Joint Replacement Registries Significantly Reduce Revision Rates

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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:

$$Y_{it} = \beta_0 + \beta_1 R_{it} + \beta_2 P_{it} + \beta_3 T + \beta_4 R_{it} {*} P_{it} + (a_i + \varepsilon_{it})$$

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; a_i represents unobserved time-invariant characteristics of countries that may affect the outcome, and ε_{it} is the random noise. The five β_s are the parameters to be estimated, where β_0 is the intercept; β_1 represents the average difference in revision rate between registry countries (category C and D) and non-registry countries (category A and B); β_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); β_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; β_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, β_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 β_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.

	Period reported	Reported data	Other details	Source
Included studies				
New Zealand	1980–1991	Hip	Pre-registry data	[16]
Iceland	1982–1996	Hip	Country without joint registry	[17]
United States	1990–2002	Hip and Knee	Pre-registry data	[18]
United States	2005–2011	Hip and Knee	Pre-registry data	[19]
England/Wales	1991–2000	Hip and Knee	Pre-registry data	[12]
Italy	2001–2005	Hip and Knee	Pre-registry data; registry established in 2006;	[14]
Spain	1997–2011	Knee	Country without joint registry.	[11]
Taiwan	1998–2009	Hip and Knee	Country without joint registry.	[20]
Excluded studies due to too few observations				
Spain	2001–2008	Hip	Country without joint registry.	[21]
France	2012–2018	Hip and Knee	Country without joint registry.	[10, 22]
Austria	2009–2015	Hip and Knee	Country without joint registry.	[9]
Korea	2007–2011	Hip	Country without joint registry.	[23]
Korea	2001–2010	Knee		[8]
Germany	2005–2011	Hip and Knee	Pre-registry data; registry established in 2012;	[19]
Brazil	2003–2010	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
Included reports						
Sweden	Knee: 1975 Hip: 1979	Hip and knee replacements; knee osteotomy.	MGT: medical society. Both registries managed separately. SHP: voluntary	Validation: yes, and continuous. Completeness: primary, 97%; revision, 92%. PROM: 82%	Annual; all-electronic online statistics for knee available; periodic update online.	[4, 25]
Finland	1980	Hip and knee replacements.	MGT: managed by the government since 1993. SHP: mandatory	Validation: yes, and continuous. Completeness: primary, 95%; revision, 82%.	Updated daily; all-electronic online report available.	[15]
Norway	Hip: 1987; other joints started in 1994 CL: 2004 Hip fracture: 2005 Paediatric hip: 2010	Four-in-one register: joint replacements; hip fracture; cruciate ligament; and paediatric hip	MGT: Norwegian orthopaedic association. SHP: voluntary	Validation: yes, and continuous. Completeness: 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]
Denmark	Hip: 1995 Knee: 1997	Hip and knee replacements.	MGT: orthopaedic society. SHP: voluntary	Validation: yes, and continuous. Completeness: 94%	Annual; updated periodically; annual report in Danish	[27, 28]

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. Funded by the government. SHP: voluntary	Validation: yes, and continuous. Completeness: 97.8% PROM data collection ongoing.	Annual; periodic reporting; online data collection forms.	[1]
New Zealand	1999	Hip, knee, shoulder, ankle, elbow, lumbar and cervical disc replacements	MGT: orthopaedic society. SHP: voluntary	Validation: yes, and continuous. Completeness: > 90% PROM data collection: 70%	Annual; periodic reporting; online data collection forms.	[7]
England/Wales	2003	Hip, knee, shoulder, ankle and elbow replacements.	MGT: government SHP: voluntary	Validation: yes, and continuous. Completeness: 96% PROM data: 94%	Annual; periodic update of the registry online; statistics of procedures updated online	[6]
Italy	2006	Hip, knee and shoulder replacements	MGT: government SHP: voluntary. Legal process ongoing to make participation mandatory	Validation: yes, and continuous. Completeness: 66%	Annual reporting	[29]
United States	2012	Hip and knee replacements.	MGT: orthopaedic society. SHP: voluntary	Validation: yes, and continuous. Completeness: 86% PROM data collection: 20% and ongoing	Annual	[13]
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. Completeness: > 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. Completeness: 72% PROM data collection ongoing.	Annual; periodic reporting.	[30]
Slovakia	Hip: 2003 Knee: 2006	Hip and knee replacements.	MGT: government SHP: voluntary	Validation: yes, and continuous. Completeness: 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. Completeness: > 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 (β_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 (β_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 (β_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 (β_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 (β_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							
	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
β_0	19.01***	1.85	18.24***	1.86	19.40***	1.84	19.57***	1.84	19.59***	1.84
β_1	-3.89*	2.04	-3.03	2.05	-4.40**	2.03	-4.65**	2.03	-4.69**	2.03
β_2	2.17***	0.61	3.26***	0.62	1.13*	0.63	0.28	0.65	0.25	0.76
β_3	-0.06***	0.02	-0.07***	0.01	-0.05***	0.02	-0.04**	0.02	-0.04**	0.01
β_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.

