Lifetime risk of primary total knee replacement surgery in New Zealand from 2000 to 2015

Isobella S Henzell, Lifeng Zhou, Chris Frampton, Gary Hooper, Ilana Ackerman, Simon W Young

ABSTRACT

AIM: To estimate the lifetime risk of total knee replacement surgery (TKR) including unicompartmental knee replacement surgery (UKR) for osteoarthritis (OA) in New Zealand, and to identify if lifetime risk is changing over time.

METHOD: Data on primary TKR procedures performed for OA from 2000 to 2015 in New Zealand was obtained from the New Zealand joint registry. Life tables and population data were sourced from Statistics New Zealand and the Ministry of Health of New Zealand. Lifetime risk of TKR was calculated for each year from 2000 to 2015 using registry population data and life tables.

RESULTS: The overall lifetime risk of TKR in New Zealand increased markedly from 2000 to 2015, with females having an overall greater lifetime risk increasing from 9.4% in 2000 to 16.8% in 2015, a relative increase of 78%. However, males showed the greatest increase in risk from 8.1% in 2000 to 16.0% in 2015, a relative increase of 97%.

CONCLUSIONS: Current lifetime risk of knee replacement in New Zealand is approximately one in six for males and females. This lifetime risk has increased significantly from 2000 to 2015. These results can be used to guide public health policy planning and division of public health resources.

Osteoarthritis (OA) is a common condition affecting over 15% of adult New Zealanders.1 It represents a significant public health challenge internationally, with the lifetime risk of developing symptomatic OA of the knee estimated to be up to 47%.2 The incidence of OA increases with age, with a significant rise after the age of 60.2 With New Zealand’s ageing population, we can expect OA to become more common in the future.3 It is estimated that by the late 2030s, the over-65 age group will make up over one-quarter of the population.4 Additionally, not only is the population ageing, but this group of society is more likely to remain healthy and physically active for a longer period compared to previous generations.5,6

OA of the knee is the most common indication for joint replacement in New Zealand,7 which relieves pain and restores function.8,9 While current data shows that the number of joint replacements has increased,7 it is important for future healthcare planning to be guided by comprehensive population-level data incorporating around disease burden and healthcare utilisation.10 The ‘lifetime risk’ measurement considers population life expectancy and all-cause mortality to provide a cumulative measure of risk.11,12 This gives a more tangible measure for both health professionals and policymakers to assess utilisation in the community and plan the allocation of resources.13

Recently, Ackerman et al compared the lifetime risk of TKR for osteoarthritis between countries, including Australia, Denmark, Finland, Norway and Sweden, in 2003 and 2013 using registry data.10 Prior to this, data on this lifetime risk of TKR surgery was limited, using incomplete national datasets from observational studies or...
administrative databases. Registry data, which collect reliable and more complete national data, has enabled robust and precise estimates of the lifetime risk of TKR. All patients undergoing knee replacement in New Zealand are registered in the New Zealand joint registry (NZJR) for which there is 98% compliance.

This study aimed to answer the following questions concerning patients undergoing primary knee replacement (UKR and TKR):

1. What are the population characteristics (age and gender) and changes over time in New Zealand?
2. What is the lifetime risk of knee replacement and how has risk changed over a 15-year period?
3. What are the utilisation rates (by age and gender) in New Zealand, and how have they changed from 2000 to 2015?

Methods

Study design
A national, population level retrospective analysis was undertaken.

Data sources
Data on all primary TKR and UKR procedures performed for OA from 1 January 2000 to 31 December 2015 in New Zealand was obtained from the NZJR. The NZJR was established in 1999 by the New Zealand Orthopaedic Association, and collects data on all patients undergoing total hip replacement (THR) and TKR within New Zealand in both the public and private sectors.

De-identified, aggregate data on the number of surgical procedures and the number of patients receiving TKR and UKR in each year were obtained from the New Zealand Joint Registry (NZJR). The extracted data included gender, date of birth, hospital where the TKR or UKR was performed, side and operation type.

Complete life table data for the years ‘2000–2002’, ‘2005–2007’, ‘2010–2012’ and ‘2012–14’ were obtained from Statistics New Zealand. Life table data for 2003/2004 and 2008/2009 were not available, as Statistics New Zealand did not produce it. The number of people expected to be alive at the middle point of each age group stratified by gender. Lifetime risk of TKR was calculated for the years 2000–2015 by gender for New Zealand. Confidence intervals (95%CI) were estimated using the method proposed by Sasieni et al. Simultaneous bilateral TKR was counted as one TKR procedure to avoid potential overestimation of lifetime risk. Where staged (non-simultaneous) bilateral TKR procedures were performed within the same year, only the first procedure was included in the dataset.

