Joint Replacement Registries Significantly Reduce Revision Rates

Charles Ebuka Okafor (charles.okafor@griffithuni.edu.au)  
Griffith University  https://orcid.org/0000-0002-7048-910X

Son Nghiem  
Griffith University School of Medicine

Christopher Vertullo  
Griffith University Menzies Health Institute Queensland

Joshua Byrnes  
Griffith University School of Medicine

Research article

Keywords: Joint replacement registry, arthroplasty, revision rate, hip, knee, impact

DOI: https://doi.org/10.21203/rs.3.rs-149537/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.  Read Full License
Abstract

Background

Despite the rapid establishment of joint replacement registries (JRR), its effect on key outcomes such as revision rates is uncertain. While some countries with JRR have recorded reductions in revision rates, other countries without JRR also have reported similar reductions. This study evaluated the impact of JRR on revision rates across countries while controlling for non-JRR related factors and JRR outcomes transfer (to non-registry countries) that could contribute to reduction in revision rates.

Methods

This assessment was performed by a difference-in-differences statistical approach using a panel regression model. We compared revision rates of non-registry countries to registry countries, and further compared non-registry period revision rates to registry period (of registry countries) revision rates. We controlled for non-JRR related factors and JRR outcomes transfer by the inclusion of a linear trend in the model. Data were collected from 1980 – 2018. Registry data were obtained from JRR databases while non-registry data were obtained from literature search in Medline and Google Scholar.

Results

The average difference in revision rates between registry countries compared to non-registry countries was not statistically significant for hip (p-value = 0.056) and knee (p-value = 0.501) respectively. The average difference in revision rate in the registry period of registry countries relative to the non-registry periods was statistically significant for hip (p-value < 0.0001) and knee (p-value = 0.004) respectively. The impact of JRR on revision rate reduction as a percentage was 19.23% (95% CI: 10.86 – 31.55%) and 13.07% (95% CI: 3.28 – 31.18%) for hip and knee respectively.

Conclusions

Joint replacement registries cause significant reduction in revision rates and its effect on this outcome may be further improved by increasing surgeons’ participation. Establishment of JRR in countries or regions yet to would be a worthwhile decision.

Introduction

The purpose of joint replacement registries (JRR) is to define, improve and maintain the quality of care for patients who undergo arthroplasty, with the reduction in revision rate as the principal outcome measure [1]. Since the establishment of the Swedish knee and hip JRR in 1975 and 1979 respectively, over 23 countries have established national or regional JRR, with more countries planning to [2, 3]. Joint registries are initiated, funded and maintained by governmental bodies, medical societies and or healthcare institutions and until recently were primarily focused on hip and knee arthroplasty.

Despite the rapid establishment of JRR, its effect on key outcomes such as revision rates is uncertain. While some countries with JRR have recorded reductions in revision rates [1, 4–7], other countries without JRR also have reported similar reductions [8–11]. Additionally, in many countries with JRR, the revision trend is relatively
similar to the period before (pre-registry) their JRR establishment [12–14]. Plausible reasons for the obscured impact of JRR are the focus of most previous studies on country-level analyses; no control for non-JRR related factors (e.g., technological progress from improved surgical technique or improved prostheses) that may contribute to the reduction of revision rates; and no control for the transfer of JRR outcomes or findings to countries without JRR. It is, therefore, pertinent to evaluate the impact of JRR on revision rates across countries while controlling for non-JRR related factors and JRR outcomes transfer that may contribute to the reduction in revision rates.

This study aims to evaluate the impact of JRR by comparing revision rates across countries and over time using a difference-in-differences approach.

**Methods**

**Data sources, PRISMA statement and inclusion criteria**

Data on hip and knee revision rates were searched from the year 1980 to 2018. Registry data were collected from the online databases of JRR. Some registry data components were not clearly described or available online and were therefore obtained upon request from the data custodians. Non-registry data were obtained from literature search in Medline and Google scholar. Our focus was on hip and knee replacements as they are the most common types of joint replacement procedures performed [1, 4, 5, 15]. Studies were included if they reported revision rates for hip or knee or the number of primary and number of revision cases. Reoperations without revision were excluded and reports for primary arthroplasty rates without revisions rates were also excluded.

