

Excess cost associated with primary hip and knee joint arthroplasty surgical site infections: a driver to support investment in quality improvement strategies to reduce infection rates

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ABSTRACT

AIM: To determine the excess costs attributable to surgical site infections (SSI) following primary hip and knee joint arthroplasty at Auckland City Hospital.

METHODS: A retrospective case-control study. Cases were patients who developed a SSI following primary hip (THA) and knee arthroplasty (TKA) surgery within 90 days of the procedure. Cases were matched 1:2 with controls; patients whose primary hip and knee arthroplasty procedures were not complicated by infection. Controls were matched for age, gender, date of surgery, type of surgery, and ASA category. The length of stay (LOS) and hospital costs for the initial admission and subsequent readmission for infection were calculated from the clinical costing system at Auckland District Health Board.

RESULTS: Eleven cases were identified; 3 following TKA, 7 following THA, and 1 following hemiarthroplasty of the hip. Infections were classified as superficial, 1; joint space, 1; and deep incisional, 9. Five SSIs were identified during the initial admission for joint arthroplasty and 6 patients were readmitted with an SSI. Compared to the control patients, SSIs were associated with an excess mean cost of \$40,121 and an excess mean LOS of 42 days.

CONCLUSIONS: There is a significant increase in LOS and cost associated with SSI following primary THA and TKA at Auckland City Hospital. In addition to the excess cost associated with SSI, there are also opportunity costs resulting from their impact on elective surgical waiting lists. This reinforces the significant positive economic impact a successful strategy to reduce SSIs associated with primary joint arthroplasty procedures will have.

Healthcare-associated infections (HAI) are costly, debilitating and are associated with excess mortality.¹ Overall, along with urinary tract infections, surgical site infections (SSI) are the first or second most common form of HAI, and account for 14–30% of HAIs.^{1–3} Patients undergoing surgery experience a higher burden of HAI than patients not

undergoing surgery with SSI being the most common HAI, followed by hospital-acquired pneumonia, urinary tract and bloodstream infections.⁴ Surgical site infections are the most common complication occurring after discharge in total hip and knee arthroplasty and in general surgical patients in the US. Also, patients who have a post-discharge complication of any sort have an increased

likelihood of reoperation and death within 30 days of the procedure.^{5,6}

In the US, it is estimated that in 2012 the total annual cost for the five major HAIs was \$9.8 billion (95% CI, \$8.3–\$11.5 billion), with SSI contributing the most overall costs (34% of the total).⁷ In Australia, it was estimated in 2005 that the annual costs of all HAI was at least \$1 billion.⁸ More recent costing data for SSI following total hip and knee arthroplasties estimated an annual cost in Australia of \$97 million.⁹ In New Zealand, there is only limited information, mostly from a single hospital, about the cost of HAI.^{10,11} Infection rates determined by point prevalence studies in the 1990s at the same hospital has subsequently been used to estimate the annual cost of HAI in New Zealand. In 2003, this was estimated at approximately \$137 million per annum.¹²

SSI, along with dislocation and prosthesis loosening, are the most common complications of total hip arthroplasty (THA) and total knee arthroplasty (TKA) with worldwide reported infection rates of approximately 1–2%.^{13,14} The cost of SSI associated with hip and knee arthroplasty is unknown in New Zealand. The aim of this study was to determine excess cost and length of stay (LOS) associated with SSI following these procedures. This will allow for more informed decision making when planning quality improvement initiatives aimed at reducing SSI rates.

Methods

This study was conducted at Auckland City Hospital, a 710 bed tertiary referral centre, using data obtained as part of the New Zealand Health Quality and Safety Commission's Surgical Site Infection Improvement (SSII) Programme.

Data was collected prospectively on all hip and knee arthroplasty procedures. Where possible data was extracted electronically from existing Auckland District Health Board (ADHB) data warehouses. Data collected included: patient demographics; admission and procedure date and LOS; type of procedure (TKA, THA, or hemiarthroplasty of the hip, primary or revision); surgical antimicrobial prophylaxis; duration of surgery; American Society of Anaesthe-

sologists' (ASA) physical status category; presence of an SSI; type of SSI (superficial, deep incisional or joint space); the organism(s) identified; and timing of SSI.¹⁵ The US National Healthcare Safety Network (NHSN) definition for SSI was used.¹⁶

Matching

A case-control study was performed with a 1:2 match for all patients with a SSI following joint arthroplasty in the first year of the SSII programme (1 March 2013–28 February 2014). A case was defined as a patient who met the criteria for a SSI. A control was a patient who did not get an SSI.