Similar to previous methods, overall and age-specific utilisation rates for TKR were calculated in 2000 and 2015 for New Zealand data. This was calculated by dividing the number of procedures from the New Zealand joint registry by the relevant population (with regard to gender and age group)
for that year. These are reported as TKR utilisation rates per 100,000 populations, with separate calculations for males and females. Where bilateral TKRs were performed, these were counted as two operations to avoid underestimating the true utilisation of TKR, different from the approach in the estimation of the lifetime risk.

**Results**

**What are the population characteristics (age and gender) and changes over time in New Zealand?**

The population size of New Zealand has grown by 758,225 people since 2000 and the life expectancy has increased by 3.3 years (Table 1). The number of TKRs per year has increased from 3,014 in 2000 to 7,265 in 2015. The percentage of TKRs performed on females has decreased from 56.6% in 2000 to 51.8% in 2015. The proportion of TKRs performed in younger patients is increasing. In 2000 and 2003, the greatest proportion of TKRs were performed in the 70–79 year age group, however in 2013 and 2015 the greatest number have been performed for the 60–69 year age group. The number of TKRs performed in the 70–79 years age group and ≥80 year age group has decreased from 41.6% to 32.3% and from 11.5% to 9.9% respectively.

**What is the lifetime risk of knee replacement and how has risk changed over a 15-year period?**

The lifetime risk for TKR in New Zealand increased markedly from 2000 to 2015 (Table 2). A statistically significant increase was evident given there was no overlap of the 95% confidence intervals in 2000 and 2015. The lifetime risk of TKR in New Zealand for males in 2000 was 8.1% (7.63–8.54) increasing to 15.9% (15.37–16.53) in 2015. The lifetime risk of TKR for females in 2000 was 9.4% (8.92–9.87), increasing to 16.8% (16.16–17.33) in 2015. The lifetime risk of TKR in New Zealand was higher for females than males at each time point (Figure 1).

In contrast to TKR, there has been no increase in lifetime risk of UKR from 2000 to 2015 in New Zealand (Figure 1). The lifetime risk of UKR for males was consistently higher than for females. The lifetime risk of UKR for males in 2000 was 1.0% (0.84–1.15) and in 2015 was 1.8% (1.63–2.01). For females, the lifetime risk of UKR in 2000 was 0.8% (0.70–0.98) and in 2015 it was 1.5% (1.30–1.63).

**What are the utilisation rates (by age and gender) in New Zealand, and how have they changed from 2000 to 2015?**

The comparison of age-specific utilisation rates for TKR in New Zealand between 2000 and 2015 demonstrate an overall increase in utilisation rates in all age groups for males and females. In both 2000 and 2015, the utilisation rates in the 70–79 year age group were the highest, and this group also saw the greatest increase between the years (Table 3). The 50–59 and 60–69 year age groups utilisation rates almost doubled between 2000 and 2015. The difference in the overall utilisation rate by year for both females and males was statistically significant (P<0.0001, Chi Square Test).

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**Table 1: Population characteristics and TKR demographics.**

<table>
<thead>
<tr>
<th>Population data</th>
<th>TKR data from NZJR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population size</td>
<td>% Female</td>
</tr>
<tr>
<td>New Zealand</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>3,838,070</td>
</tr>
<tr>
<td>2015</td>
<td>4,596,295</td>
</tr>
</tbody>
</table>

*Data on population life expectancy at birth were obtained from OECD.Stat.  
†Bilateral procedures performed within the same year were counted as two TKRs.  
‡Proportion of those who received primary TKR at each time point.
Table 2: Lifetime risk of TKR from 2000 to 2015.

<table>
<thead>
<tr>
<th>Year</th>
<th>Lifetime risk (95% CI)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>2000</td>
<td>9.39 (8.92–9.87)</td>
<td>8.08 (7.73–8.54)</td>
</tr>
<tr>
<td>2001</td>
<td>9.09 (8.62–9.57)</td>
<td>8.52 (8.06–8.99)</td>
</tr>
<tr>
<td>2002</td>
<td>8.87 (8.40–9.33)</td>
<td>7.46 (7.04–7.89)</td>
</tr>
<tr>
<td>2003</td>
<td>8.97 (8.51–9.43)</td>
<td>7.80 (7.37–8.23)</td>
</tr>
<tr>
<td>2004</td>
<td>11.98 (11.45–12.52)</td>
<td>11.15 (10.61–11.68)</td>
</tr>
<tr>
<td>2010</td>
<td>15.58 (15.00–16.16)</td>
<td>14.49 (13.92–15.06)</td>
</tr>
<tr>
<td>2011</td>
<td>15.53 (14.95–16.10)</td>
<td>14.44 (13.88–15.00)</td>
</tr>
<tr>
<td>2013</td>
<td>15.88 (15.32–16.45)</td>
<td>14.41 (13.87–14.95)</td>
</tr>
<tr>
<td>2014</td>
<td>16.89 (16.31–17.46)</td>
<td>15.73 (15.17–16.28)</td>
</tr>
<tr>
<td>2015</td>
<td>16.75 (16.16–17.33)</td>
<td>15.95 (15.37–16.53)</td>
</tr>
</tbody>
</table>

