New Zealand Joint Registry data underestimates the rate of prosthetic joint infection

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Background and purpose — Recent studies have revealed deficiencies in the accuracy of data from joint registries when reoperations for prosthetic joint infections (PJIs) are reported, particularly when no components are changed. We compared the accuracy of data from the New Zealand Joint Registry (NZJR) to a multicenter audit of hospital records to establish the rate of capture for PJI reoperations.

Methods — 4,009 cases undergoing total knee or hip arthroplasty performed at 3 tertiary referral hospitals over a 3-year period were audited using multiple hospital datasets and the NZJR. The number of reoperations for PJI that were performed within 2 years of the primary arthroplasty was obtained using both methods and the data were compared.

Results — The NZJR reported a 2-year reoperation rate for PJI of 0.67%, as compared to 1.1% from the audit of hospital records, giving the NZJR a sensitivity of 63%. Only 4 of 11 debridement-in-situ-only procedures and 7 of 12 modular exchange procedures were captured in the NZJR.

Interpretation — The national joint registry underestimated the rate of reoperation for PJI by one third. Strategies for improving the accuracy of data might include revising and clarifying the registry forms to include all reoperations for PJI and frequent validation of the registry data against other databases.

Prosthetic joint infection (PJI) is a leading cause of knee and hip arthroplasty revisions (Tande and Patel 2014). The emergence of large nationwide joint registries has improved our understanding of primary and revision arthroplasties performed for PJI. Revision rate, the main outcome used in joint registries, depends on accurate reporting of reoperations. Omissions are particularly problematic for PJIs; early PJI is often caused by contamination at the time of surgery, and registry data can often help to identify risk factors (Bongartz et al. 2008, Namba et al. 2013). Recent studies have revealed deficiencies in the reporting of secondary procedures performed for PJI (Lindgren et al. 2014, Gundtoft et al. 2015). Both of the latter studies used surrogate measures of infection to detect the true reoperation rate for PJI in nationwide cohorts. The aim of this study was to identify the true incidence of reoperations for PJI in 3 tertiary referral hospitals using published diagnostic criteria to define PJI (Osmon et al. 2013). These data could then be used to evaluate the performance of the New Zealand Joint Registry (NZJR) in reporting reoperations for PJI.

Methods

The NZJR was established in 1999, and covers arthroplasty data from all 52 New Zealand hospitals that perform arthroplasty. Participation is voluntary with funding sourced from the Ministry of Health, a compulsory implant levy and donations from the private sector. The registry is validated against the New Zealand Health Information database for public hospitals and by cross-checking with implant manufacturers’ databases for private hospitals. Discrepancies are investigated and data entry is done centrally by barcode scanning and cross-checked manual entry. Since its establishment, the registry has recorded almost 170,000 primary hip and knee arthroplasties along with 14,000 hip revision procedures and 5,500 knee revision procedures. The overall capture rate has been evaluated to be more than 95% (NZJR reports are available at www.nzoa.org.nz).

Between January 1, 2006 and December 31, 2008, the NZJR recorded 4,009 primary arthroplasties performed at 3 tertiary hospitals in Auckland, including 2,157 total knee arthroplas-
etiology, or (3) acute inflammation on histology of a periprosthetic specimen, or (4) acute infection occurring within 2 years of the primary procedure. A PJI diagnosis could not be made. Reoperations to treat PJIs occurring within 2 years of the primary procedure were included in the study. Again, multiple operations for the same case were counted as a single episode. Finally, the datasets from the NZJR and from hospital records were compared.

Statistics
The cumulative incidences of reoperation due to PJI were calculated for both the NZJR data and the retrospective audit data. This was done by dividing the numbers identified by the total number of arthroplasties performed. The sensitivity and specificity values of the NZJR relative to the audit data were also calculated. Agreement between the NZJR data and audit data was calculated using Cohen’s kappa.

Results
Of the 4,009 primary arthroplasty cases (2,157 knees and 1,852 hips), the NZJR identified 27 reoperations for PJI (16 knees and 11 hips) within 2 years of the primary procedure (Table 2). In 22 cases, component exchange was performed. This gave a PJI reoperation rate of 0.67% (0.74% for knees and 0.59% for hips).

During the same time period, the audit of hospital records of our primary cohort identified 43 reoperations for PJI within 2 years, involving 19 hips and 24 knees (Table 2). All 27 reoperations identified by the registry were captured by the audit of hospital records. The overall infection rate was 1.07% (1.03% for hips and 1.11% for knees). This gave the NZJR a sensitivity of 0.63 and a specificity of 1 compared to the audit of hospital records.