For non-registry data search, we used the following Medical Subject Headings (MeSH) “arthroplasty, replacement, knee” and “arthroplasty, replacement, hip”, which were combined to form a union (cluster A). The union was combined with the text word ”revision” to form an intersection (cluster B). The text words ”trend”, and ”prevalence”, were combined to form a union (cluster C). Cluster B and cluster C were combined to form an intersection (cluster D), from which the selection was done. Next, we screened the title and abstract of the articles. After the screening, the full texts of included studies were assessed for eligibility (clarity; specificity for revision hip or knee; and revision rates reported over a period).

Inclusion of countries in the analysis was based on the number of available observations in the time series. The maximum expected observations (revision rate each year from 1980 - 2018) per country was 39. Countries with less than 13 observations in the time series were excluded in the analysis.

**Data categorization**

Included data were primarily classified as a non-registry country or registry country data. Data from each country-category were further sub-classified into pre-registry period and registry period data. The pre-registry period for a registry country refers to the period before their JRR establishment, whilst the registry period refers to the period after its establishment. For a non-registry country, these periods refer to corresponding periods with a registry country. As countries with JRR have different pre-registry and registry periods, there is no specific pre-registry and registry period for a non-registry country unless when compared to a specific registry country. To enable multi-country comparison, we defined the registry period for non-registry countries as 1999 – 2018, because year the 1999 corresponds to the median year registry countries included in the assessment established JRR, and it also
represents the median year of the assessment period (1980 – 2018). Data for non-registry countries and the pre-registry data for registry countries were collectively defined as ‘non-registry period’ data.

Assessment approach

A pragmatic approach comparing revision rates of non-registry countries to registry countries, and further comparing non-registry period revision rates to registry period (of registry countries) revision rates from 1980 – 2018 was employed. This was performed by a difference-in-differences statistical approach using a panel regression model. Non-JRR related factors that may contribute to the reduction in revision rates (e.g. technological progress), and the transfer of JRR outcomes or findings to non-registry countries were collectively controlled for with the inclusion of a linear trend variable in the model, with hip and knee revision rates compared separately. The linear trend which represents both country-categories implies that non-registry countries and registry countries have the same revision trend with or without JRR. Data curation was performed using a moving average to provide missing data where applicable and to correct some outliers or acute fluctuations in the time series. The data entry and curation were performed using Microsoft Excel 365 (Microsoft, Seattle, USA), while the data analysis was performed using STATA 14 software (StataCorp, College Station, USA). Estimates with p-values ≤ 0.05 were considered statistically significant. Figure 1 describes the elected approach using the data categories. For sensitivity check, we defined registry period for non-registry countries as: 1994 – 2018; 2003 – 2018; 2006 – 2018; and 2012 – 2018.

Model specification

The impact of JRR are specified as:

\[ Y_{it} = \beta_0 + \beta_1 R_{it} + \beta_2 P_{it} + \beta_3 T + \beta_4 R_{it} \times P_{it} + (\alpha_i + \epsilon_{it}) \]

where \( Y_{it} \) = revision rate of country \( i \) in year \( t \); \( R \) = Registry country, represented by ‘0’ for non-registry countries, and ‘1’ for registry countries; \( P \) = Dummy variable for registry period, represented by ‘0’ for all pre-registry periods (category A and C), and ‘1’ for registry periods (category B and D); \( T \) = linear trend, which represents changes in revision rates due to non-JRR related factors and JRR outcomes transfer to non-registry countries; the asterisk symbol (*) represents the interaction between the variables; \( \alpha_i \) represents unobserved time-invariant characteristics of countries that may affect the outcome, and \( \epsilon_{it} \) is the random noise. The five \( \beta \)s are the parameters to be estimated, where \( \beta_0 \) is the intercept; \( \beta_1 \) represents the average difference in revision rate between registry countries (category C and D) and non-registry countries (category A and B); \( \beta_2 \) represents the average difference in revision rate between the pre-registry periods (category A and C) and the registry periods (category B and D); \( \beta_3 \) represents the annual change in revision rate in whole sampling period due to non-JRR factors and JRR outcomes transfer to non-registry countries; \( \beta_4 \) (difference-in-differences) represents the average difference in revision rate in the registry period (category D) of registry countries relative to their pre-registry period (category C) and the pre-registry (category A) and registry (category B) periods of non-registry countries. In other words, \( \beta_4 \) represents the average difference in revision rate in the registry period (category D) of registry countries relative to the non-registry periods (category A, B and C). Therefore, the impact of JRR will be quantified by \( \beta_4 \).
The estimation was performed using the random-effects and fixed-effects panel-data regression models. The choice of appropriate estimator was determined using the Hausman test. The null hypothesis of the Hausman test assumes no correlation between the regressors and unobserved country characteristics included in the error terms. If the null hypothesis is rejected, the fixed-effect estimators will be preferred as it is more consistent. Otherwise, the random effects estimator will be preferred.

