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## Comparing contemporary revision burden among hip and knee joint replacement registries

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### ABSTRACT

**Background:** Hip and knee arthroplasties are common and successful procedures, however, success and durability are not guaranteed. The revision burden, defined as the ratio of implant revisions to the total number of arthroplasties in a specific period, is a measure of the steady state of arthroplasty success in a given registry. This study examines the hypothesis that revision burden would be similar among contemporary joint replacement registries and improving over time compared with historic controls.

**Methods:** We evaluated the national joint registries of 5 health systems (Australian Orthopaedic Association National Joint Replacement Registry [AOANJRR]; National Joint Registry of England, Wales, Northern Ireland, and the Isle of Man; New Zealand Joint Registry [NZJR]; Swedish Hip Arthroplasty Register [SHAR] and Swedish Knee Arthroplasty Register [SKAR]; and the American Joint Replacement Registry [AJRR]) for hip and knee revision burden over the past 4 years or since registry inception. Historic controls were obtained from previously published reports.

**Results:** The 2014 hip revision burden varied from 9.7 percent (NJR) to 11.9 percent (NZJR), and the unweighted average was 10.4 percent. The 2011, 2012, and 2013 mean hip revision burden was 11.9, 11.9, and 11.4 percent. The 2014 knee revision burden varied from 6.0 percent (NJR) to 8.1 percent (AJRR), and the unweighted average for the 5 registries studied was 7.0 percent. The 2011, 2012, and 2013 mean knee revision burden was 6.9, 7.0, and 7.0 percent. Historically, the observed hip revision burden was 15.8 percent and the knee revision burden 8.0 percent.

**Conclusions:** Revision burden has gradually decreased for hip replacements and has remained relatively constant for knee replacements both for the last 4 years and compared to historic controls. Knee revision burden was lower than hip revision burden for each period examined. Revision burden is one measure that may be helpful in following the effect of changes in surgical technique and implant design over time in registry populations and may be a helpful way to compare overall results between registries.

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### Introduction

Hip and knee arthroplasties are common and successful procedures, however, success and durability are not guaranteed. The major outcome measure in modern joint registries is surgical

revision. Revision may be for deep infection, aseptic loosening, instability, periprosthetic fracture, prosthetic failure or high wear, stiffness, or unexplained pain, to list the most common causes [1–3]. Importantly, compared with the relative cost and results of primary hip and knee replacement, numerous studies have documented that revision surgeries require more resources and have poorer durability and outcomes [4–6].

The concept of revision burden, defined as the ratio of implant revisions to the total number of arthroplasties in a given period, is a measure of the steady state of arthroplasty success in a given registry. This concept, first introduced by Dr. Henrik Malchau [7], director of the Swedish Hip Arthroplasty Register (SHAR), was envisioned to be used “to facilitate comparison between different

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national registries.” In addition to these comparisons, revision burden has also been used for result reporting [8], economic analysis [6], and estimation of changes in procedure numbers and resource utilization over time [4,9].

Joint registries serve many functions and are now a critical part of many major health systems. Comparison data between contemporary registries may be limited by differences in specific data collected and metrics applied, but revision burden is one simple universally comparable parameter. When hip or knee revision burden is significantly different between major registries, explanations for the observed difference and discussion around best practices are prompted which may promote favorable changes allowing improvement in those systems with higher rates. On the other hand, when the revision burden for a specific registry is similar to all others, this serves to reinforce the effectiveness of arthroplasty care in that particular system when compared to other diverse health systems achieving similar revision outcomes.

This study examines the hypothesis that current revision burden is relatively similar across major national joint replacement registries and that this burden has decreased over the recent past compared to historic values.

## Material and methods

We evaluated major national joint replacement registries of 5 health systems [8,10–25] for hip and knee revision burden over the last 4 years or since registry inception. These include the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR); National Joint Registry of England, Wales, Northern Ireland, and the Isle of Man (NJR); New Zealand Joint Registry (NZJR); Swedish Hip Arthroplasty Registry (SHAR) and Swedish Knee Arthroplasty Registry (SKAR); and the American Joint Replacement Registry (AJRR). We chose these registries because revision burden data were publicly reported and readily available from the respective registries' annual reports. Of note, the SHAR 2014 hip data are not yet available in English translation, so the (1878 revisions/16,565 primaries + 1878 revisions = 10.2% revision burden) data were obtained by personal communication with Ola Rolfson on April 18, 2016.

Although revision definition between registries may differ slightly [26], we chose to calculate revision burden based on the inherent definition of revision for each reporting registry. Non-weighted averages were used for overall comparison (ie, the overall volume of arthroplasties in a given health system was not taken into account for the conglomerate totals—each health system was given equal weight).

