia
pchoong@unimelb.edu.au
NHMRC Practitioner Fellowship Recipient (APP1154203)

Corresponding author
Dr Jason Trieu
University of Melbourne Department of Surgery, St Vincent's Hospital
Level 2, Clinical Sciences Building, 29 Regent Street, Fitzroy VIC 3065, Australia
Email: trieu@student.unimelb.edu.au
Mobile: 0468 636 220
University of Melbourne Research Training Program Scholarship Recipient (APP1116325)

Figures included: 1
Tables included: 1
Supplementary files: 2

Abstract word count: 234 words
Text word count: 2486 words

This article is protected by copyright. All rights reserved.

Author Manuscript

Author Manuscript

Abstract

Background

The utilisation of total knee replacement has increased significantly. The objective of this study was to assess the impact of changes in population demography (population growth, ageing, and gender) and body mass indices on the additional volume of knee replacement surgery undertaken in Australia.

Methods

Using national data, we compared estimates based on changes in population demography and body mass indices to the reported increase in total knee replacement between 2007 and 2017. The costs of additional surgery were estimated using the National Hospital Cost Data Collection.

Results

An additional 25,814 total knee replacements were performed in 2017 compared to 2007. Contributions from population growth, ageing, and changing body mass indices were 27.1%, 10.4%, and 6.3% to 15.3% respectively. Other drivers contributed between 47.2% to 56.2%, representing 12,176 to 14,506 total knee replacements at a financial cost of A$320.9 million to A$382.3 million per year in 2017.

Conclusion

The volume of additional surgery being performed considerably exceeded estimates based on changing population demography and rising rates of obesity. The other drivers of additional total knee replacement utilisation will likely have significant implications for the health budget and warrant further investigation. This may involve an examination of the current indications for surgery and the

This article is protected by copyright. All rights reserved.

cost-effectiveness of total knee replacement in various settings, reviewing patient expectations and preferences, and assessing the impact of policies which relate to the funding and provision of total knee replacement.

Key words: orthopaedic surgery, health economics, health services research, utilisation, total knee replacement

Author Manuscript

Introduction

Ageing and obesity are thought to have driven the increased use of total knee replacement (TKR).(1) The changing epidemiology of knee arthritis, changing patient expectations, expansion of surgical indications, and improved surgical outcomes have been considered other possible drivers of increased use.(2, 3) It remains unclear whether the increase in surgical volume reflects a rising disease burden or a combination of the aforementioned factors.

Understanding the prime drivers of utilisation will be important because there are concerns that the financial consequences from increased surgical volume incur an unsustainable burden to the nation's health budget.(4) Identifying the relative contributions from changes in population demography (population growth, ageing, gender) and body mass indices (BMI) towards growth in TKR utilisation would be informative in directing research towards strategies of value-based care which are critical at times of rising cost constraint.

National population and registry data were used to explore the effects of these changes, cast a focus on the indications for surgery, and assist with healthcare planning. The primary aim of this study was to determine the impact of changing population demography and changing BMI on TKR utilisation. Secondary aims were to identify the impact of other drivers on additional surgical volume, the costs of surgery, and on surgical activity.

This article is protected by copyright. All rights reserved.

Author Manuscript

Methods

A retrospective population-level analysis using national demographic and joint replacement registry data.

Data sources

Reported surgical volume

Reported TKR utilisation for the years 2007 and 2017 were accessed through the Australian Orthopaedic Association's National Joint Replacement Registry (AOANJRR)(2). The AOANJRR an Australian Government-funded clinical registry that collects joint replacement data from public and private hospitals in Australia. The data set enables the performance of implanted prostheses to be monitored.

Estimated surgical volume

Population estimates were accessed through the Australian Bureau of Statistics (ABS).(5) These estimates are based on the Census of Population and Housing.

This article is protected by copyright. All rights reserved.

BMI data from the ABS National Health Surveys 2007-08 and 2017-18 were used to identify the proportion of adults who were classified as normal or underweight (BMI <25 kg/m^2), overweight (BMI 25-29.9 kg/m^2), or obese (BMI ≥30 kg/m^2).(6, 7)

The gender distribution of TKR recipients for 2007 was accessed through St Vincent's Hospital Melbourne Arthroplasty Outcomes Registry (SMART) compiled by the Department of Orthopaedic Surgery and based at the Department of Surgery, St Vincent's Hospital Melbourne. SMART is an institutional registry that prospectively collects data relating to patients undergoing total joint replacement at the hospital.(8, 9)

Item numbers 49518, 49519, and 49521 (total knee replacement, bilateral total knee replacement, and total knee replacement with major bone grafting) were accessed through Medicare Item Reports to identify the age distribution of TKR recipients. Medicare is a universal health insurance scheme funded by the Australian Government that subsidises access to health services for all Australians.