**Results**

**Characteristics of included registries and non-registries data**

A total of 467 non-registry studies were identified. After screening, only 33 studies reported revision rates of joint replacements for hip or knee or both. Of these, 17 of the studies were excluded due to non-specificity for hip or knee. A total of 16 studies from 13 countries met the inclusion criteria for non-registry revision rates. A further 8 studies (from 6 non-registry and 1 registry countries) were excluded due to a lack of observations. Registry revision rates data were obtained from 12 countries but only 9 had sufficient observations for inclusion. Excluded non-registry studies and registry data due to few observations are described in Table 1 and Table 2 respectively. Table 1 shows the characteristics of the studies in the non-registry period category while Table 2 shows the characteristics of data in the registry category for registry countries.
Table 1
Characteristics of studies in the non-registry period category.

| Included studies | Reported data | Other details | Source |
|------------------|---------------|---------------|--------|
| New Zealand      | Hip           | Pre-registry data | [16]   |
| Iceland          | Hip           | Country without joint registry | [17]   |
| United States    | Hip and Knee  | Pre-registry data | [18]   |
| United States    | Hip and Knee  | Pre-registry data | [19]   |
| England/Wales    | Hip and Knee  | Pre-registry data | [12]   |
| Italy            | Hip and Knee  | Pre-registry data; registry established in 2006; | [14]   |
| Spain            | Knee          | Country without joint registry. | [11]   |
| Taiwan           | Hip and Knee  | Country without joint registry. | [20]   |

| Excluded studies due to too few observations | Reported data | Other details | Source |
|----------------------------------------------|---------------|---------------|--------|
| Spain                                        | Hip           | Country without joint registry. | [21]   |
| France                                       | Hip and Knee  | Country without joint registry. | [10, 22] |
| Austria                                      | Hip and Knee  | Country without joint registry. | [9]     |
| Korea                                        | Hip           | Country without joint registry. | [23]   |
| Korea                                        | Knee          |                | [8]     |
| Germany                                      | Hip and Knee  | Pre-registry data; registry established in 2012; | [19]   |
| Brazil                                       | Knee          | Country without joint registry; regional data. | [24]   |
Table 2
Characteristics of included studies in the registry category for registry countries.

| Country      | Year registry established | Surgeries reported                          | Management and participation | Validation and completeness | Reporting style                      | Source        |
|--------------|---------------------------|---------------------------------------------|------------------------------|---------------------------|-------------------------------------|--------------|
| Sweden       | Knee: 1975                | Hip and knee replacements; knee osteotomy.  | MGT: medical society. Both registries managed separately. | Validation: yes, and continuous.  
Complete: primary, 97%; revision, 92%. 
PROM: 82% | Annual; all-electronic online statistics for knee available; periodic update online. | [4, 25] |
|              | Hip: 1979                 |                                             | SHP: voluntary               |                          |                                     |              |
| Finland      | 1980                      | Hip and knee replacements.                  | MGT: managed by the government since 1993. SHP: mandatory | Validation: yes, and continuous.  
Complete: primary, 95%; revision, 82%. | Updated daily; all-electronic online report available. | [15] |
| Norway       | Hip: 1987; other joints started in 1994  CL: 2004 | Four-in-one register: joint replacements; hip fracture; cruciate ligament; and paediatric hip | MGT: Norwegian orthopaedic association. SHP: voluntary | Validation: yes, and continuous.  
Complete: hip: 93% knee: 91%  
PROM data collection recently initiated. | Annual; updated periodically; electronic recording surgeon form recently developed for CL registry; also, electronic recording of other procedures available. | [26] |
|              | Hip fracture: 2005        |                                             |                              |                          |                                     |              |
|              | Paediatric hip: 2010      |                                             |                              |                          |                                     |              |
| Denmark      | Hip: 1995                 | Hip and knee replacements.                  | MGT: orthopaedic society. SHP: voluntary | Validation: yes, and continuous.  
Complete: 94% | Annual; updated periodically; annual report in Danish | [27, 28] |
|              | Knee: 1997                |                                             |                              |                          |                                     |              |