During the study period, 17 patients met the definition for SSI. However, six patients were excluded because the SSI followed revision surgery and the small number of revision procedures prevented matching. Cases were matched as follows: age (+/- 5 years); gender; type of surgery (hemi/full arthroplasty, hip vs knee); date of surgery (+/- 3 months); and ASA category.

Population size/power calculations were not performed. Non-parametric tests (Mann-Whitney U test) for continuous variables; contingency tables to determine Pearson's chi-squared and linear chi-squared functions for categorical data were used. P values ≤ 0.05 were considered statistically significant.

Costing

Data to assess the cost relating to admission for cases and controls were extracted from ADHB clinical costing system (Power Performance Manager, Power Health Solutions). The cost of individual patient care is identified by capturing every item of utilisation on each patient during their stay. Expenditure is allocated according to utilisation. The cost of admission for the initial arthroplasty (initial admission) and any subsequent admissions within 90 days of the initial surgery related to complications of surgery (subsequent admissions) were calculated. The impact on LOS was calculated as the mean difference between cases and matched controls. Hospital costs arise from costs associated with laboratory testing, allied health input, radiological investigation, drug therapy, and bed costs. Impact on cost was calculated as mean difference. Excess cost and LOS is presented.

Table 1: Patient demographics, total and excess length of hospital stay, average and excess cost for cases and controls

Variable	Cases (n=11)	Controls (n=22)	P value
Age: median years (range, IQR)	69 (49–78, 61.5–75.5)	62.5 (52–80, 60–74.75)	
Gender :			
Male	8	16	
Female	3	6	
Type of surgery:			
TJA Hip	7	14	
TJA Knee	3	6	
HA Hip	1	2	
ASA physical status category (n)			
1	0	0	
2	3	6	
3	7	16	
4	1	0	
Length of operation median hours (range)	1:40 (1:12–2:05)	1:52 (1:14–2:36)	0.55
LOS (mean days \pm SD)			
Initial admission (SSI not diagnosed)	5 \pm 0.55	7.7 \pm 9.1	
Initial admission (SSI diagnosed)	75 \pm 39.5	N/A	
Re-admission for SSI	16 \pm 19.6	N/A	
Total LOS	49.6 \pm 37.6	7.7 \pm 9.1	<0.0001
Excess LOS (mean days)	41.9		
Total cost NZD 2015			
Initial admission (mean \pm SD)	55,255 \pm 49,211		
Re-admission (mean \pm SD)	42,936 \pm 36,869		
Total (mean \pm SD)	61,157 \pm 41,414	21,035 \pm 6,296	<0.0001
Excess cost per SSI	\$40,121		

TJA = total joint arthroplasty; HA = hemiarthroplasty of hip; ASA = American Society of Anaesthesiologists; LOS = length of stay.

Results

During the first year of the SSII programme, there were 517 primary hip and knee arthroplasties performed at ACH, and 11 procedures (2.7%) were complicated by a SSI. The SSI followed THA, 7, TKA, 3, and hemiarthroplasty of the hip, 1. The SSI were classified as a superficial SSI, 1, deep incisional SSI, 9 and joint space SSI, 1. Five deep incisional SSI occurred during the initial admission; the other 6 SSI resulted in readmission. All 11 cases required surgical intervention for the management of the SSI. The median (range) number of procedures was 2 (1–4).

The 11 cases were matched with 22 controls. There was no significant difference in the patient characteristics between the cases and controls for the matching criteria (Table 1). Also, there was no significant difference in the length of the operation.

The SSI occurred a median of 15 (range 7–70) days after the procedure. A microor-

ganism was isolated in 9 cases; two cases were infected with methicillin-susceptible *Staphylococcus aureus*, one case each was infected with methicillin-resistant *S. aureus*, Streptococcus Group G, *Streptococcus pyogenes*, *Clostridium perfringens* and *Enterobacter* sp., and two cases had polymicrobial infections with *S. epidermidis* and *Corynebacterium* sp., and *Proteus mirabilis* and *Serratia marcescens*. Two cases with deep/organ space infections had tissue sent for culture, but the cultures were negative.

The overall mean (\pm SD) LOS was significantly longer for the cases compared to the controls; 49.6 \pm 37.6 days for cases and 7.7 \pm 9.1 days for the controls ($p <0.0001$). The mean excess LOS was 41.9 days. Overall, the 11 cases stayed an excess 262 days in hospital.

The mean cost of the initial and subsequent admissions for the cases was \$61,157 \pm \$41,414 compared to the mean cost for the controls of \$21,035 \pm \$6,296 giving an excess cost associated with the SSI of \$40,414.

