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Factors influencing prosthesis selection and variation: a survey of orthopaedic surgeons in Australia

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ABSTRACT

Background There is increasing demand for knee and hip arthroplasty with considerable health system cost implications. Despite the high surgical costs relating to the prosthesis used, little is known about which factors are most influential in prosthesis choice, nor is it clear what level of variation may be warranted for clinical reasons.

Objectives This study had dual objectives: (1) identify factors influencing prosthesis selection for total hip arthroplasty (THA) and total knee arthroplasty (TKA) and (2) develop a working definition for unwarranted variation in THA and TKA implant selection.

Design A three-stage prospective study: (1) develop and pilot a questionnaire with input from orthopaedic surgeons; (2) a cross-sectional survey with orthopaedic surgeons across Australia and (3) an expert panel to finalise the working definition of unwarranted variation.

Setting and participants Study activities were conducted both virtually and in person, primarily with hospital-based orthopaedic surgeons and orthopaedic registrars across Australia, but also included health economists and health administrators in the expert panel stage.

Results Revision rates, familiarity with an implant and implant quality were prioritised when choosing a prosthesis, while other factors, including cost, were reported to have limited influence. Technological advancement and revision rates were influential for past changes in prostheses, and strong clinical evidence is expected to precede future changes. The consensus was reached on a working definition of unwarranted variation that focused on implants with revision rates of 20% or higher compared with published benchmarks. The use of multiple cost thresholds was recommended for defining narrow and broad definitions of unwarranted variation.

Conclusion Study findings provide valuable insights into the decision-making process for prosthesis selection, as well as what surgeons believe might constitute unwarranted variation. This information can advance our understanding of the magnitude and impact of unwarranted variation in prosthesis selection, as well as inform strategies to address it.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ By exploring key factors influencing surgeon decision-making and advancing a definition of unwarranted variation, this study enables health services to assess the scale of unwarranted variation and inform future strategies to address this issue.
⇒ A representative sample of consultant orthopaedic surgeons across Australia completed the survey; however, this was not the case for registrars, and therefore, those specific results must be interpreted with caution.
⇒ Terminologies such as 'prosthesis quality' and 'departmental consensus' were not explicitly defined, which may have resulted in multiple interpretations within the survey responses.

INTRODUCTION

The number of total hip arthroplasty (THA) and total knee arthroplasty (TKA) surgeries is increasing globally, particularly across Organisation for Economic Co-operation and Development countries.[1] High-income countries, including the USA, are currently experiencing very high incidence rates for both THA and TKA, while in other high-income countries, such as Australia, rates are expected to double in the coming decades.[2–4] In the Australian context, where the present study was conducted, projected costs are expected to reach $A1.38 billion for TKA and $A953 million for THA, respectively, by the year 2030,[5] with the cost of the implant itself averaging approximately 60% of the total expenditure.[6 7]

In high-income countries, prosthesis selection is largely driven by orthopaedic surgeons, but little is known about what factors influence their decision-making. A recent systematic review to identify the factors influencing surgeons' prosthesis selections for knee and hip arthroplasty in high-income countries highlighted a range of factors, including patient anatomy, familiarity with the implant,

implant quality and the friendliness of the sales representative.[8] However, due to the small number and heterogeneity of studies on this topic, no strong conclusions about the relative importance of these factors were articulated.

A better understanding of factors influencing prosthesis selection is needed to support the development and implementation of strategies to improve patient outcomes and reduce unwarranted variations. Unwarranted variation that is unrelated to clinical need, evidence or patient preferences can lead to poorer outcomes for patients or other detrimental effects, including higher costs or wasted healthcare resources.[9 10] The dual objectives of this study were to (1) identify factors influencing prosthesis selection by surgeons for THA and TKA and (2) develop a working definition for what could be considered unwarranted variation in implant selection for THA and TKA. This working definition will be used to inform an economic analysis of unwarranted variation.

METHODS

Study design

Informed by our recently completed scoping review of factors influencing prosthesis selection,[8] we undertook a three-stage mixed methods study to address the objectives. The first stage comprised (1) interviews with orthopaedic surgeons to inform the questionnaire design and (2) piloting the questionnaire. The second stage was conducting a cross-sectional survey with orthopaedic surgeons in Australia. The results of the survey were then reviewed by the expert panel in stage three, which was convened to consolidate a working definition of unwarranted variation for implant selection for THA and TKA.