MGT: management; SHP: surgeon or hospital participation; CL: cruciate ligament; PROM: patient-reported outcome measure.
| Country          | Year registry established | Surgeries reported                                      | Management and participation | Validation and completeness | Reporting style | Source |
|------------------|---------------------------|--------------------------------------------------------|------------------------------|-----------------------------|-----------------|--------|
| Australia        | 1999                      | Hip, knee and shoulder replacements.                   | MGT: orthopaedic society.    | Validation: yes, and        | Annual;        | [1]    |
|                  |                            |                                                        | Funded by the government.    | continuous.                 | periodic        |        |
|                  |                            |                                                        | SHP: voluntary               | Completeness: 97.8%         | reporting;     |        |
|                  |                            |                                                        |                              | PROM data collection        | online data    |        |
|                  |                            |                                                        |                              | ongoing.                    | collection forms.|        |
| New Zealand      | 1999                      | Hip, knee, shoulder, ankle, elbow, lumbar and cervical disc replacements | MGT: orthopaedic society.    | Validation: yes, and        | Annual;        | [7]    |
|                  |                            |                                                        | SHP: voluntary               | continuous.                 | periodic        |        |
|                  |                            |                                                        |                              | Completeness: > 90%         | reporting;     |        |
|                  |                            |                                                        |                              | PROM data collection:       | online data    |        |
|                  |                            |                                                        |                              | 70%                         | collection forms.|        |
| England/Wales    | 2003                      | Hip, knee, shoulder, ankle and elbow replacements.     | MGT: government              | Validation: yes, and        | Annual;        | [6]    |
|                  |                            |                                                        | SHP: voluntary               | continuous.                 | periodic        |        |
|                  |                            |                                                        |                              | Completeness: 96%           | update of the registry online; |
|                  |                            |                                                        |                              | PROM data: 94%              | statistics of procedures updated online |
|                  |                            |                                                        |                              |                             |                 |        |
| Italy            | 2006                      | Hip, knee and shoulder replacements.                   | MGT: government              | Validation: yes, and        | Annual         | [29]   |
|                  |                            |                                                        | SHP: voluntary               | continuous.                 | reporting       |        |
|                  |                            |                                                        |                              | Completeness: 66%           |                 |        |
| United States    | 2012                      | Hip and knee replacements.                             | MGT: orthopaedic society.    | Validation: yes, and        | Annual          | [13]   |
|                  |                            |                                                        | SHP: voluntary               | continuous.                 |                 |        |
|                  |                            |                                                        |                              | Completeness: 86%           |                 |        |
|                  |                            |                                                        |                              | PROM data collection:       |                 |        |
|                  |                            |                                                        |                              | 20% and ongoing             |                 |        |

Excluded countries due to too few observations

MGT: management; SHP: surgeon or hospital participation; CL: cruciate ligament; PROM: patient-reported outcome measure.
| Country     | Year registry established | Surgeries reported                           | Management and participation                  | Validation and completeness | Reporting style                                                                 | Source |
|------------|---------------------------|---------------------------------------------|-----------------------------------------------|-----------------------------|---------------------------------------------------------------------------------|--------|
| Romania    | 2001                      | Hip and knee replacements; spine and CL surgery. | MGT: government SHP: mandatory                | Validation: yes, and continuous. Comprehensiveness: > 99% | Annual; monthly update online; statistics updated online; | [5]    |
| Canada     | 2001                      | Hip and knee replacements.                  | MGT: government and orthopaedic society SHP: mandatory in 3 provinces; voluntary to other provinces. | Validation: yes, and continuous. Comprehensiveness: 72% | Annual; periodic reporting.                                                      | [30]   |
| Slovakia   | Hip: 2003 Knee: 2006      | Hip and knee replacements.                  | MGT: government SHP: voluntary                | Validation: yes, and continuous. Comprehensiveness: 100% | Annual; periodic update of the registry online; statistics of procedures updated online; | [31]   |
| Germany    | 2012                      | Hip and knee replacements.                  | MGT: orthopaedic society SHP: voluntary       | Validation: yes, and continuous. Comprehensiveness: > 70% | Annual                                                                          | [32]   |

MGT: management; SHP: surgeon or hospital participation; CL: cruciate ligament; PROM: patient-reported outcome measure.