Discussion

In New Zealand in 2013 there were approximately 16,000 primary and revision hip and knee arthroplasties performed in District Health Board (DHB) hospitals and private surgical (third-party funded) hospitals.¹⁴ The SSII Programme reports an overall infection rate for hip and knee arthroplasty procedures performed in DHB hospitals of 1.3%.¹⁷ Therefore, we estimate that just over 200 patients each year in New Zealand have an SSI requiring inpatient care following these procedures. At an excess cost of \$40,000 per SSI, the cost to the DHBs would amount to about \$8 million per year.

This is probably a gross underestimate of the true cost of SSI for a number of reasons. Firstly, this cost does not include the personal costs to the patient, or their family and whānau, or the costs covered by the Accident Compensation Corporation (ACC). ACC provides a comprehensive ‘no faults’ personal injury cover for all New Zealand residents and visitors to New Zealand. This includes ‘treatment injuries’, such as SSI, occurring during medical treatment. Secondly, it does not cover the costs associated with managing infections in the community. Up to a third of all SSI occur after discharge from hospital and a significant proportion will be managed by primary care providers. And finally, it does not take into account the long-term economic consequences for these patients arising from the physical and psychological impact of the SSI.

This study confirms the finding of other studies that there is a significant excess cost associated with surgical site infections complicating hip and knee arthroplasty procedures.^{9,18-21} A case-control study performed at a US tertiary university hospital and a community hospital showed orthopaedic SSIs accounted for 15 days excess hospitalisation, four-fold increased cost, and adversely affected quality of life when compared with surgery not complicated by SSI.¹⁸ A nested case-control study conducted between 2000 and 2004 estimated the impact of hip arthroplasty-associated SSI on morbidity and LOS. Cases with a SSI had a median excess LOS of 32.5 days; this was even more pronounced in the deep-wound

subset at 49 days.¹⁹ The Victorian Nosocomial Infection Surveillance (VICNIS) programme reviewed 20 months of total joint arthroplasty SSI in 2006, and found an average cost following hip arthroplasty infection of AU\$34,138 and knee arthroplasty infection of \$40,940.²¹ More recently, a study conducted at a single centre in Melbourne showed that the base cost of hip and knee arthroplasty surgery without modifying factors was AU\$13,000, or an estimated AU\$1.13 billion per year. The complication of SSI accounted for 74% of readmissions in the first 30 days following surgery and added AU\$97 million to arthroplasty costs.⁹

The excess costs are incurred because of the increased LOS required for diagnosing and managing the infection. The clinical costing software programme used in this study captures both direct costs (those associated with the delivery of care to each individual patient) and indirect costs (those not directly linked to individual patient care). A significant proportion of the excess cost, up to 85%, is a fixed cost that occurs regardless of whether the bed is occupied or not.²² This fixed cost covers the daily operational costs for the hospital, including staff salaries. Variable costs are those costs arising from the consumable items used to diagnosis and manage the infection. In the absence of an SSI these costs are avoided and resources can be allocated elsewhere. One of the strengths of this study is the completeness of the costing data including both direct and indirect costs.

A review of 16 studies looking at increased costs resulting from SSI reported that not only is the cost of a patient with an SSI approximately twice the amount of a patient without an infection, but that the LOS also more than doubles.²³ This is comparable to New Zealand data which showed that in 2003 a SSI prolonged the LOS by a median 12 days in surgical patients and was associated with an excess cost of \$32,134.¹² When the bed occupancy is high, such as in DHB hospitals, the increase in LOS associated with SSI may impact upon elective surgery waiting lists. Using the data from this study, we estimate that on average about 8,400 fewer orthopaedic bed-days will be available for elective surgery admissions annually

Table 2: Comparison of the method for determining the excess cost and length of stay associated with surgical site infections following hip and knee joint arthroplasty.