	Main model		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
β_0	7.40***	1.13	7.39***	1.13	7.45***	1.12	7.50***	1.12	7.59***	1.12
β_1	-0.84	1.24	-0.80	1.25	-0.80	1.24	-0.75	1.24	-0.62	1.24
β_2	0.87***	0.33	0.57*	0.34	1.04***	0.34	1.16***	0.34	1.14***	0.41
β_3	-0.02***	0.01	-0.02**	0.01	-0.02***	0.01	-0.02***	0.01	-0.02**	0.01
β_4	-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 β_1 and β_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

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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.

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Figures

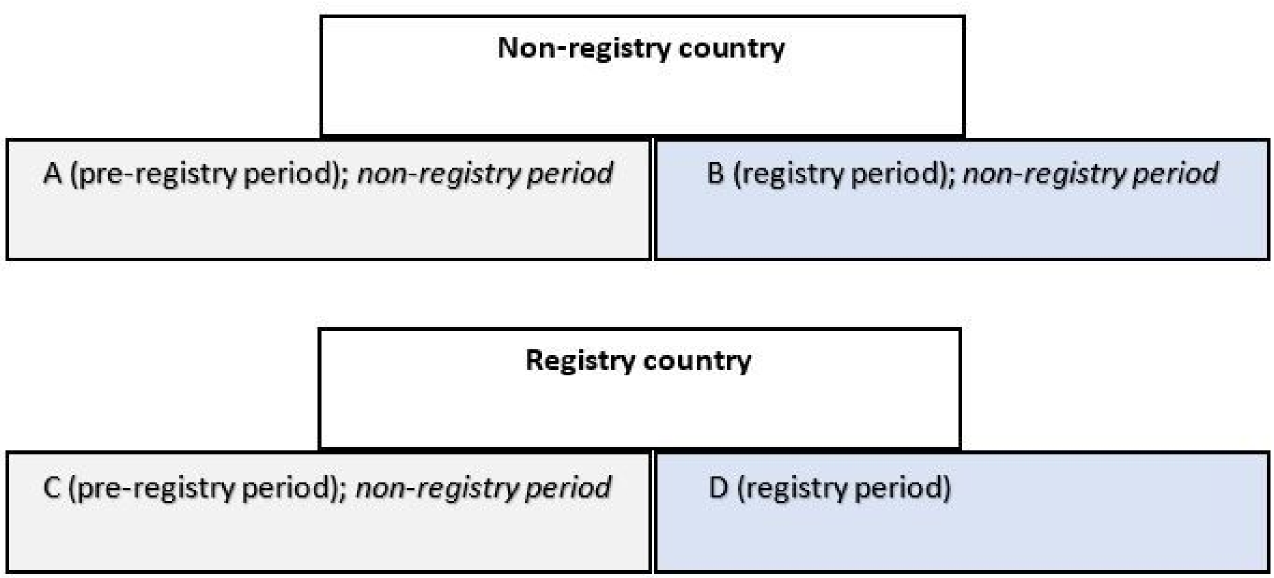

Figure 1

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.