**Hip and knee registries effect**

The Hausman test failed to reject the null hypothesis of no correlation between the regressors and the residuals for hip (*p-value* = 0.457) and knee (*p-value* = 0.400) respectively. Thus, we present the results of the random effect estimator.

The average difference (\(\beta_1\)) in revision rates between registry countries compared to non-registry countries was not statistically significant for hip (*p-value* = 0.056) and knee (*p-value* = 0.501) respectively. This indicates that non-registry countries also experienced reductions in hip and knee revision rates. On average, registry countries had 3.89% and 0.84% points reduction in revision rates for hip and knee respectively, relative to non-registry countries for the whole sampling period.
The average difference ($\beta_2$) in revision rates between the pre-registry periods (category A and C) and the registry periods (category B and D) was statistically significant for hip ($p$-value $< 0.0001$) and knee ($p$-value $= 0.009$) respectively. On average, the revision rates in the pre-registry periods of both registry and non-registry countries was higher by 2.17% (for hip) and 0.87% (for knee) points relative to their registry periods for the whole sampling period.

There was an annual decrease ($\beta_3$) in revision rates across both country-categories due to non-JRR factors and JRR outcomes transfer, which was statistically significant for hip ($p$-value $< 0.0001$) and knee ($p$-value $= 0.008$) respectively. Annually, both registry and non-registry countries experienced a reduction of 0.06% and 0.02% points for hip and knee revision rates respectively.

Finally, the average difference in revision rate ($\beta_4$) in the registry period of registry countries relative to their pre-registry period (category C) and the pre-registry (category A) and registry (category B) periods of non-registry countries was statistically significant for hip ($p$-value $< 0.0001$) and knee ($p$-value $= 0.004$) respectively. On average, the registry period of registry countries relative to their pre-registry period and the pre-registry and registry periods of non-registry countries was associated with 3.66% and 0.97% points reduction in revision rates for hip and knee respectively for the whole sampling period. Therefore, the impact of JRR on revision rate reduction as a percentage of the intercept ($\beta_0$) was 19.23% (95% CI: 10.86–31.55%) and 13.07% (95% CI: 3.28–31.18%) for hip and knee respectively. Table 3 and Table 4 show details of the hip and knee JRR impact on revision rate, while Fig. 2 and Fig. 3 present their impact in predictive linear trends. Appendix 1 and Appendix 2 present the mean annual rate of hip and knee revisions respectively for registry versus non-registry countries. Further details on the data used for analysis and the results (from the model) are available in Additional file 1 and Additional file 2.

The sensitivity test showed that changes in the registry period for non-registry countries did not affect the results as the JRR impact was still statistically significant for hip and knee respectively.
Table 3
Hip registries impact on revision rate.

|                | Main model | Sensitivity test | Sensitivity test | Sensitivity test | Sensitivity test |
|----------------|------------|------------------|------------------|------------------|------------------|
|                |            | Registry period for non-registry countries |                |                  |                  |
|                |            | 1999–2018 | 1994–2018 | 2003–2018 | 2006–2018 | 2012–2018 |                |
|                | Coef. | Std. err | Coef. | Std. err | Coef. | Std. err | Coef. | Std. err | Coef. | Std. err |
| $\beta_0$     | 19.01*** | 1.85     | 18.24*** | 1.86     | 19.40*** | 1.84     | 19.57*** | 1.84     | 19.59*** | 1.84     |
| $\beta_1$     | -3.89*    | 2.04     | -3.03    | 2.05     | -4.40**  | 2.03     | -4.65**  | 2.03     | -4.69**  | 2.03     |
| $\beta_2$     | 2.17***   | 0.61     | 3.26***  | 0.62     | 1.13*    | 0.63     | 0.28     | 0.65     | 0.25     | 0.76     |
| $\beta_3$     | -0.06***  | 0.02     | -0.07*** | 0.01     | -0.05*** | 0.02     | -0.04**  | 0.02     | -0.04**  | 0.01     |
| $\beta_4$     | -3.66***  | 0.61     | -4.55*** | 0.62     | -2.86*** | 0.63     | -2.22*** | 0.65     | -2.21**  | 0.77     |
| Hausman test  |            |            | Test-statistics | 0.55 | 0.47 | 0.67 | 0.78 | 0.79 | P-value | 0.46 | 0.49 | 0.41 | 0.38 | 0.37 |