Public or patient involvement

There was no public or patient involvement in the design or conduct of this study.

Stage 1: evelopment and pilot of questionnaire

Key informant interviews with three orthopaedic surgeons were used to explore the findings of the systematic review and develop a questionnaire for surgeons within the Australian context. Key informant sampling was used, with participants for the interviews and pilot recruited via email through existing professional networks. A semi-structured interview guide was used to explore factors influencing prosthesis selection and what constitutes unwarranted variation (online supplemental file 1). Online piloting of the questionnaire was undertaken to review question wording and structure to ensure clinical relevance, as well as usability for participants.

Analysis and question development

Initial interviews with key informants were audio recorded and transcribed. Framework analysis of the interview transcripts was undertaken using the seven-step process of transcription, familiarisation with the data, coding, framework development, applying the framework, charting the data and interpreting the data for meaning.[11] The initial framework was based on inductive coding and deductive coding relating to the factors derived from the systematic review. Codes were grouped to create themes and then used to formulate the questions. Multiple iterations of the draft questionnaire were shared, both electronically and in person, with available interview participants and the research team to refine the question content, phrasing and structure of the questionnaire. To pilot the penultimate questionnaire, an orthopaedic surgeon, a health economist and a healthcare administrator were emailed a link to the questionnaire, with feedback emailed to the lead author (MJA).

Final questionnaire

The final questionnaire had six sections: respondent characteristics, level of autonomy, factors influencing prosthesis selection, changing prosthesis selection, registry results and unwarranted variation. It contained between 15 and 28 questions depending on the responses. The questionnaire used branching, whereby the number and type of questions depended on whether participants indicated they were a consultant or a registrar, whether they performed THA, TKA or 'both' and whether they worked in a public hospital, private hospital or both. For example, if a respondent indicated that they only conducted THA, then no subsequent questions relating to TKA would be shown. There were no required fields, and respondents could choose not to answer any of the questions.

Section 1: Respondent characteristics

The questionnaire was built on Qualtrics and included several questions to describe respondent characteristics, including their age, number and location of surgeries performed.

Section 2: evel of autonomy and knowledge of cost

Both the systematic review and the interviews highlighted that there needed to be questions relating to the level of autonomy that surgeons have in relation to prosthesis selection in their context, as well as their awareness of the cost of the prostheses they use, to support the interpretation of results, which were both added to the final survey.

Section 3: actors influencing prosthesis selection

Twelve factors derived from the systematic review and interviews were included in the questionnaire. Pilot and interview participants suggested that selecting the top five factors influencing selection would be sufficient to gain useful insight, without being too onerous.

Section 4: hanging prosthesis selection

Interview participants suggested that surgeons might select prostheses and their associated suppliers based on what they had been trained on. Therefore, questions were included regarding whether surgeons changed prostheses in the past, the reasons for doing so and the potential reasons for future changes.

Section 5: egistry results

Australia has a national joint registry that publishes revision rates for implants and combinations of implants, including individual surgeon-level data. Questions on the use of registry data were also included.

Section 6: nwarranted variation

Three questions about unwarranted variation were included using 5-year and 10-year revision rates and cost thresholds informed by national reporting measures and interview data.

Stage 2: urvey of orthopaedic surgeons

Participants

A cross-sectional survey was conducted with:

1. Consultant orthopaedic surgeons who undertake hip and/or knee surgery in Australia and are registered on the member email list of the Arthroplasty Society of Australia, a subspecialty group of the Australian Orthopaedic Association.
2. Orthopaedic registrars.

Recruitment

Survey participants were contacted via email sent from the Arthroplasty Society of Australia that contained a link to the questionnaire. The Arthroplasty Society of Australia has 121 members on its mailing list. 20 registrars were also emailed a link to the questionnaire through informal clinical networks, with the request to share it with other registrars. The questionnaire remained active for months to allow time for completion.

Analysis

The questionnaire responses were analysed using descriptive statistics and use of a numerical score to identify the highest priority factor. For this prioritisation exercise, respondents were asked to select the five most important factors (from a list of 12) that they consider when selecting an implant. All free text comments provided have been reported.