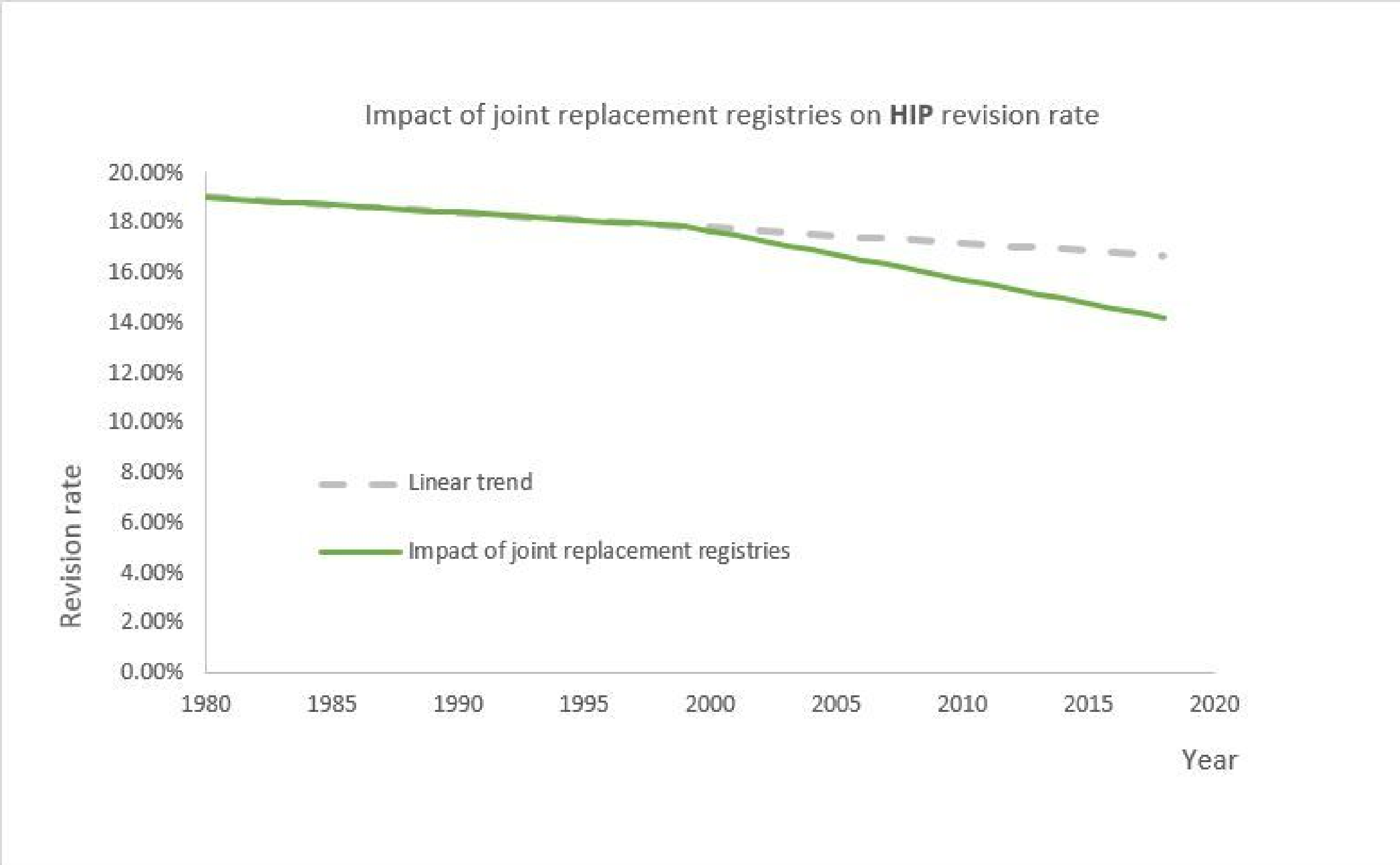

Figure 2

Predictive trend of joint replacement registries impact on HIP revision rate.