Cost of surgery and surgical activity

Procedural costs for TKR ("Knee Replacement, Minor Complexity", code 104B) were obtained from the National Hospital Cost Data Collection (NHCDC) and standardised to 2017 Australian dollars using the total health price index.(10, 11) The NHCDC is a collection of health system costs across both public and private hospitals and is used to determine public hospital funding. Public healthcare services are jointly funded by Federal, State, and Territory Governments. Private healthcare services are funded through a combination of government subsidies, private health insurance, and self-funding from users.(12)

Surgical workface data was accessed through reports from the Royal Australasian College of Surgeons and Health Workforce Australia.(13, 14) The Health Workforce Australia report provided workforce data for 2009; reported surgical volumes for the same year were used for comparison.

Data analysis

Using Medicare Item Reports, we identified that >99% of TKR recipients were ≥45 years of age and restricted analysis of demographic and BMI changes to this group.

National data from the ABS and the NHS were populated according to age (45 to 54 years, 55 to 64 years, 65 to 74 years, and ≥75 years), gender (male, female), and BMI (<25 kg/m^2, BMI 25-29.9

This article is protected by copyright. All rights reserved.

Author Manuscript

kg/m^2, and BMI ≥30 kg/m^2). TKR procedural volumes for 2007 and 2017 reported by the AOANJRR were similarly populated into to the same categories. TKR volume by BMI was estimated using published risk ratios for overweight and obese patients compared to normal weight patients.(15, 16) A sensitivity analysis was performed across a range of different risk ratio scenarios as described (table S2).

We used previously described methods to estimate TKR volumes for 2017.(3) Estimates were determined by changing the reported TKR volume in 2007 by the same percentage as the change in each of the age, gender, and BMI subgroups. The underlying assumption was that the utilisation rate remained constant. Estimates were compared to reported volumes. The residual difference between estimated and reported volume represented the impact of other drivers on additional TKR utilisation. As age and gender were not included in the sensitivity analysis, variations in the residual difference were due to associated variations in BMI estimates.

The financial cost of this additional utilisation was then estimated using NHCDC data as described and then weighted according to the public and private share of additional TKR since 2007.

The annual volume of TKR for the years 2009 and 2017 were compared with the number of orthopaedic surgeons to determine surgical activity.

Analysis was performed in Microsoft Excel 2016 Version 1909 (Microsoft, Washington, United States).

This study was not referred to an ethics committee because data were publicly accessible, de-identified population-level data.

Results

Approximately 29,298 TKRs were performed amongst 7.9 million individuals aged ≥45 years in 2007. The rate of use increased by 88.1% over a ten-year period to approximately 55,112 TKRs amongst 9.8 million individuals in 2017, representing an additional 25,814 TKRs each year.

Population

This article is protected by copyright. All rights reserved.

Author Manuscript

Population growth contributed to an increase from 29,298 TKRs to 36,290 TKRs. The additional 6,992 TKRs represented 27.1% of the observed growth in TKR volume over this period (table S1).

Ageing

Ageing contributed a further 2,685 TKRs, representing 10.4% of the growth in TKR volume (table S1). The highest rate of growth in population group by age was 49.5% in individuals aged sixty-five to seventy-four years old, and the lowest rate of growth occurred in individuals aged forty-five to fifty-four years old with this population expanding by 10.5%.

Gender

The changing gender composition contributed an estimated 10 additional TKRs, or less than 0.1%, to the observed growth in TKR volume over this period (table S1).

BMI

An estimated 1,631 additional TKRs were a result of changes in BMI composition, representing 6.3% of the growth in TKR volume (figure 1). Under the sensitivity analysis, changes in BMI contributed up to 3,961 additional TKRs representing 15.3% of the growth in TKR volume. The highest rate of growth was observed in the obese at 59.1%, followed by the overweight population at 14.3%, and normal and underweight individuals at 2.1%.

Other drivers

Other drivers accounted for a minimum 47.2% of the growth in TKR volume (figure 1). This represented an additional 12,176 TKRs each year. Under the sensitivity analysis, this increased up to 56.2%, representing an additional 14,506 TKRs.