SURVEY RESULTS

Respondent characteristics

The survey was completed by 59 participants, including 50 consultants and 9 registrars, with a response rate of 41% and 45%, respectively. Respondent characteristics are outlined in table 1, noting respondents from all Australian states and territories, except the Northern Territory, and a 75%–25% split between those practising in metropolitan compared with regional hospitals. Most respondents practised in both public and private hospitals (56%, n=33), with the remainder split evenly between public only and private only. The majority of consultants noted that they were either 15–20 years (n=12, 24%) or 20+ years (n=20, 40%) postorthopaedic specialisation training.

Level of autonomy and knowledge of cost

For those practising in private hospitals, all respondents noted full autonomy over prosthesis selection. Approximately half of the consultants practising in public hospitals reported full autonomy (51%, n=19), closely followed by departmental consensus (46%, n=17), with a single participant noting limited input. When combined with registrar responses, the departmental consensus became the most selected response overall (n=21, 46%) for those practising in public hospitals. Free text comments highlighted that several consultants with full autonomy in public hospitals noted some hospital processes to minimise variation (that were not enforced), while registrar choices were directed. Further, most respondents (n=51, 88%) either knew the cost of the implant/s they use most often (n=19, 32%) or knew the approximate price range (±$A1000) (n=32, 54%). Further details on autonomy and knowledge are shown in table 2.

Factors influencing prosthesis selection

The factor selected most often as surgeons' first priority was revision rate (n=20). The two most frequently selected 'top 5' factors, regardless of position, were revision rates and familiarity with the implant (selected 45 and 40 times, respectively). Cost, availability of implants at hospitals and length of time in surgery were the lowest-ranked factors. The prioritisation of factors is outlined in table 3.

Changes to prosthesis selection

Questions related to changes in prosthesis selection were split into those who conduct THA (n=44) and those who conduct TKA (n=49), with some respondents answering questions in both categories.

Total hip replacement (n=44)

Post training, the number of different THA implants used had a mixed spread, with more than five different implants being the most common response (25%, n=11). Most respondents (61%, n=30) had changed at least one of the implants they used during training. Technological advancement (67%, n=18), followed by registry data (56%, n=15), were the most commonly selected reasons, with the least selected being cheaper alternatives providing similar results (11%, n=3). For future changes, of the 15 out of 53 THA respondents who answered the question, strong clinical evidence for or against (93%, n=14) was the most commonly selected response.

Total knee replacement (n=49)

Post training, the number of different TKA implants used was equally split between one or two implants, respectively (22%, n=11 each), followed by more than five different implants (18%, n=9). 61% of respondents (n=27) had changed at least one of the implants they used during training. Registry data (67%, n=20), followed by technological advancement (60%, n=18), were the most commonly selected, with cheaper alternatives providing similar results (7%, n=2) being the least common. For future changes, of the 17 out of 58 TKA respondents who answered the question, strong clinical evidence for or against (77%, n=13) was chosen.

Table 1 Respondent characteristics

Q1: Which state or territory do you primarily work in?		
State or territory	**Responses (n)**	**Percentage of total (n=59) (%)**
Queensland	20	34
New South Wales	19	32
Victoria	7	12
South Australia	5	8
Tasmania	4	7
Western Australia	2	3
Australian Capital Territory	1	2
Northern Territory	0	0
Missing	1	2
Q2: What setting do you primarily work in?		
Setting	**Responses (n)**	**Percentage of total (n=59) (%)**
Metropolitan	44	75
Regional	15	25
Rural or remote	0	0
Q3: Are you currently a:		
Professional role	**Responses (n)**	**Percentage of total (n=59) (%)**
Consultant orthopaedic surgeon	50	85
Registrars	9	15
Q4: How many years post-training (consultant only)?		
Year range (years)	**Responses (n)**	**Percentage of total (n=50) (%)**
0–5	11	22
6–10	5	10
11–15	2	4
15–20	12	24
20+	20	40
Q5: What is your age group?		
Age range (years)	**Responses (n)**	**Percentage of total (n=59) (%)**
20–34	9	15
35–49	19	32
50–64	26	44
65+	4	7
Prefer not to say	1	2
Q6: Do you conduct (select all that apply):		
Surgery type	**Responses (n)**	**Percentage of total (n=59) (%)**
THA only	1	2
TKA only	5	8
Both THA and TKA	53	90
If selected, THA includes Q7 and enables Q15–18. If selected, TKA includes Q8, also enabling Q19–21.		
Q7: How many total hip replacements do you carry out per year?		
THR range	**Responses (n)**	**Percentage of total (n=54) (%)**
<20	11	20
20–50	7	13
50–100	18	33
100+	18	33
Q8: How many total knee replacements do you carry out per year?		
TKR range	**Responses (n)**	**Percentage of total (n=58) (%)**
<20	8	14
20–50	10	17