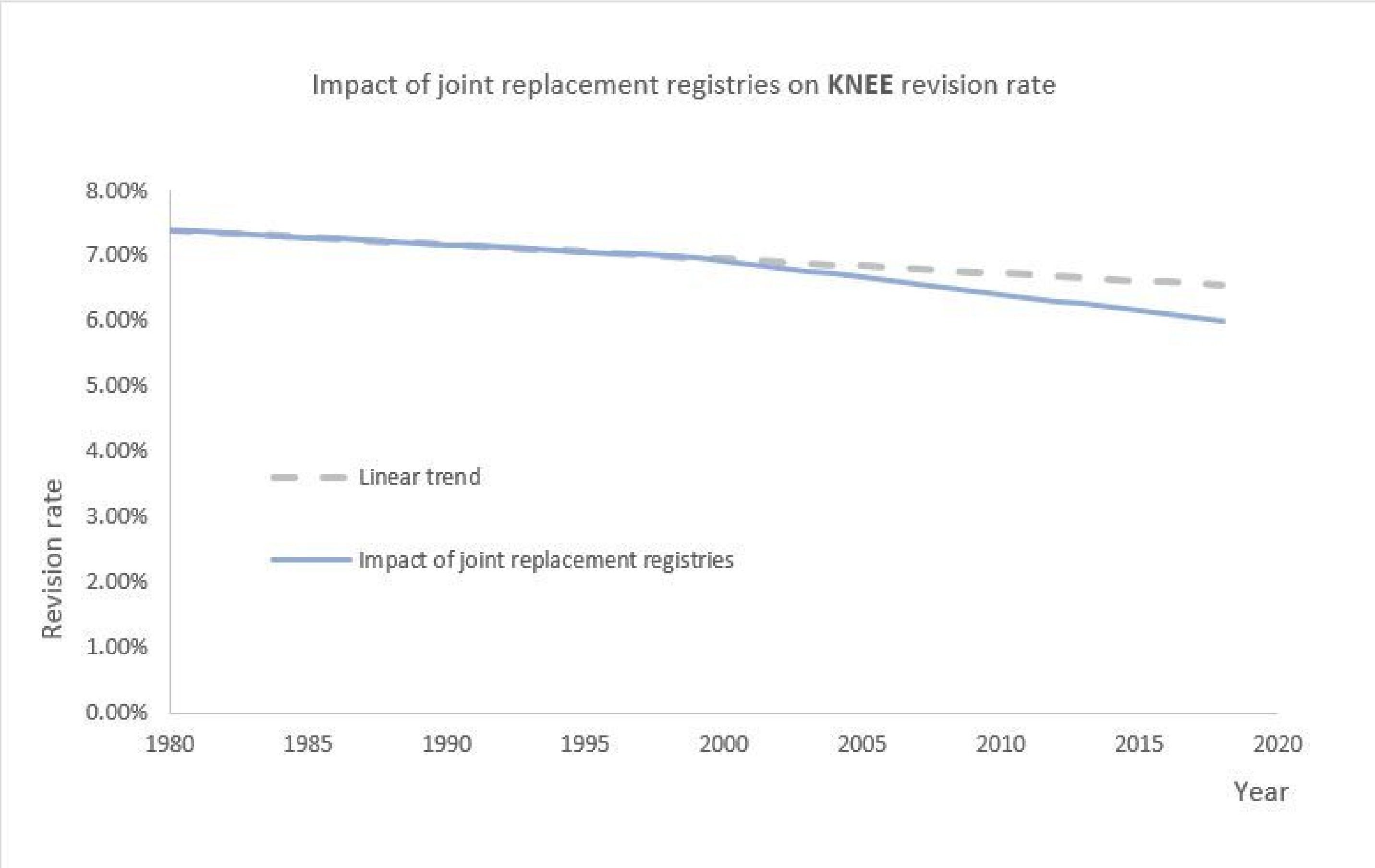

Figure 3

Predictive trend of joint replacement registries impact on KNEE revision rate.

Supplementary Files

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

- Appendix.docx
- Additionalfile1DATA.xlsx
- Charlespanelmain.do
- Paneldata.csv