A second dataset was generated from NZJR data on secondary procedures for deep infection recorded for the same 4,009 cases, from January 1, 2006 to December 31, 2010. Deep infection is defined by the registry as infection below the deep fascia, probably involving the implant. Case records were then checked manually to confirm PJI and exclude cases where a PJI diagnosis could not be made. Reoperations to treat PJIs occurring within 2 years of the primary procedure were included in the study. Again, multiple operations for the same case were counted as a single episode. Finally, the datasets from the NZJR and from hospital records were compared.

Table 1. Patient demographics (n = 4,009)

| Mean age (SD) | 69 (11) |
|---------------|---------|
| Sex           |         |
| Male          | 1,684 (42%) |
| Female        | 2,325 (58%) |
| Hospital      |         |
| Auckland Hospital | 770 (19%) |
| Middlemore Hospital | 1,744 (37%) |
| North Shore Hospital | 1,495 (43%) |
| Joint         |         |
| Hips          | 1,852 (46%) |
| Knees         | 2,157 (54%) |
| Indication    |         |
| Osteoarthritis | 3,593 (90%) |
| Fracture      | 172 (4%) |
| Rheumatoid arthritis | 86 (2%) |
| Other inflammatory arthritides | 27 (0.5%) |
| Neoplasm      | 57 (1%) |
| Others        | 74 (2%) |

Table 2. New Zealand Joint Registry data

| Number of primary procedures | PJJ within 2 years |
|------------------------------|--------------------|
|                             | Hips n = 1,852     |
|                             | Knees n = 2,157    |
|                             | Total n = 4,009    |
| NZJR data, n                | 11                 |
| Percent (95% CI)            | 0.59 (0.24–0.94)   |
| Audit data, n               | 19                 |
| Percent (95% CI)            | 1.03 (0.37–1.49)   |

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During the same time period, the audit of hospital records of our primary cohort identified 43 reoperations for PJI within 2 years, involving 19 hips and 24 knees (Table 2). All 27 reoperations identified by the registry were captured by the audit of hospital records. The overall infection rate was 1.07% (1.03% for hips and 1.11% for knees). This gave the NZJR a sensitivity of 0.63 and a specificity of 1 compared to the audit of hospital records.

When compared to the audit data, the registry failed to identify 16 cases (8 hips and 8 knees) that were reoperated for PJI within 2 years of the primary procedure. 7 were debridement-in-situ-only procedures, 2 of which eventually progressed to staged revisions (defined as exchange of non-modular com-
and 2003, the Finnish Knee Register (FKR) reported a 1-year fi ed under-reporting of reoperations for PJIs. Between 1997
rate of 1.3% (Chen et al. 2013). This is again in keeping with
patients found a combined deep surgical site infection and PJI
PJIs (Pederson et al. 2012), while a meta-analysis of 54,000
Data from the Danish Knee Register (DKR) between 1997
ment, this equates to a reoperation rate of around 1.2–1.3%.
low arthroplasty patients for more than 12 months. They
reported a combined deep infection rate of 1.4% for hips and
The NZJR has an overall capture rate of greater than
90%, which compares favorably with other international reg-
tries. Despite this, we identifi ed defi ciencies in its reporting,
using multiple data sources. Over a 3-year period at 3 large
public hospitals involving 4,009 THAs and TKA cases, the
NZJR identifi ed a PJI reoperation rate of 0.67%—as compared
to the 1.1% found from hospital records. Thus, the NZJR had
an accuracy of 63% when detecting reoperations for PJI.
Components) outside the catchment time. 5 were modular component
exchange procedures and 4 were staged revisions. The reasons
for reoperation of 2 of the 4 patients were recorded as “acetabular loosening” and not “deep infection” in the registry
(Table 3). Of these 16 missed cases, 9 occurred within 90 days
of the primary procedure.
Compared to the audit data, the sensitivity of the registry in identifying PJI reoperations was 63%. It managed to cap-
ture 15 of 19 staged revisions, 7 of 12 modular component
exchange procedures, and 4 of 11 debridement-in-situ-only
procedures. Cohen’s kappa between the registry data and audit
data was 0.74.