Study	Procedures	Number (SSI rate)	Surveillance method	Costing method	Excess cost (\$)	Excess length of stay (days)
Whitehouse, 2002 US ¹⁸	Orthopaedic including THA and TKA	5050 (1.2%)	CDC (NNIS), follow-up for 1 year	Fixed and variable costs obtained from hospital accounting system. Outpatient costs not captured	US\$18,000	15
Jorda, 2006 Spain ¹⁹	THA	1260 (2.6%)	CDC (NNIS) Length of follow-up unclear	No costing performed	Not provided	31
VICNISS, 2006 Australia ²¹	THA and TKA	Not recorded	CDC (NNIS), 1 year follow-up	Cost per bed day, treatment, diagnostic and procedure costs	AU\$34,000 and AU\$41,000	27
Miletic, 2014 US ²⁰	THA and TKA	7658 (1.3%)	AHRQ surveillance ICD-9-CM, 1 year follow-up	MarketScan Commercial Claims and Encounter database and Medicare Supplemental database	US\$20,000	7.4
Peel, 2014 Australia ⁹	THA and TKA	827 (4%)	CDC (NNIS), 30 day follow-up	Hospital administrative databases. Fixed and variable costs using a “bottom-up” approach	Population not individual cost calculated	Not provided
Gow, 2015 New Zealand (this report)	Primary THA and TKA	517 (2.7%)	CDC (NHSN), 90 day follow-up	Power Performance Manager, Power Health Solutions	NZ\$40,414	41.9

CDC = Centers for Disease Control and Prevention, USA, NNIS = National Nosocomial Infection Surveillance programme and NHSN = National Healthcare Safety Network, THA = total hip arthroplasty, TKA = total knee arthroplasty, AHRQ = Agency for Healthcare Research and Quality, US.

because these beds are occupied by patients receiving treatment for a SSI following a hip and knee arthroplasty procedure.

It is difficult to compare the cost of these infections between different studies because the approaches used to capture the cases and the cost varies (Table 2). Care provided after discharge, including outpatient and primary care visits, was not included in our study but may have been included in other studies. The cost and approach to healthcare delivery between countries varies. Regardless of these differences, the excess cost associated with SSI following THA and TKA is significant.

Strategies aimed at reducing the rate of SSI have been shown to reduce SSI rates by as much as 60%.²⁴ However, the implementation of these strategies is often poor

because of the so called ‘implementation gap’ for infection prevention, ie, we know what we should do to reduce infections but we don’t do it. In 2013, the New Zealand Health Quality & Safety Commission (the Commission) established the National Surgical Site Infection Improvement (SSII) Programme. The aim of the Programme is to reduce the harm and cost associated with SSI. The Programme, in collaboration with all DHBs, has implemented a consistent, evidence-based approach for collecting and reporting quality data following hip and knee arthroplasty.²⁵ Through a consultative process, the SSII Programme aims to promote best practice interventions known to reduce SSI rates. These interventions focus primarily on surgical antimicrobial prophylaxis and skin antisepsis. It is anticipated that improvement in adherence to

these interventions will reduce the SSI rate and hence avoid the unnecessary excess cost associated with these infections. This will result in better outcomes for patients and a freeing up of health resources for other initiatives aimed at improving care. Other national programmes, such as the Ministry of Health's 'Enhanced Recovery After Surgery (ERAS) Pathway', may also be contributing to an improvement in clinical outcomes and a reduction in overall LOS by standardising the clinical care pathway and incorporating the Commission's SSII programmes infection prevention best practice interventions into its guidance.²⁶

This study has a number of limitations. It involved a single centre and included a relatively low number of procedures and patients with SSI. The excess LOS was determined by the local approach to managing these infections. Different strategies in other centres may have resulted in shorter lengths of stay and hence, lower costs. To reduce the bias from a single centre's SSI rate when extrapolating the national annual cost of these infections, we used the aggregated national SSI rate.¹⁷ However, the national annual cost may be falsely high for the same reason mentioned above. We are also unaware of the SSI rates in the private surgical hospitals—the rates may be lower than in the DHB hospitals leading to an over-estimate of the overall annual

cost. However, we included these patients in our estimate because typically patients who develop a deep or joint space infection following surgery in a private hospital will be managed in a DHB hospital. While we matched cases with controls to minimise bias, we could not totally eliminate it. We did not capture data on all risk factors associated with infection and it is possible that our patients had risk factors associated with increased LOS regardless of whether they developed an infection or not. We also did not determine if other post-operative complications may have contributed to an increased LOS.

In summary, we have shown that the excess LOS and cost associated with primary THA and TKA procedures is substantial. Although it is not possible to totally eliminate the risk of SSI, all efforts should be made to ensure that strategies known to reduce SSI rates are implemented in a consistent manner and that SSI, when they do occur, are managed promptly to minimise the long-term impact on the patient. National programmes such as the SSII programme and the ERAS pathway are essential to facilitate the delivery of quality improvement initiatives that will lead to improvement in outcomes for patients and to minimise the unnecessary use of health resources required for managing surgical complications such as SSI.

Competing interests:

AJ Morris reports they are the Clinical Lead for the New Zealand Surgical Site Infection Improvement Programme. JT Munro reports personal fees from Zimmer Biomet and DePuy Synthes outside the submitted work.

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