For historic controls, we abstracted data previously compiled and reported by Kurtz et al. [4].

## Results

Overall results of contemporary revision burden for the 5 surveyed registries are summarized in Table 1.

**Table 1**  
Results of contemporary revision burden, in percent.

Registry	2011		2012		2013		2014	
	Hip	Knee	Hip	Knee	Hip	Knee	Hip	Knee
AJRR	NA	NA	NA	NA	NA	NA	10.0	8.1
AOANJRR	12.5	8.1	11.8	7.8	10.6	8.0	10.2	7.7
NJR	10.8	6.1	11.6	6.6	10.9	6.3	9.7	6.0
NZJR	13.6	6.6	13.2	7.7	13.7	6.8	11.9	6.8
SHAR/SKAR	10.5	6.1	10.8	5.7	10.3	6.8	10.2	6.5
Unweighted average	11.9	6.9	11.9	7.0	11.4	7.0	10.4	7.0

References: [8–25].  
NA, not applicable.

The 2014 hip revision burden varied from 9.7 percent (NJR) to 11.9 percent (NZJR), and the unweighted average was 10.4 percent. The mean 2011, 2012, and 2013 hip revision burden was 11.9, 11.9, and 11.4 percent. The 2014 knee revision burden varied from 6.0 percent (NJR) to 8.1 percent (AJRR), and the unweighted average was 7.0 percent. The mean 2011, 2012, and 2013 knee revision burden was 6.9, 7.0, and 7.0 percent.

Results of historic revision burden are summarized in Table 2. Of note, only AOANJRR, SHAR, SKAR, and AJRR data allow direct (health system specific) comparison to historic data, and the comparison United States data are actually calculated from National Hospital Discharge Survey information [4]. In addition, historic data spans various periods for individual countries' joint replacement registries. Historic hip revision burden varied from 11.0 percent (Sweden, 1992–2000) to 18.3 percent (Finland, 1990–2001), and the unweighted overall average was 15.8 percent. Historic knee revision burden varied from 6.1 percent (Canada, 2002–2003) to 10.8 percent (Australia, 1999–2002), and the unweighted overall average was 8.0 percent.

## Discussion

Revision is an important parameter in the understanding of arthroplasty science, the economics of joint replacement, and in facilitating progress in joint replacement care. Researchers have estimated that demand for revision surgeries will markedly increase over time, related to expected growth in the number of primary procedures performed, and that demand will need to be addressed with increased economic resources, operative efficiency, technical capacity, and implant longevity [4,9,27]. While the combination and analysis of different registry results may be somewhat problematic [26,28,29], comparing and contrasting the range of worldwide results can have significant value in surveillance of outcomes, outlier identification, and the development of care improvement opportunities.

Revision burden is a concept previously introduced by Malchau et al. [7] and used for subsequent analysis and comparison by others [4,6,8,9]. The ratio is relatively easily calculated but is a complex measure affected by both more recent primary arthroplasty practices but also by historical treatment methods and implant usage patterns over the many years and even decades prior. However, as an overall measure, it has several advantages related to large population reporting. Namely, it can be calculated for any population or registry and can be followed for change or trends over time. It may also be used as a high level comparison between different joints and between individual registries. It does not require direct data linkage between the original and revision surgery, which may be difficult to perform [29]. On the other hand, the ratio is affected by multiple variables (Table 3) which may make it difficult to fully explain observed differences without further data gathering and study.

**Table 2**  
Results of historic revision burden, in percent.

Registry	Hip	Knee	Years
United States <sup>a</sup>	17.5	8.2	1990–2002
Australia	18.2	10.8	1999–2002
Canada	13.1	6.1	2002–2003
Finland	18.3	7.9	1990–2001
Norway	16.4	8.0	1994–1998
Sweden	11.0	7.2	1992–2000 <sup>b</sup>
Unweighted average	15.8	8.0	

<sup>a</sup> Derived from National Hospital Survey (NHDS) data; other data registry based.

<sup>b</sup> Hip only; knee time frame 1988–1997.

Based on Kurtz, et al, JBJS, 2005 [4].