Financial cost

Procedural cost for TKR in public was A$19,684 and in private was A$28,408 in the year 2017 (table 1). The weighted cost was A$26,358. The financial cost resulting from other drivers of utilisation was estimated at A$320.9 million to A$382.3 million per year.

This article is protected by copyright. All rights reserved.

Author Manuscript

Surgical activity

Approximately 33,884 TKRs were performed amongst 1,168 orthopaedic surgeons in 2009, an average of 29.0 TKRs per surgeon (19.5 TKRs in private hospitals and 9.5 TKRs in public hospitals). This increased to 40.9 TKRs per surgeon (28.5 TKRs in private hospitals and 12.4 TKRs in public hospitals) in 2017, with 55,122 TKRs performed amongst 1,348 orthopaedic surgeons. Over this period, 76.5% of the additional volume was undertaken in private hospitals and 23.5% in public hospitals.

Author Manuscript

This article is protected by copyright. All rights reserved.

Discussion

The primary aim of this study was to determine the impact of changing population demography and changing BMI on TKR utilisation. These drivers were largely insufficient in explaining the significant growth in procedural volume reported (figure 1). An additional 25,814 TKRs were performed in 2017 compared to 2007. Contributions from population growth, ageing, and changing body mass indices were 27.1%, 10.4%, and 6.3% to 15.3% respectively. Other drivers contributed between 47.2% to 56.2%, representing 12,176 to 14,506 TKRs at a financial cost of A$320.9 million to A$382.3 million per year in 2017 (table 1).

Population growth contributed an estimated 6,992 additional TKRs (table S1). Whilst population growth has been postulated to drive increased use of TKR, our findings were consistent with research which suggested that the contribution from population growth to the significant rise in procedural volumes over time was constrained.(3, 17) Interestingly, the impact of age as a driver of TKR use was considerably less than population growth despite strong associations between advancing age and increased TKR utilisation.(2) We estimated that ageing contributed an additional 2,685 TKRs each year. The highest rates of growth were observed in individuals aged 65 to 74 years, which expanded by 50% over the ten-year period. Despite this, we note that ageing similarly had a limited impact on driving additional TKR volume. The changing gender composition had a largely neutral effect on TKR utilisation. Gender composition shifted towards an increased proportion of males who had lower utilisation rates than females. This mostly occurred in the population of individuals >65 years of age who had higher utilisation rates compared to younger individuals.

The higher rates of obesity across all age groups translated to a shift in the population's BMI composition. This transitioned the most common BMI group from overweight to obese. We estimated that changing BMI composition contributed an additional 1,631 to 3,961 TKRs each year (table S2). The association between increasing BMI and risk of TKR is well recognised.(16, 18) However, our estimates suggested that the impact of rising obesity as a driver of TKR utilisation was unable to explain the growth observed. This was consistent with findings from Culliford et al. who reported that changing BMI compositions in the British population was estimated to contribute only 7% to growth in TKR utilisation through to the year 2035.(19)

It has been suggested that the increased use of TKR over time could reflect additional surgery being performed to address unmet need following the introduction of private health insurance incentives.(20) In publicly funded healthcare systems, elective surgery waiting lists are commonly

This article is protected by copyright. All rights reserved.

Author Manuscript

employed to prioritise the allocation of limited resources towards competing patient demand for surgery.(21) An increasing number of patients experience TKR waitlist times exceeding six months, and approximately ten percent wait up to a year for surgery – these times do not include the period from initial referral to placement on the waiting list.(22) Research has suggested that patients who wait longer than six months have higher levels of anxiety, poorer post-operative patient-reported outcome scores, and higher rates of dissatisfaction.(23) High uptake of private health insurance may encourage patients to seek access to TKR privately as an alternative, and this may contribute to the increased utilisation observed in private hospitals.(24, 25) A greater proportion of TKR was performed in private hospitals over time, with approximately three-quarters of additional TKR volume being undertaken in this setting.(25) The increased utilisation of TKR in both hospital settings translated to greater levels of surgical activity on average amongst practising orthopaedic surgeons. Surgical activity increased by 40.1%, rising from 29.0 TKRs per surgeon in 2009 to 40.9 TKRs per surgeon in 2017. Whilst we recognise that not all orthopaedic surgeons perform TKR, these data serve to highlight a role for orthopaedic surgeons in appropriately stewarding resource-intensive interventions which can be cost-effective in the right setting.(26)

The suggestion that the additional surgical volume is partially due to an expansion of TKR eligibility towards patients with less severe symptoms may have implications for patient outcomes and the cost-effective delivery of surgery.(27) The growth in TKR utilisation has been reported to primarily occur in lower volume hospitals.(28) In contrast, surgery undertaken at higher-volume centres and performed by higher-volume surgeons have been associated with lower mortality, lower risk of adverse peri-operative outcomes, and more cost-effective delivery of surgery.(29-31) The distribution of additional surgical volume and its implications is an area that merits further exploration.(29) Research should consider the distribution of additional TKR cases according to hospital volume, and whether this has an impact on the cost-effectiveness of surgery in Australia.