Data are presented as percentages. Simultaneous bilateral TKR was counted as one TKR procedure to avoid potential overestimation of lifetime risk. Where staged bilateral TKR procedures were performed within the same year, only the first procedure was included in the dataset.

Figure 1: Comparison of lifetime risk of TKR and UKR.
Discussion

This study found the lifetime risk of total knee replacement in New Zealand to be 8.1% for males and 9.4% for females in 2000. In 2015, the lifetime risk of TKR was 15.9% for males and 16.8% for females. The lifetime risk has increased significantly in the last 15 years for both males and females. Lifetime risk measurements provide a more considered assessment of joint replacement burden than incidence or utilisation rates as they also take life expectancy and age-specific mortality into account.22,23

The lifetime risk of TKR increased most rapidly in New Zealand between 2004 to 2008. This period correlates with the Ministry of Health introducing a ‘Joint Initiative’ funding drive in 2004, aiming to increase the rate of publicly funded major joint replacements. The sustained increase for the four years following this may represent ‘catch up’ of previous unmet need. In New Zealand, it is government policy that there should be nationally consistent access to surgery. Prioritisation tools such as the Clinical Priority Access Criteria (CPAC) score and the Hip and Knee prioritisation tool developed by the Orthopaedic Working Group of the National Waiting Times Project are used to varying degrees across the country.24 When the clinical priority criteria were introduced, two crucial issues were whether they would correctly and consistently prioritise patients according to symptoms and ability to benefit from surgery, and whether the thresholds would be chosen so as not to leave patients with clear needs untreated.25

As a similar analysis approach was used, the New Zealand lifetime risk of TKR can be directly compared to previously published data for Australia, Denmark, Finland, Norway and Sweden in 2003 and 2013.10 In 2013, lifetime risk for females ranged from 9.7% in Norway to 21.1% in Australia, and for males ranged from 5.8% in Norway to 15.4% in Australia. Similar to our New Zealand findings, all countries showed an increase in lifetime risk of TKR between 2003 and 2013, and the lifetime risk of TKR for females was consistently higher compared to males for all six countries. While the overall lifetime risk percentages were most similar between New Zealand and Australia, the lifetime risk percentage relative increases between 2003 and 2013 were most similar for females in New Zealand to females in Denmark, and for males in New Zealand to males in Sweden. In 2003, the lifetime risk for females in New Zealand was 8.9% (8.51–9.43), this increased to 15.9% (15.32–16.45) in 2013, a relative increase of 77%. In 2003, the lifetime risk for females in Denmark was 5.8% (5.69–5.99), this increased to 10.9% (10.65–11.06) in 2013, a relative increase of 85%. For males in 2003, the lifetime risk in New Zealand was 7.8% (7.37–8.23), this

| Table 3: Comparison of age-specific utilisation rates for TKR. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | Utilisation rate* per 100,000 people |                |                |                |                |                |
|                | Overall | <40 years | 40–49 years | 50–59 years | 60–69 years | 70–79 years | ≥80 years |
| Females†       |         |          |            |            |            |            |            |
| 2000           | 101 2 18 | 120 396 | 697 362 |         |                |                |            |
| 2015           | 173 1 30 | 232 599 | 896 436 |         |                |                |            |
| Males‡         |         |          |            |            |            |            |            |
| 2000           | 92 1 13  | 104 428 | 722 452 |         |                |                |            |
| 2015           | 177 1 34 | 253 689 | 900 520 |         |                |                |            |

*The overall utilisation rate was calculated using the total number of procedures for females (or males) as the numerator and the number of females (or males) in the population as the denominator. Age-specific utilisation rates were calculated using the number of procedures for each age group as the numerator and the age-specific population as the denominator. Bilateral procedures performed within the same year were counted as two TKRs for calculating utilisation rates to avoid underestimating the true utilisation of TKR.
†The difference in the overall utilisation rate by year for females was statistically significant (P<0.0001, Chi Square Test).
‡The difference in the overall utilisation rate by year for males was statistically significant (P<0.0001, Chi Square Test).
increased to 14.4% (13.87–14.95) in 2013, a relative increase of 85%. In 2003, the lifetime risk in Sweden was 4.9% (4.79–5.07), this increased to 8.9% (8.69–9.06) in 2013, a relative increase of 80%. Given the 95% CIs did not overlap in any of these cases, the difference between 2003 and 2013 for these countries was significant.