Continued

Table 1 Continued

50–100	20	34
100+	20	34
Q9: Do you practise in (select all that apply):		
Hospital type	**Responses (n)**	**Percentage of total (n=59) (%)**
Public only	13	22
Private only	13	22
Both public and private	33	56
Hospital type	**Responses (n)**	**Percentage of total (n=59) (%)**
Public hospital	46	78
Private hospital	46	78

THA, total hip arthroplasty; TKA, total knee arthroplasty.

Factors influencing previous changes to implant selection and expected future reasons are summarised in figures 1 and 2 and online supplemental file 2_table 1.

Registry results

Just over half of consultant participants checked their results once a year (54%, n=27), with another 32% (n=16) checking their own results multiple times each year. Two consultant respondents (4%) indicated that they had never checked registry results. When asked how important joint registry outcomes were to them, more than 75% of respondents indicated extremely or very important (extremely important 39% (n=23) and very important 37.3% (n=22)). Further details are given in table 4.

Unwarranted variation

Cost of prostheses

Participants were asked about unwarranted variation in relation to prosthesis cost (unwarranted variation is summarised in online supplemental file 2_table 2). Answers were mixed, with 27% (n=16) indicating that a prosthesis costing 20% more than an equivalent was unwarranted variation, but this was closely followed by 24% (n=14) indicating that a prosthesis costing 10% more than an equivalent was unwarranted variation. This question was not answered by 14% (n=8) of participants. The distribution of responses was broadly consistent between consultants and registrars.

5-year revisions

58% of respondents (n=34) selected 5-year revision rates 'more than 20%' higher than equivalent prostheses' as an indicator of unwarranted variation. This option was selected by 62% (n=31) of consultants and a third (33%) of registrars. However, nearly a third (29%, n=17) of respondents selected a lower threshold. Of note, 14% of surgeons (n=8) did not answer this question.

10-year revisions

'More than 20% increase in 10-year revision rates' was also the most commonly selected response as the indicator for unwarranted variation for this question, with 59% (n=35) selecting this overall, comprising 62% (n=31) and 44% (n=4) of consultants and registrars, respectively. Similar to the 5-year revision rates, 27% (n=16) of respondents selected a lower threshold, with the same number of respondents (n=8, 14%) not selecting a threshold at all.

Stage 3: anel discussion to define unwarranted variation

Survey results were reviewed by a panel of two orthopaedic surgeons and a health economist with expertise in unwarranted variation convened to consolidate a working definition of unwarranted clinical variation. This definition will be used as part of a future economic evaluation, using current prosthesis use data. Key outcomes from the panel meeting are summarised below.

1. Revision rates are a key indicator that should form part of the working definition.
2. Revision rates of 20% or higher than an agreed benchmark rate at 5-year and 10-year intervals were suitable for a working definition. It was noted by panel participants that 20% is similar to international benchmarking.
3. Uncertainty would always be present in estimates of unwarranted variation; for example, if derived from registry data revision rates, confidence intervals could be used for defining conservative narrow and broad definitions of unwarranted variation.
4. Cost is a useful indicator of unwarranted variation. However, given the mixed responses in the survey, the panel suggested that multiple cost thresholds, along with revision rates, should be used within the working definition.

Further research is needed to explore other potentially confounding factors and consider how this is accounted for in future studies investigating unwarranted variation in this field. Confounding factors may include cemented versus uncemented prosthetics or the age of implant recipients.