With increasing focus on the high cost of TKR, it is important to consider whether current TKR practice is addressing needs in a financially sustainable manner.(26, 32, 33) Surgical volumes are projected to increase further.(4) Healthcare service providers and agencies are looking towards cost savings and ways of improving the value of care provided.(26) We have demonstrated that there are other drivers of increased utilisation beyond changes in population demography and rising obesity which are responsible for a considerable volume of additional surgery at significant financial cost. The changing epidemiology of knee arthritis, changing patient expectations, expansion of surgical

This article is protected by copyright. All rights reserved.

Author Manuscript

indications, and improved surgical outcomes have been raised as the other possible drivers of increased utilisation.(2, 3) Differential access to surgery through the public and private hospital systems may also play a role. These other drivers warrant further investigation. This may require detailed examination of the current indications for surgery and the cost-effectiveness of TKR in various settings, review of patient expectations and preferences, and assessment of the impact of policies related to the funding and provision of TKR services.(3, 26, 34)

Several limitations warrant mention. AOANJRR data used to inform our estimates presented utilisation data inclusive of all TKR recipients <55 years of age - our estimates of TKR use in the 45 to 54-year age group include TKRs performed in patients <45 years of age and are therefore over-estimates. Whilst distribution of reported TKR volume by BMI according to published risk ratios only provided estimates, the relative distribution of TKR across BMI groups in 2017 based on these ratios are consistent with reports from the AOANJRR. The SMART gender distribution was available for each age subgroup and therefore used to estimate the impact of changing gender composition over time. The gender distribution from SMART showed that the proportion of female TKR recipients was higher than the national proportion reported by the AOANJRR. However, findings remained robust following sensitivity analysis using the AOANJRR gender distribution. This required the assumption that the AOANJRR gender distribution was equivalent across each age subgroup; gender distribution at this level was not available from the annual report.

Conclusion

The volume of additional surgery being performed considerably exceeded estimates based on changing population demography and rising rates of obesity. The other drivers of additional TKR utilisation will likely have significant implications for the health budget and warrant further investigation. This may involve an examination of the current indications for surgery and the cost-effectiveness of TKR in various settings, reviewing patient expectations and preferences, and assessing the impact of policies which relate to the funding and provision of TKR.

Disclosures

All listed authors do not have any conflicts of interest to declare.

This article is protected by copyright. All rights reserved.

Author Manuscript

Author Manuscript

References

1. Derman PB, Fabricant PD, David G. The Role of Overweight and Obesity in Relation to the More Rapid Growth of Total Knee Arthroplasty Volume Compared with Total Hip Arthroplasty Volume. J Bone Joint Surg Am. 2014;96(11):922-8.
2. Australian Orthopaedic Association. Hip, Knee & Shoulder Arthroplasty. Annual Report. 2018.
3. Losina E, Thornhill TS, Rome BN, Wright J, Katz JN. The dramatic increase in total knee replacement utilization rates in the United States cannot be fully explained by growth in population size and the obesity epidemic. J Bone Joint Surg Am. 2012;94(3):201-7.
4. Ackerman IN, Bohensky MA, Zomer E, Tacey M, Gorelik A, Brand CA, et al. The projected burden of primary total knee and hip replacement for osteoarthritis in Australia to the year 2030. BMC Musculoskeletal Disorders. 2019;20(1):90.
5. Australian Bureau of Statistics. TABLE 59. Estimated Resident Population By Single Year Of Age, Australia. Australian Demographic Statistics. 2019.
6. Australian Bureau of Statistics. 4364.0 - National Health Survey: Summary of Results, 2007-2008 (Reissue). 2009.
7. Australian Bureau of Statistics. 4364.0.55.001 - National Health Survey: First Results, 2017-18. 2018.
8. Dowsey MM, Spelman T, Choong PF. Development of a Prognostic Nomogram for Predicting the Probability of Nonresponse to Total Knee Arthroplasty 1 Year After Surgery. The Journal of arthroplasty. 2016;31(8):1654-60.
9. Dowsey MM, Choong PFM, Paxton EW, Spelman T, Namba RS, Inacio MCS. Body Mass Index Is Associated With All-cause Mortality After THA and TKA. Clinical orthopaedics and related research. 2018;476(6):1139-48.
10. Independent Hospital Pricing Authority. Cost Weights for AR-DRG Version 8.0, Round 21 (2016-17). National Hospital Cost Data Collection 2019.
11. Australian Institute of Health and Welfare. Health expenditure Australia 2017-18, Supplementary tables. Health expenditure Australia 2017-18. 2019.