Note: .01 - ***; .05 - **; .1 - *;
Table 4
Knee registries impact on revision rate.

| Registry period for non-registry countries | Main model | Sensitivity test |
|-------------------------------------------|------------|-----------------|
|                                           | Coef.      | Std. err         | Coef.      | Std. err         | Coef.      | Std. err         | Coef.      | Std. err         | Coef.      | Std. err         |
| 1999–2018                                 | 7.40***    | 1.13             | 7.39***    | 1.13             | 7.45***    | 1.12             | 7.50***    | 1.12             | 7.59***    | 1.12             |
| 1994–2018                                 | -0.84      | 1.24             | -0.80      | 1.25             | -0.80      | 1.24             | -0.75      | 1.24             | -0.62      | 1.24             |
| 2003–2018                                 | 0.87***    | 0.33             | 0.57*      | 0.34             | 1.04***    | 0.34             | 1.16***    | 0.34             | 1.14***    | 0.41             |
| 2006–2018                                 | -0.02***   | 0.01             | -0.02**    | 0.01             | -0.02***   | 0.01             | -0.02***   | 0.01             | -0.02**    | 0.01             |
| 2012–2018                                 | -0.97***   | 0.33             | -0.75**    | 0.35             | -1.10***   | 0.34             | -1.21***   | 0.35             | -1.28***   | 0.41             |

Hausman test

| Test-statistics | 0.71 | 0.78 | 0.68 | 0.68 | 0.75 |
|-----------------|------|------|------|------|------|
| P-value         | 0.40 | 0.38 | 0.41 | 0.41 | 0.39 |

Note: .01 - ***, .05 - **; .1 - *;

Discussion

This study used existing data on the revision rates for hip and knee replacement surgeries to evaluate the impact of joint registries from the global perspective from 1980 to 2018. The results showed that joint registries have a significant impact with a net contribution of about 16% reduction in revision rates.

Our findings were different from other studies. An international survey showed that revision rate in the registry and the non-registry countries were similar [33]. Another study showed that revision rates of all clinical studies for specific implants do not differ significantly from revision rates for the same implants from registry data [34]. Failure of other studies to control for technological transfer of JRR findings to non-registry countries is a plausible reason why our results were different. The JRR findings are publicly available and accessible by many non-registry surgeons and countries, which could lead to the similarity in surgical practices across countries.

Several factors could be responsible for the significant impact of JRR. Most JRR monitor implants and devices and surgical techniques performance by patients’ follow-up. This has led to the identification of optimal surgical techniques and prostheses with a low risk of revision. The identified best clinical practices are not only made known to JRR surgeons but are also transferred to non-JRR surgeons and countries through scientific publications, conferences, webinars etc., which explains why non-registry countries also experienced a reduction in revision rate as indicated in the results (parameter $\beta_1$ and $\beta_3$, Fig. 2 and Fig. 3).
This study has some limitations. First, a gold standard approach to evaluate the impact of JRR on revision rate is to conduct a randomized control trial. However, this may not be feasible in this context because it may require many countries’ involvement, a large effect size such as all patients that have undergone joint replacement surgeries and may require a long period (over 10 years) of monitoring and follow-up of patients (based on protheses lifespan) to ensure robustness and validity of findings [35]. So, we employed the difference-in-differences approach using retrospective data. Second, the availability of limited non-registry data led to assessment with limited non-registry countries. Thus, the results should be interpreted with caution in the context of generalizability since the data we used in the non-registry country category were from a few countries. However, this was expected due to poor monitoring of patients in the non-registry period. The limited data also led to the application of moving average where necessary to provide missing data at some points in the time series.

**Conclusion**

Joint replacement registries cause significant reduction in revision rates and its effect on this outcome may be further improved by increasing surgeons’ participation and partnership. Establishment of JRR in countries or regions yet to would be a worthwhile decision.

**Abbreviations**

JRR: Joint replacement registries  
PRISMA: Preferred reporting items for systematic review and meta-analysis  
MeSH: Medical subject heading  
SHP: Surgeon and hospital participation  
CL: Cruciate ligament  
PROM: Patient reported outcome measure

**Declarations**

**Ethical approval and consent to participate**

Not applicable

**Consent for publication**

Not applicable

**Availability of data and materials**

All data generated and analysed during this study are included in this published article and its supplementary files.
Competing interest

The authors declare that they have no competing interests

Funding

The authors received no funding for this study.