Discussion
Registries often under-report revisions, particularly revisions
for PJIs. The NZJR has an overall capture rate of greater than
95%, which compares favorably with other international reg-
ries. Despite this, we identifi ed defi ciencies in its reporting,
using multiple data sources. Over a 3-year period at 3 large
public hospitals involving 4,009 THAs and TKA cases, the
NZJR identifi ed a PJI reoperation rate of 0.67%—as compared
to the 1.1% found from hospital records. Thus, the NZJR had
an accuracy of 63% when detecting reoperations for PJI.
The 2-year reoperation rate of 1.1% for PJI identifi ed in
our hospital audit is similar to those in international studies.
Lindeque et al. (2014) collated data from 6 studies that fol-
followed arthroplasty patients for more than 12 months. They
reported a combined deep infection rate of 1.4% for hips and
knees. As approximately 90% of PJIs receive operative treat-
ment, this equates to a reoperation rate of around 1.2–1.3%. Data
from the Danish Knee Register (DKR) between 1997 and 2010 showed a 2 year reoperation rate of 0.85–1.5% for
PJIs (Pederson et al. 2012), while a meta-analysis of 54,000
patients found a combined deep surgical site infection and PJI
rate of 1.3% (Chen et al. 2013). This is again in keeping with
our fi ndings.
Previous studies using national joint registries have identi-
fied under-reporting of reoperations for PJIs. Between 1997
and 2003, the Finnish Knee Register (FKR) reported a 1-year
reoperation rate of 0.77% for PJIs—less than the 0.89% reop-
eration rate identifi ed by the Finnish Patient Register database
during the same time period (Jamsen et al. 2009). In particu-
lar, modular exchange arthroplasty and excision procedures
were often missed. There is evidence to suggest that national
patient databases may also underestimate PJI reoperations.
Gundtoft et al. (2015) followed a cohort of almost 33,000
primary THAs and used an algorithm based on laboratory
results to identify reoperations for PJI. They reported a 1-year incidence of 0.86% and 5-year incidence of 1.03%.
These fi gures are 40% higher than the PJI reoperation rate reported by both the Danish Hip Arthroplasty Register and the Danish
Patient Register. Lindgren et al. (2014) captured primary total
hip arthroplasty patients from the Swedish Hip Arthroplasty
Register (SHAR) who were also recorded in the Swedish
Prescribed Drug Register as receiving outpatient antibiotics over more than 4 weeks. Questionnaires were sent to the
patients’ primary arthroplasty provider. The authors found
that the reoperation rate for PJI within 2 years of the primary
procedure was 1.3%. Only 67% of these had been recorded
correctly in the SHAR. When the reoperation did not involve
exchange of components, the sensitivity of the SHAR dropped
further to 57%. This refl ects our fi ndings, with only 4 of 11
such reoperations correctly reported to the NZJR.
There are a number of explanations for the poor capture
rate. The NZJR forms for hip and knee secondary procedures
do not include a column for “debridement-in-situ-only” pro-
cedures. Some surgeons may not consider these to be report-
able if no components are exchanged, leading to the low cap-
ture rate for these procedures. Secondly, the acute nature in
which these operations are often performed undermines the
reporting process. Staged revisions are routinely performed in
daylight hours, with regular theater staff who are experienced
in registry reporting. Debridement procedures with or without
component exchange are often performed out of hours in the
acute setting. Only 7 of 12 modular exchange procedures were
reported to the NZJR. This issue has also been identifi ed by
the SHAR and the FKR (Jamsen et al. 2009, Lindgren et al.
2014). In particular, the FKR captured 92% of staged revi-
sions but only 78% of modular exchange revisions and 0% of
debridement-only procedures.
As with its international counterparts, the NZJR performed
best when identifying staged revisions for infection. Its cap-
ture rate of 15 of 19 compares favorably with overseas data;
the SHAR reported a 74% capture rate for similar revisions
due to infection. However, these fi gures are still lower than
the generally accepted capture rate of 90–95% for registries
(Soderman 2000, Arthursson et al. 2005, Karrholm 2010).
Most registries are validated against national patient registers,
which have also been shown to under-report reoperations for
PJIs, and this may cause an overestimation of registry accu-

Table 3. NZJR data versus audit data

|                        | Patients missed by NZJR | Patients captured by NZJR |
|------------------------|-------------------------|---------------------------|
| Hips / knees           | 8 / 8                   | 11 / 16                   |
| Debridement in situ only| 7                       | 4                         |
| Modular exchange procedure | 5                     | 7                         |
| Staged revision        | 4 *                     | 15                        |
| Excisional procedure   | 0                       | 1                         |
| Total                  | 16                      | 27                        |

* 2 reported as acetabular loosening
Confusion regarding registry reporting requirements may also be an explanation for the poor capture rate (Lindgren et al. 2014, Witso 2015). Revisions for PJI often occur earlier than revisions for other causes. Of 16 reoperations that were missed by the NZJR were performed within 90 days of the primary procedure. This suggests there is a lack of clarity regarding when a reoperation can be reported after the primary, especially if the 2 events have occurred within 90 days (Arthursson et al. 2005).