**Table 3**  
Components of revision burden [7] calculation.

Component of revision burden equation	Factors affecting component of equation
Numerator = revision joint replacement in a given period	<ul style="list-style-type: none"> <li>• Population with prior primary joint surgery</li> <li>• Population with prior revision joint surgery</li> <li>• Criteria for revision or rerevision joint surgery</li> <li>• Availability (surgeons/hospital) to offer revision joint surgery</li> <li>• Population life expectancy</li> <li>• Definition of revision joint replacement</li> </ul>
Denominator = revision and primary joint replacements in the same period	<ul style="list-style-type: none"> <li>• Numerator</li> <li>• Criteria used for primary joint surgery (definition of surgical arthritis within a health system)</li> <li>• Population with surgical arthritis</li> <li>• Availability (surgeons/hospital) to offer primary joint surgery</li> </ul>

Yearly revision burden is a ratio that includes both early (less than 1 year) and late (greater than or equal to 1 year) revisions performed on a registry population during the preceding year. The failures are related to the population with prior implants (both primary and revision surgeries), the life expectancy of that population, and the implemented indications for and availability of revision surgery. Likewise, the denominator of the ratio depends on similar criteria for both primary and revision joint replacement surgeries. Each of these criteria may be unique to a given health system [30,31].

One potential weakness of a worldwide comparison like this is reporting bias associated with different registries. Whereas the completeness of data capture around revision procedures may be quite high in the international registries examined here, registries such as AJRR without near 100 percent participation may under or over estimate the revision burden based on what may be a biased sample of the nationwide total. High compliance as a part of mandatory reporting for a given health system increases the reliability of the data [27], but reporting bias and variable compliance in a voluntary initiative such as AJRR may still introduce problems such as a higher capture rate for primary vs revision surgery.

If we recognize and accept the potential weaknesses of this steady-state ratio, we can look to broad comparisons between registry populations and periods. For total knee replacement, revision burden appears to be quite stable over time and between joint replacement registries. With the exception of the early Australian experience (revision burden 10.8 percent, 1999–2002) the range for revision burden is between 5.7 percent and 8.2 percent over the last 2 decades. This may reflect the fact that knee replacement design and surgical techniques, as well as materials, have been more stable than the hip over this period.

For total hip replacement, on the other hand, revision burden appears to have decreased over time, and current rates appear to be continuing to diminish. Over a similar 2 decades, the combined revision burden has dropped for hip replacement by about one third, from 15.8 to 10.4 percent. This decrease may be related to a variety of design, surgical technique, or prosthetic material changes, but the widespread adoption of cross-linked polyethylene has almost certainly played a role in explaining a major portion of this change [32].

Nonetheless, the overall hip revision burden is higher than that for knee replacement. This has undoubtedly been influenced by increased short-term failures related to relatively recently adopted and subsequently abandoned new technology with poor outcomes and implant recalls including metal-on-metal designs and double

modular necks [33–35]. Better understanding of the contributions of implant design to changes in revision burden is dependent on accurate data on the devices removed at revision, which can be problematic for even comprehensive and mature registries. Recent in-depth analysis of retrieved implants at the time of revision surgery showed that only 37.6% of these cases had been reported and had helped contribute to the respective implant survival curves in the NJR [29]. The authors concluded that data on revisions and implant-specific failure rates may be more vulnerable to under-reporting and missing data, compared to primary arthroplasty procedures.

Revision burden analysis may be most useful within a given health system or country, where the variation in the components of the ratio are minimal, or at least, better defined. For example, based on historic data, the revision burden for Australia was 18.2 percent for hips and 10.8 percent for knees in the 1999–2002 era [4]; between 2011 and 2014, yearly hip revision burden decreased to 12.5 [10], 11.8 [11], 10.6 [12], and 10.2 [13] percent and yearly knee revision burden decreased to 8.1 [10], 7.8 [11], 8.0 [12], and 7.7 [13] percent. Decreases in revision burden appear to be not only due to improvements in materials or implant design (such as highly crosslinked polyethylene) but also as a consistent and positive effect of national registry surveillance and the feedback of surgeons, hospitals, manufacturers, payors, and the public, all of whom may change behavior in response to these data.

Additional research is appropriate and warranted to further analyze changes in revision burden, allowing surgeons and health systems to “drill-down” and identify specific factors that positively affect prosthesis longevity. As population size, obesity prevalence, life expectancy, and patient expectations increase [27], we will want to carefully follow the changes in revision burden. Furthermore, refinements that apply the revision burden concept to not only surgical revisions, but failures of other types (eg, “poor” clinical results based on patient-reported outcomes or revisions specifically related to one failure mode, such as infection) will also be very helpful in improving patient outcomes and satisfaction in joint replacement surgery.

## Conclusions

Revision burden, defined as the ratio of implant revisions to the total number of arthroplasties in a given period, is a measure of the steady state of arthroplasty success in a given registry. It has gradually decreased for hip replacements and has remained relatively constant for knee replacements both for the last 4 years and compared to historic controls. Knee revision burden was lower than hip revision burden for each period examined. Revision burden is one measure that may be helpful in following the effect of changes in surgical technique and implant design over time in registry populations and may be a helpful way to compare overall results between registries.

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