Authors’ contributions

CV, CO and JB were responsible for conceptualization. SN and CO developed the study design and model, inclusion and exclusion. CO did the literature search and data extraction. JB and SN reviewed the search and data collected. CO, JB and SN contributed to the synthesis and data analyses. CO wrote the first draft of the manuscript. JB, SN and CV revised the manuscript. All authors reviewed the final manuscript.

Acknowledgement

Not applicable

References

1. Australian Orthopaedic Association. Joint Replacement Annual Report. 2019. https://aoanjrr.sahmri.com/annual-reports-2019. Accessed 12 Jun 2020.
2. Ceyhan E, Gursoy S, Akkaya M, Ugurlu M, Koksal I, Bozkurt M. Toward the Turkish National Registry System: A Prevalence Study of Total Knee Arthroplasty in Turkey. J Arthroplasty. 2016;31:1878–84. doi:10.1016/j.arth.2016.02.033.
3. ISAR. International Society of Arthroplasty Registries. 2021. https://www.isarhome.org/. Accessed 8 Jan 2021.
4. Lund University. The Swedish Knee Arthroplasty Register - Annual report. 2020. https://stat.myknee.se/?lang=en. Accessed 15 May 2020.
5. Romanian Ministry of Health. Romanian Arthroplasty Register. 2020. https://www.me.ro/me/informatii/. Accessed 15 Jun 2020.
6. The National Joint Registry Steering Committee. National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. 2019; December 2018. https://reports.njrcentre.org.uk/. Accessed 10 Jun 2020.
7. New Zealand Orthopaedic Association. Joint Registry Report. 2020. https://nzoa.org.nz/nzoa-joint-registry. Accessed 15 Jun 2020.
8. Koh IJ, Kim TK, Chang CB, Cho HJ, In Y. Trends in use of total knee arthroplasty in Korea from 2001 to 2010 knee. Clin Orthop Relat Res. 2013;471:1441–50.
9. Leitner L, Türk S, Heidinger M, Stöckl B, Posch F, Maurer-Ertl W, et al. Trends and Economic Impact of Hip and Knee Arthroplasty in Central Europe: Findings from the Austrian National Database. Sci Rep. 2018;8:6–10.
10. Erivan R, Tardieu A, Villatte G, Ollivier M, Jacquet C, Descamps S, et al. Knee surgery trends and projections in France from 2008 to 2070. Orthop Traumatol Surg Res. 2020. doi:10.1016/j.otsr.2020.02.018.
11. Guerrero-Ludueña RE, Comas M, Espallargues M, Coll M, Pons M, Sabatés S, et al. Predicting the Burden of Revision Knee Arthroplasty: Simulation of a 20-Year Horizon. Value Heal. 2016;19:680–7.
doi:10.1016/j.jval.2016.02.018.

12. Dixon T, Shaw M, Ebrahim S, Dieppe P. Trends in hip and knee joint replacement: Socioeconomic inequalities and projections of need. Ann Rheum Dis. 2004;63:825–30.

13. American Academy of Orthopaedic Surgeons. American Joint Replacement Registry-2019 Report. 2019;6th. http://connect.ajrr.net/2019-ajrr-annual-report. Accessed 20 Jun 2020.

14. Torre M, Romanini E, Zanoli G, Carrani E, Luzi I, Leone L, et al. Monitoring outcome of joint arthroplasty in Italy: Implementation of the national registry. Joints. 2017;5:70–8.

15. National Institute of Health and Welfare. Finnish Arthroplasty Register Online. 2018. https://www2.thl.fi/endo/report/#html/welcome. Accessed 9 Jun 2020.

16. Poon PC, Rennie J, Gray DH. Review of total hip replacement. The Middlemore Hospital experience, 1980-1991. N Z Med J. 2001;114:254–6.

17. Ingvarsson T, Hägglund G, Jónsson H, Lohmander LS. Incidence of total hip replacement for primary osteoarthrosis in Iceland 1982-1996. Acta Orthop Scand. 1999;70:229–33.

18. Kurtz S, Mowat F, Ong K, Chan N, Lau E, Halpern M. Prevalence of primary and revision total hip and knee arthroplasty in the United States from 1990 through 2002. J Bone Jt Surg - Ser A. 2005;87:1487–97. doi:10.2106/JBJS.D.02441.