It is worth noting that over a longer follow-up period, the NZJR would have captured a larger proportion of patients treated operatively for PJI. Many patients undergoing debridement-in-situ-only procedures will eventually require staged total component exchange procedures, which are more likely to be captured. We observed this in 2 of 7 such cases missed by the NZJR.

The strength of the present study lies in the standardized way in which PJI reoperations were identified. All 3 hospitals share a clinical records system, and all cases of PJI reoperations were confirmed by an orthopedic surgeon and an infectious diseases specialist. This result is applicable to all of New Zealand, as all centers routinely report to the NZJR. However, there may be regional differences in reporting, which might affect the generalizability of our results. All 3 hospitals in our audit were public hospitals, which is a possible source of bias—as reporting rates at private hospitals may differ. While every attempt was made to identify every reoperation through our audit, it is possible that some reoperations were missed—for example, if a patient had moved out of area. However, no such patients were identified in the national database of the NZJR. Additionally, surgeons may not suspect deep infection as the most likely cause of reoperation at the time. This is a possible cause of under-reporting by the NZJR, and it is a weakness of our study. In our series, an audit of clinical notes of all 16 cases missed by the NZJR showed clear evidence that infection was the most likely cause. It is also worth noting that 12 of the 16 cases eventually underwent component exchange or 2-stage revision procedures, giving surgeons more than 1 opportunity to correctly report to the NZJR.

Our findings suggest that registry reporting needs to improve before it can be reliably used to gauge PJs and their risk factors. Strategies to improve completeness include frequent validation against national patient registries (Serra-Sutton et al. 2009, Kolling et al. 2007, Paxton et al. 2010, Barsoum et al. 2012). The Swedish Knee Register missed up to 20% of all revisions until routine validation was performed (Roberson et al. 2014). This system is used as frequently as every 3 months in the Danish Knee Registry (Pederson et al. 2002). Currently the NZJR is only validated against the New Zealand Health Information Service every 3 years. Electronic form submission and validation should also be considered, as these limit errors in data reporting and can significantly reduce the resources required for validation (Paxton et al. 2010, Barsoum et al. 2012). Lastly, the NZJR reporting forms can be improved by including procedures without component exchange as an option.

Specialized databases can help reduce the number of missed cases. The Surgical Site Infection Improvement programme (SSIIP) was established in New Zealand in March 2013 (New Zealand Health Quality and Safety Commission). It tracks all hip and knee arthroplasty patients in New Zealand and reports any infections within 90 days of the indexed primary procedure. We found that reoperations during the first 90 days are poorly reported to the NZJR. If the NZJR database had been validated against the SSIIP during the study period, its capture rate would have increased to 84%. The process of sharing data between the NZJR and the SSIIP is currently under way.

A number of previous studies have used national joint registry data on deep infection as an outcome measure (Hooper et al. 2011, Namba et al. 2013), particularly when assessing risk factors for PJI. Our data suggest that a high number of PJs are in fact missed in registry data, and this should be taken into account when interpreting these findings. However, we believe that such studies still provide useful information, and registries provide a way of achieving the large numbers required to investigate rare complications such as PJI.

In summary, we found that the NZJR data significantly underestimated the true incidence of reoperation for PJI. In particular, it had poor sensitivity when identifying modular exchange and debridement-in-situ-only procedures. Steps to improve this may include modifying registry forms to highlight the option of procedures without exchange of components, improving feedback to orthopedic surgeons, and frequent validation against other national datasets. In doing so, the registry can become a more useful tool for identifying PJs and their associated risk factors.

**Supplementary data**

The Appendix is available on the Acta Orthopaedica website ([www.actaorthop.org](http://www.actaorthop.org)), identification number 9637.

MZ: data gathering and analysis, and preparation of manuscript. SR: data gathering and analysis. CF: data gathering. CL: data gathering and preparation of manuscript; senior author. SY: preparation of manuscript; senior author.

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