This article is protected by copyright. All rights reserved.

12. Australian Government Department of Health. The Australian health system. Available from https://wwwhealthgovau/about-us/the-australian-health-system. 2019.
13. Royal Australasian College of Surgeons. Activities Report 2017. Available from https://wwwsurgeonsorg/media/25670553/2018-05-09_rpt_activities_report_pdf_finalpdf. 2018.
14. Health Workforce Australia. Health Workforce Australia 2012: Health Workforce 2025 – Volume 3 – Medical Specialties. 2019.
15. Muthuri SG, Hui M, Doherty M, Zhang W. What if we prevent obesity? Risk reduction in knee osteoarthritis estimated through a meta-analysis of observational studies. Arthritis Care & Research. 2011;63(7):982-90.
16. Leyland KM, Judge A, Javaid MK, Diez-Perez A, Carr A, Cooper C, et al. Obesity and the Relative Risk of Knee Replacement Surgery in Patients With Knee Osteoarthritis: A Prospective Cohort Study. Arthritis & rheumatology (Hoboken, NJ). 2016;68(4):817-25.
17. Crowninshield RD, Rosenberg AG, Sporer SM. Changing demographics of patients with total joint replacement. Clin Orthop Relat Res. 2006;443:266-72.
18. Hussain SM, Wang Y, Shaw JE, Wluka AE, Graves S, Gambhir M, et al. Relationship of weight and obesity with the risk of knee and hip arthroplasty for osteoarthritis across different levels of physical performance: a prospective cohort study. Scand J Rheumatol. 2019;48(1):64-71.
19. Culliford D, Maskell J, Judge A, Cooper C, Prieto-Alhambra D, Arden NK. Future projections of total hip and knee arthroplasty in the UK: results from the UK Clinical Practice Research Datalink. Osteoarthritis Cartilage. 2015;23(4):594-600.
20. Ackerman IN, Bohensky MA, de Steiger R, Brand CA, Eskelinen A, Fenstad AM, et al. Substantial rise in the lifetime risk of primary total knee replacement surgery for osteoarthritis from 2003 to 2013: an international, population-level analysis. Osteoarthritis Cartilage. 2017;25(4):455-61.
21. Curtis AJ, Russell CO, Stoelwinder JU, McNeil JJ. Waiting lists and elective surgery: ordering the queue. The Medical journal of Australia. 2010;192(4):217-20.
22. Australian Institute of Health and Welfare. Elective surgery waiting times 2017–18: Australian hospital statistics. Health services series 2018;88.
23. Lizaur-Utrilla A, Martinez-Mendez D, Miralles-Muñoz FA, Marco-Gomez L, Lopez-Prats FA. Negative impact of waiting time for primary total knee arthroplasty on satisfaction and patient-reported outcome. International orthopaedics. 2016;40(11):2303-7.
24. Johar M, Jones G, Keane M, Savage E, Stavrunova O. Waiting times for elective surgery and the decision to buy private health insurance. Health Econ. 2011;20(S1):68-86.
25. Australian Orthopaedic Association. Demographics of Hip, Knee and Shoulder Arthroplasty. Annual Report. 2019.
26. Dakin H, Gray A, Fitzpatrick R, MacLennan G, Murray D. Rationing of total knee replacement: a cost-effectiveness analysis on a large trial data set. BMJ Open. 2012;2(1):e000332.
27. Ferket BS, Feldman Z, Zhou J, Oei EH, Bierma-Zeinstra SMA, Mazumdar M. Impact of total knee replacement practice: Cost effectiveness analysis of data from the Osteoarthritis Initiative. BMJ (Online). 2017;356:j1131.
28. Leskinen J, Eskelinen A, Huhtala H, Paavolainen P, Remes V. The incidence of knee arthroplasty for primary osteoarthritis grows rapidly among baby boomers: a population-based study in Finland. Arthritis Rheum. 2012;64(2):423-8.
29. Losina E, Walensky RP, Kessler CL, Emrani PS, Reichmann WM, Wright EA, et al. Cost-effectiveness of total knee arthroplasty in the United States: patient risk and hospital volume. Archives of internal medicine. 2009;169(12):1113-22.