DISCUSSION

This study indicates that the most influential factors for surgeon decision-making in relation to prosthesis

Table 2 Level of autonomy and knowledge of cost

Q10: In the public setting, what level of autonomy over choice of implant do you have?			
Autonomy level	**Consultant orthopaedic surgeon (n=37) (%)**	**Registrar (n=9) (%)**	**Total (n=46) (%)**
Full autonomy	19 (51)	0 (0.0)	19 (41)
Departmental consensus	17 (46)	4 (44)	21 (46)
Limited input	1 (3)	3 (33)	4 (9)
Other	0 (0.0)	2 (22)	2 (4)
Free text responses: Full autonomy Department attempts to use similar implants to reduce cost… but there is no pressure to use something else. Full autonomy within [state] tender, which most companies are. Needs to be an implant with some track record, but essentially full autonomy. Full autonomy, but free to choose any prosthesis with a threshold price. Have not tested the boundaries on my full autonomy. Implant contract with one large company is threshold based. Although autonomous in choice as there is no pressure to switch to this company. Departmental consensus Choice of two determined by departmental consensus. Patients over 75 have all cemented implant. Have departmental rules regarding over costs for implant. [company] agreement in public for hip and knee arthroplasty. No restrictions for revisions. Two primary THR and two primary TKR choices available for use. Implant tender tied to robot use!! Limited input/Other Do what I'm told. Implant selected by consultant.			
Q11: In the private setting, what level of autonomy over choice of implant do you have?			
Autonomy level	**Responses (n)**	**Percentage of total (n=46) (%)**	
Full autonomy	46	100	
Departmental consensus	0	0	
Limited input	0	0	
Free text responses: Required to be in top 10% registry survivorship at minimum 5 years.			
Q12: Do you know the cost of the implant/s you use most often?			
Knowledge level		**Responses (n)**	**Percentage of total (n=59) (%)**
Yes, I know the cost of the implant/s I use		19	32
I know the approximate price range (±$A1000)		32	54
No, I am not really sure of the cost of the implant/s I use		3	5
Missing (none selected)		5	9

THA, total hip arthroplasty; TKA, total knee arthroplasty.

Table 3 Distribution of factors influencing prosthesis selection based on ranking priorities (n=50)

Q13: Please select your top five factors you consider when selecting an implant. Click on the item and drag and drop into the boxes 1–5 (1=top priority, 2=second priority, etc).		Top priority N (%)	2nd priority N (%)	3rd priority N (%)	4th priority N (%)	5th priority N (%)
1	Familiarity with implant	8 (16)	13 (26)	6 (12)	6 (12)	7 (14)
2	Length of time in surgery	0 (0)	0 (0)	0 (0)	1 (2)	1 (2)
3	Patient age (years)	2 (4)	2 (4)	5 (10)	5 (10)	2 (4)
4	Reason for replacement (eg, osteoarthritis, trauma and inflammatory arthritis)	4 (8)	1 (2)	1 (2)	2 (4)	3 (6)
5	Implant cost	0 (0)	2 (4)	2 (4)	2 (4)	8 (16)
6	Patient postoperative functionality	3 (6)	10 (20)	5 (10)	3 (6)	3 (6)
7	Revision rate	20 (40)	11 (22)	10 (20)	2 (4)	2 (4)
8	Ease of use in theatre	1 (2)	1 (2)	8 (16)	11 (22)	3 (6)
9	Implant quality	11 (22)	8 (16)	3 (6)	6 (12)	3 (6)
10	Education and support provided with the implant	1 (2)	1 (2)	6 (12)	6 (12)	7 (14)
11	Relationship with the implant supplier/ company	0 (0)	1 (2)	2 (4)	4 (8)	10 (20)
12	Type/brand of implant available at the hospital where I work	0 (0)	0 (0)	2 (4)	2 (4)	1 (2)

selection are revision rate, familiarity with the implant and implant quality, while other factors, including cost, have limited influence. Technological advancement and revision rates were influential factors in past changes to the choice of prosthesis, while strong clinical evidence was reported as influential for future changes. A working definition of unwarranted variation was agreed on, which focused on implants with revision rates of at least 20% higher than published benchmarks with multiple cost thresholds.