19. Wengler A, Nimptsch U, Mansky T. Hip and Knee Replacement in Germany and the USA. Dtsch Arztebl Int. 2014;111:407–16.

20. Kumar A, Tsai WC, Tan TS, Kung PT, Chiu LT, Ku MC. Temporal trends in primary and revision total knee and hip replacement in Taiwan. J Chinese Med Assoc. 2015;78:538–44. doi:10.1016/j.jcma.2015.06.005.

21. Villanueva-Martinez M, Hernandez-Barrera V, Chana-Rodríguez F, Rojo-Manate J, Ros-Luna A, San Roman Montero J, et al. Trends in incidence and outcomes of revision total hip arthroplasty in Spain: A population based study. BMC Musculoskelet Disord. 2012;13.

22. Erivan R, Villatte G, Dartus J, Reina N, Descamps S, Boisgard S. Progression and projection for hip surgery in France, 2008-2070: Epidemiologic study with trend and projection analysis. Orthop Traumatol Surg Res. 2019;105:1227–35. doi:10.1016/j.otsr.2019.07.021.

23. Yoon PW, Lee YK, Ahn J, Jang EJ, Kim Y, Kwak HS, et al. Epidemiology of hip replacements in Korea from 2007 to 2011. J Korean Med Sci. 2014;29:852–8.

24. De Carvalho RT, Canté JCL, Lima JHS, Tavares LAB, Takano MI, Tavares FG. Prevalência de artroplastia de joelho no estado de São Paulo entre 2003 e 2010. Sao Paulo Med J. 2016;134:417–22.

25. Department of Orthopaedics SUH. The Swedish National Hip Arthroplasty Register: Annual Report. 2018. https://shpr.registercentrum.se/in-english/annual-reports/p/rkeyyeElz. Accessed 9 Jun 2020.

26. Norwegian National Advisory Unit on Arthroplasty and Hip Fractures. Annual Report 2019. 2019. http://nrlweb.ihelse.net/eng/.

27. Regionernes Kliniske KvalitetsudviklingsProgram. Danish Knee Arthroplasty Register. 2018. https://www.sundhed.dk/sundhedsfaglig/kvalitet/kliniske-kvalitetsdatabaser/planlagt-kirugi/knaealloplastikregister/. Accessed 18 Jun 2020.

28. Aarhus University. The Danish Hip Arthroplasty Register. 2019. http://danskhoftealloplastikregister.dk/en/publications/annual-reports/. Accessed 18 Jun 2020.
29. Italian National Institute of Health. Italian Arthroplasty Registry. 2018. http://riap.iss.it/riap/en/. Accessed 17 Jun 2020.

30. Canadian Institute for Health Information. Canadian Joint Replacement Registry. 2018. https://www.cihi.ca/en/canadian-joint-replacement-registry-cjrr. Accessed 21 Jun 2020.

31. Slovak Ministry of Health. The Slovak Arthroplasty Register. 2019. https://sar.mfn.sk/pracoviska. Accessed 10 Jun 2020.

32. EPRD. German Arthroplasty Registry. 2020. https://www.eprd.de/en/. Accessed 19 Jun 2020.

33. Kurtz SM, Ong KL, Lau E, Widmer M, Maravic M, Gómez-Barrena E, et al. International survey of primary and revision total knee replacement. Int Orthop. 2011;35:1783–9.

34. Pabinger C, Berghold A, Boehler N, Labek G. Revision rates after knee replacement: Cumulative results from worldwide clinical studies versus joint registers. Osteoarthr Cartil. 2013;21:263–8. doi:10.1016/j.joca.2012.11.014.

35. Evans JT, Walker RW, Evans JP, Blom AW, Sayers A, Whitehouse MR. How long does a knee replacement last? A systematic review and meta-analysis of case series and national registry reports with more than 15 years of follow-up. Lancet. 2019;393:655–63. doi:10.1016/S0140-6736(18)32531-5.

Figures

Figure 1

Schematic description of the assessment approach using the data categories. A: pre-registry revision rate data for countries without joint replacement registries; B: registry revision rate data for countries without joint replacement registries; C: pre-registry revision rate for countries with joint replacement registries; D: registry revision rate for countries with joint replacement registries.

Supplementary Files
This is a list of supplementary files associated with this preprint. Click to download.

- Paneldata.csv