The international variation in health systems is likely to contribute to the differences in lifetime risk of TKR seen between countries. These include differences in healthcare funding, workforce issues, access to surgery, local indications and variation in symptom thresholds for which surgery is offered.26,27 The difference in availability and implementation of OA prevention and management programmes incorporating physiotherapy, disease education and exercise prior to considering surgery is also very important and variable worldwide. Orthopaedic surgeons in Nordic countries appear more likely to consider non-surgical management given their range and availability of OA prevention programs.28–31 This approach has been taken up by orthopaedic surgeons in cities in New Zealand to reduce the waiting lists, however in regional and rural towns across New Zealand these resources are scarce, making uptake of non-surgical management difficult.5 Patient knowledge and expectations may also play a role in their attitude towards conservative versus surgical management. In addition, it is not known whether conservative management programmes can ultimately reduce an individual’s lifetime risk of surgery.29

The international variation in lifetime risk of TKR is less likely to be explained by differences in knee OA prevalence or severity distribution,46 but obesity, aging population and life expectancy may be influencing factors. Obesity is known to contribute to the increasing demand for knee arthroplasty,32,33 particularly in younger individuals.34 According to the 2015/16 national health survey, 32% of New Zealand adults are obese, which is a substantial increase from 27% in 2006/7.35 The prevalence of obesity in New Zealand is higher than Australia, Denmark, Finland, Norway and Sweden.36 The ageing population may influence the observed increase in lifetime risk of TKR over the study period, with more people aged >80 years receiving TKRs. However, the improvements in implant design and surgical technique have also resulted in a decreasing threshold for offering younger patients these procedures.7 In New Zealand, this is seen by the percentage increase of 50–59 year-olds and 60–69 year-olds undergoing TKR in 2000 compared to 2015 (Table 1). The higher lifetime risk of TKR for females across the countries could be a result of the longer life expectancy for females.18 These three factors, obesity, aging population and life expectancy, are also likely to have the greatest impact on the future demand for TKRs in New Zealand.

The healthcare systems in Australia and New Zealand are most similar, both offer universal healthcare (taxpayer-funded system) and both have parallel private health systems where the patient has a choice of surgeon and decreased waiting times.10,13 The proportion of people with private health insurance in Australia is considerably higher than in New Zealand. In 2013, 54.9% of Australians had private insurance while only 29.7% of New Zealanders were privately insured.18 While increasing utilisation figures could reflect an over-servicing within New Zealand, it is unlikely that TKRs are being performed on patients with minimal symptoms, as over 50% of the replacements in New Zealand are performed within public hospitals, who must comply with national health scoring criteria to identify patients with significant discomfort and functional loss.5

This study has several key strengths, including the use of comprehensive national registry data, the inclusion of both TKR and UKR data, and the calculation of annual lifetime risk estimates which allows trends over time to be examined. There are also some study limitations to acknowledge. Firstly, we assessed TKR and UKR separately, however the diagnosis and indications for both procedures are similar, and the decision as to which procedure to perform will vary. As a percentage of all knee replacements performed in New Zealand, UKR declined from 17% in 2000 to 8% in 2015, which may explain the lack of any increase in lifetime risk of UKR despite the overall increase in lifetime risk of any knee replacement (UKR or TKR) seen in this study.
This decrease in incidence of UKR over time in New Zealand may reflect a general trend for surgeons to prefer TKR over UKR for the diagnosis of OA and this trend is comparable to the UKR data from Australia, Denmark, Finland, Norway and Sweden shown by Ackerman et al.\textsuperscript{10} Secondly, similar to previous studies, when calculating lifetime risk we treated each year separately using a cross-sectional approach rather than a cohort approach between years to avoid overestimation of the lifetime risk. Within each particular year, if the patient had a TKR regardless of simultaneous bilateral or two at separate times, they were treated as one patient and thus counted in the numerator. Ethnicity was not included in our analysis as the joint registry reporting compliance rate is not adequate.

This study found the current lifetime risk of knee replacement in New Zealand is approximately one in six for males and females. We identified a significant increase in the lifetime risk of primary TKR over a 15-year period. These data, considered in combination with estimates of the OA burden over time, can be helpful in policy settings to inform population health strategies, motivate uptake of primary and secondary prevention strategies and direct training of the surgical workforce.

**Competing interests:**
Nil.

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