National registries in Australia and other countries provide comprehensive data on revision rates for both THA and TKA implants, yet there is continued use of implants with no long-term data or those with

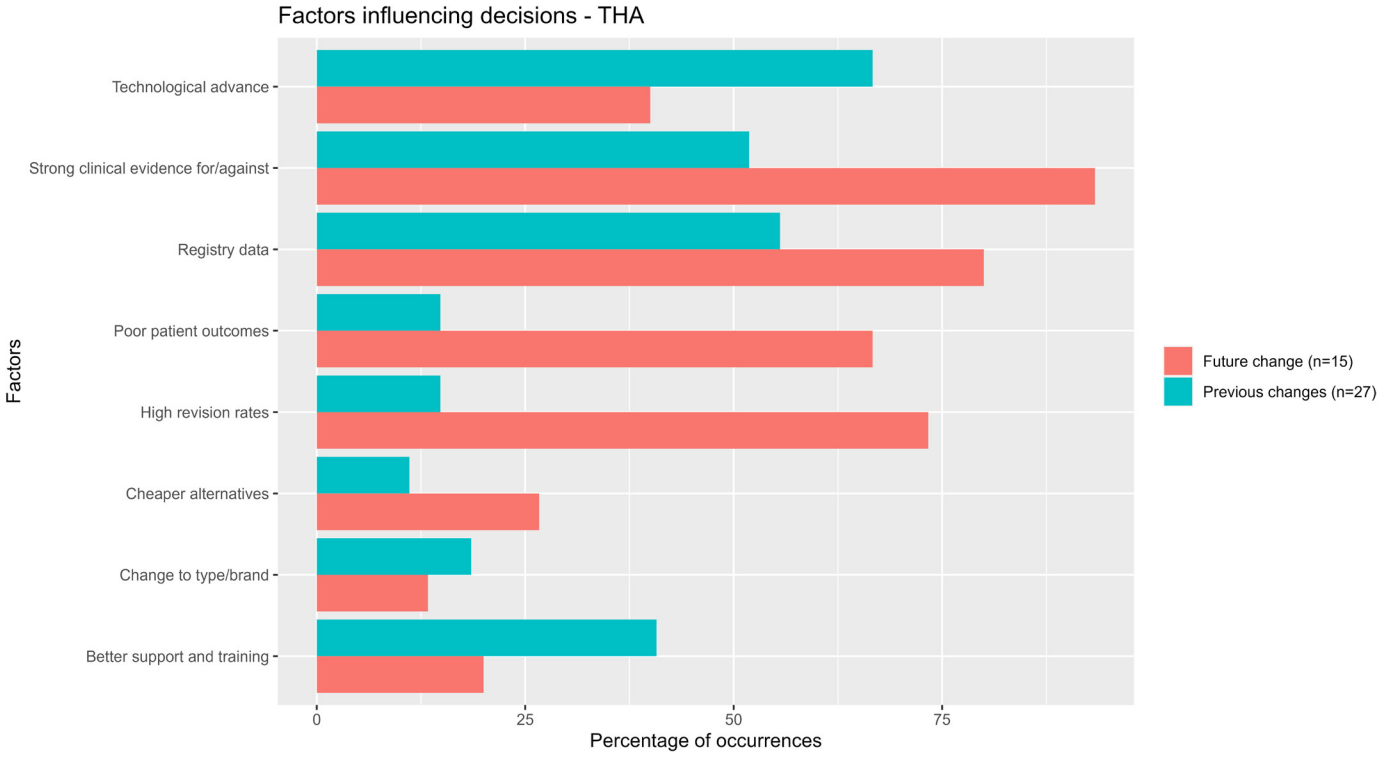

Figure 1 Factors influencing decision—total hip arthroplasty (THA).