This article is protected by copyright. All rights reserved.

Author Manuscript

30. Hervey SL, Purves HR, Guller U, Toth AP, Vail TP, Pietrobon R. Provider Volume of Total Knee Arthroplasties and Patient Outcomes in the HCUP-Nationwide Inpatient Sample. J Bone Joint Surg Am. 2003;85(9):1775-83.
31. Katz JN, Barrett J, Mahomed NN, Baron JA, Wright RJ, Losina E. Association between hospital and surgeon procedure volume and the outcomes of total knee replacement. J Bone Joint Surg Am. 2004;86(9):1909-16.
32. Peel TN, Cheng AC, Liew D, Buising KL, Lisik J, Carroll KA, et al. Direct hospital cost determinants following hip and knee arthroplasty. Arthritis Care Res (Hoboken). 2015;67(6):782-90.
33. Carducci MP, Gasbarro G, Menendez ME, Mahendraraj KA, Mattingly DA, Talmo C, et al. Variation in the Cost of Care for Different Types of Joint Arthroplasty. J Bone Joint Surg Am. 2019.
34. Losina E, Katz JN. Total knee arthroplasty on the rise in younger patients: are we sure that past performance will guarantee future success? Arthritis Rheum. 2012;64(2):339-41.

Figure 1. Decomposition of additional TKR volume according to various drivers of utilisation, modelled under a sensitivity analysis.

Supporting information:

Table S1

Table S2

This article is protected by copyright. All rights reserved.

Author Manuscript

Setting	Financial cost
Public hospital	$19,684
Private hospital	$28,408
Weighted average	$26,358

TKRs per surgeon	2009	Financial cost
Public hospital	9.5	$186,998
Private hospital	19.5	$553,956
Total	29.0	$740,954
	2017	Financial cost
Public hospital	12.4	$244,082
Private hospital	28.5	$809,628
Total	40.9	$1,053,710

	Scenario 1		Scenario 3	
Drivers	TKRs	Financial cost	TKRs	Financial cost
Population growth	6,992	$184,295,136	6,992	$184,295,136
Population ageing	2,685	$70,771,230	2,685	$70,771,230
Changing BMI composition	1,631	$42,989,898	3,961	$104,404,038
Other drivers	14,506	$382,349,148	12,176	$320,935,008
Total	25,814	$680,405,412	25,814	$680,405,412

Table 1. Financial costs associated with drivers of TKR utilisation

Author Manuscript

This article is protected by copyright. All rights reserved.

Author Manuscript

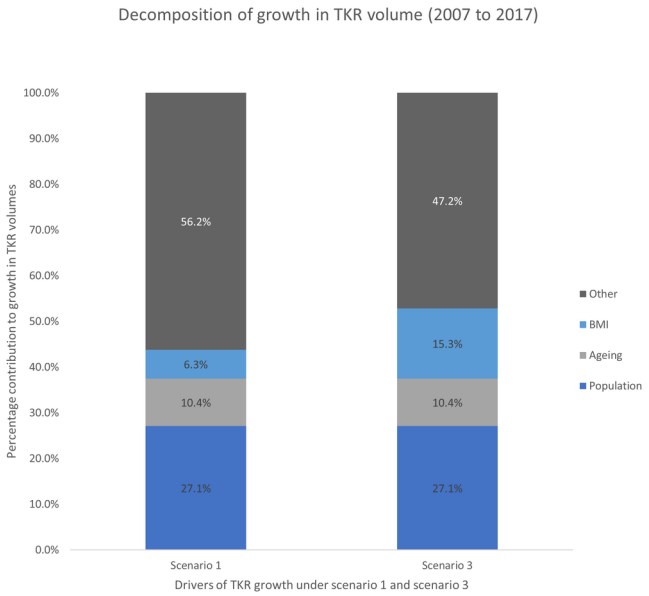


Figure 1. Decomposition of additional TKR volume according to various drivers of utilisation, modelled under a sensitivity analysis.

ANS_16120_Figure 1.tif

This article is protected by copyright. All rights reserved.