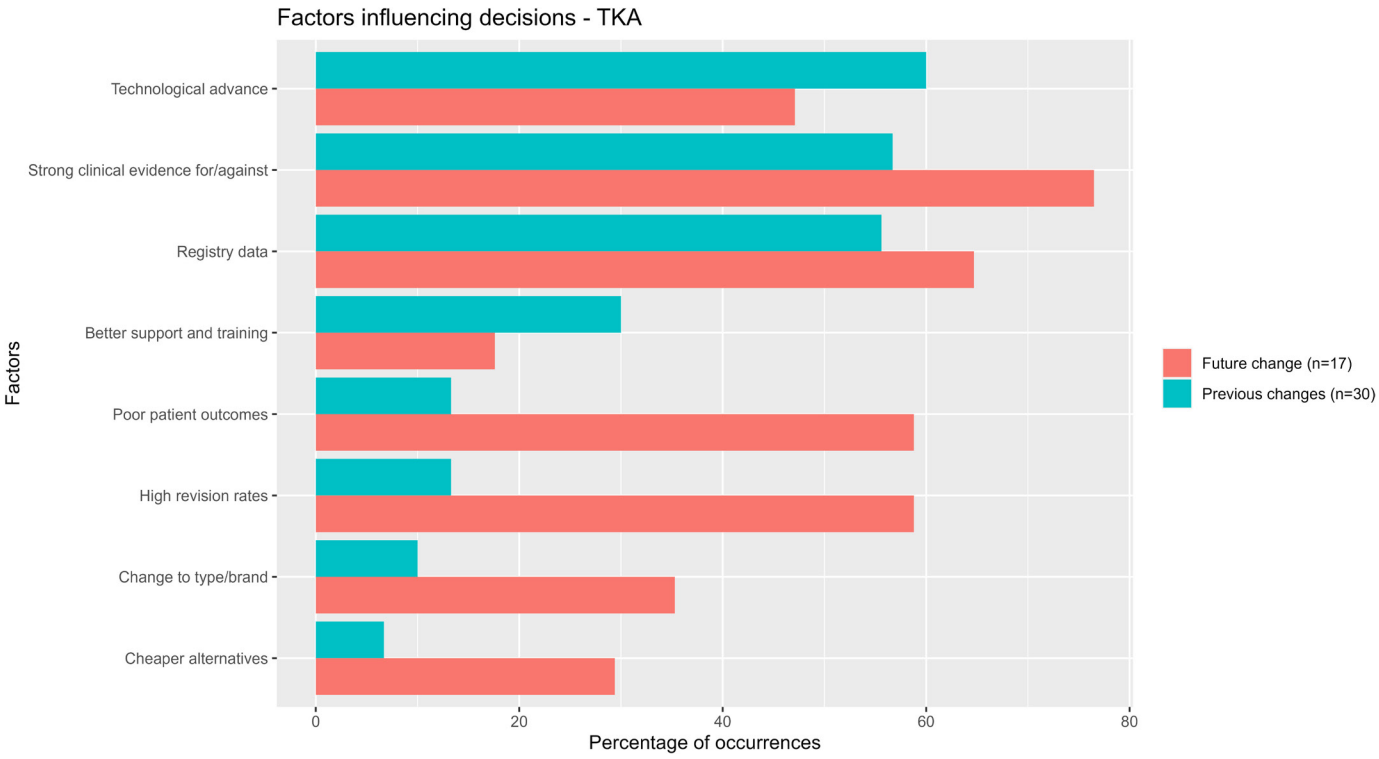

Figure 2 Factors influencing decision—total knee arthroplasty (TKA).

considerably higher revision rates.[12] Previous research has also demonstrated a large disparity in revision rates between public and private hospitals in Australia.[13] Higher revision rates in private hospitals were shown to be largely associated with differences in implant selection, with revision rates equalising where data were restricted to better-performing implants only.[13] Given that revision rates were demonstrated in this study as the key deciding factor when selecting an implant, providing a working definition of what constitutes potential unwarranted variation that includes a threshold for revision rates is a key outcome with potential applications in future research and policy.

Cost was not highlighted in this study as a major deciding factor for most surgeons. Given that the majority of respondents perceived they knew the cost or approximate

Table 4 Joint registry data use

Q24: How often do you check your individual registry results?*			
Support	**Responses (n)**	**Percentage of total (n=50) (%)**	
Multiple times a year	16	32	
Once a year	27	54	
Once every 2–3 years	2	4	
Once every 3–5 years	1	2	
Once every 5+years	0	0	
Never	2	4	
Missing	2	4	
Q25: How important are joint registry outcomes to you?			
Importance level	**Consultant orthopaedic surgeon (n=50) (%)**	**Registrars (n=9) (%)**	**Total (n=59) (%)**
Extremely important	19 (38)	4 (44)	23 (39)
Very important	20 (40)	2 (22)	22 (37)
Moderately	7 (14)	0 (0)	7 (12)
Slightly important	2 (4)	0 (0)	2 (3)
Not at all important	0 (0)	0 (0)	0 (0)
Missing	2 (4)	3 (33)	5 (9)

*NB: Q24 was answered by those who selected consultant only.

cost of the implants they use most often, the minimal role played by cost in decision-making does not appear to be related to a lack of cost awareness. This high level of cost awareness is similar to that reported by Sharkey *et al*,[14] with the majority of respondents in both studies having a high level of control over their implant selection. The authors of that study also noted that surgeons are likely to continue selecting the same implant, even if there is a more affordable implant with acceptable clinical outcomes.[14] Given our results and those of previous studies, future strategies to address unwarranted variation must move beyond mere awareness raising.

Our finding regarding familiarity with the implant being a key driver of prosthesis selection warrants further investigation. While the link between implant familiarity and better outcomes is unclear, studies have demonstrated that surgical experience and familiarity with the operating team can lead to a reduction in theatre time,[15 16] length of stay and 30-day readmission rates.[16] One study suggests that surgeons perceived that changing implants and the associated learning curve would adversely affect patients in the short term.[14] Conversely, another study found that firm preferences for specific implants were a barrier to acquiring competency in a broader range of implants that would better align with the needs of patients.[17] Our results further resonate with other research on unwarranted variation. The influence of individual and organisational capacity, as well as individual patient and clinician preferences, are potential reasons for variation, both warranted and unwarranted,[9 18] and need further consideration.

Several considerations that have been reported in previous research, including the surgeon's relationships with implant companies,[19 20] technological aspects[14 17 19 20] or patient fit,[14 17 19 20] did not feature as prominently in our study. This may be due to factors being described in more detail in the questionnaire; for example, patient age and reason for replacement are both aspects of patient fit, which may have ranked higher if they were combined. On the other hand, technological advancement was reported in this study as a factor that influenced past changes in prosthesis selection but not in relation to current decision-making. This may align with the perception that surgeons believe there are minimal differences among common prostheses, so improvements would need to be substantial before changing to an alternate prosthesis.[17]

A strength of this study is the representative sample of consultant orthopaedic surgeons across Australia. However, we did not have a large number of registrars in the sample, and their responses must be interpreted with caution. Despite piloting the questionnaire and aligning the top threshold with current reporting standards, some limitations remained, including a potential ceiling effect of using '20% and over' as the top increment for the unwarranted variation questions—both cost and revision rate. This may have led to the missing data, with several participants not selecting a threshold for unwarranted variation based on revision rates (n=8), or this may be due to the lack of importance placed on this data by some, despite revision rates being the highest ranked factor for prosthesis selection in this study. Furthermore, we did not explicitly define departmental consensus or implant quality within the questionnaire tool itself, which may have resulted in variable interpretation among participants. Reasons for future changes to implants also had missing data for 66% and 65% of THR and TKR respondents, respectively. It is unclear as to whether this is related to a lack of willingness to consider changing implants in the future or difficulty in defining reasons for future decisions. Direct observation of revealed preferences for implant selection may provide different outcomes from this survey study, presenting a useful area for future research.

CONCLUSION

This study highlights several factors that are influential in surgeon decision-making in relation to implant choice for THA and TKA. Further, it provides a working definition of unwarranted variation that can be applied in future research, policy and health system strategies to improve patient outcomes and provide better value care.

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Contributors MJA was involved in the conception and design of the study, undertook the interviews, initial coding of the transcripts and led the consolidation of themes and development of the questionnaire. MJA also contributed to writing the initial draft, provided significant intellectual contributions to subsequent drafts and reviewed and agreed on the final manuscript. DB was involved in the conception and design of the study as well as in the consolidation of themes and development of the questionnaire. DB also provided significant intellectual contributions to subsequent drafts and reviewed and agreed on the final manuscript. RC was involved in the conception and design of the study as well as in the consolidation of themes and development of the questionnaire. RC also provided significant intellectual contributions to subsequent drafts and reviewed and agreed on the final manuscript. SS was involved in the conception and design of the study, building the online questionnaire tool and subsequent quantitative analysis. SS also provided significant intellectual contributions to subsequent drafts and reviewed and agreed on the final manuscript. IAH was involved in the conception and design of the study and questionnaire development as well as provided significant intellectual contributions to subsequent drafts and reviewed and agreed on the final manuscript. LME was involved in the conception and design of the study, writing the initial draft, providing significant intellectual contributions to subsequent drafts and reviewing and agreeing on the final manuscript. RH was

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Author note RC and IAH are senior orthopaedic surgeons. DB, SS, VM and SMM are health economists with an interest in value-based care. MJA, LME and RH are health services researchers with implementation science, public health and health management backgrounds.

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