Reduction in surgical site infections in the Southern Cross Hospitals network, 2004–2015: successful outcome of a long-term surveillance and quality improvement project

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ABSTRACT

AIM: To report on the reduction in the surgical site infection (SSI) rate in the Southern Cross Hospitals network over a 12-year period, 2004–2015, following active surveillance and quality improvement actions.

METHODS: Ten hospitals in the network performed prospective SSI surveillance using standard definitions across a range of ten surgical procedure groups. Data was manually collected on a standardised form and entered into a bespoke database. Information collected included timing and dose of surgical antibiotic prophylaxis, type of surgical site skin preparation used, and patient information on smoking, diabetes and body mass index (BMI). Patients were contacted 30 days after their elective surgery to detect SSIs presenting after discharge from hospital. Surveillance results were widely reported to infection control and clinical review committees. Quality improvement activities to increase use of best practice interventions for surgical antibiotic prophylaxis and alcohol-based skin preparations were initiated during the surveillance period.

RESULTS: 42,792 procedures performed in ten hospitals were analysed. There were 932 (2.2%) SSIs. The SSI rate decreased from 3.5% in 2004 to 1.2% in 2015, ρ=-0.865, p<0.0001, a decrease of 59%, approximately 5% a year. Rates decreased in seven of the 10 hospitals, ρ≤0.02 for each, and in five of the ten procedure groups, ρ≤0.02 for each. Diabetic patients, odds ratio (OR) 1.4 (95% confidence interval (CI) 1.1–1.9), obese patients (BMI>30), OR 2.0 (95% CI 1.6–2.4), and those with a surgical risk score of ≥1 OR 1.3 (95% CI 1.1–1.6) had higher SSI rates. These three patient risk factors increased during the 12-year period. The use of alcohol-based skin preparations increased during the period from 63% to 84% in the first two and last two years respectively, p<0.0001. Use of an alcohol-based skin preparation was associated with a reduction in SSIs OR 0.54 (95% CI 0.47–0.62). On time prophylaxis improved from 72% to 95% over the 12 years, p<0.0001, and on time prophylaxis was associated with a reduction in SSIs, OR=0.62 (95% CI 0.51–0.75). The use of 2g doses of cefazolin increased significantly after 2010, p<0.0001. The most common cause of SSI was Staphylococcus aureus which was present in 54% of cases with a positive culture.

CONCLUSIONS: This long-term surveillance and quality improvement programme has made a significant contribution to the overall reduced rate of SSIs in Southern Cross Hospitals. This reduction occurred despite patient risk factors for SSI increasing. Further reduction is possible with higher adherence to best practice and interventions aimed at reducing S. aureus SSIs.
Healthcare associated infections (HAIs) cause significant morbidity, contribute to mortality and divert healthcare resources.1 Auckland District Health Board (DHB) data from the late 1990s estimated that the annual cost of hospital-acquired infections among surgical and medical admissions to all public hospitals in New Zealand was $136 million.2 In secondary and tertiary care hospitals surgical site infections (SSIs) usually cause approximately 20% of HAIs,3 in a network of elective surgical hospitals like Southern Cross Hospitals SSIs represent almost all HAIs. Approaches to reduce SSIs therefore assume greater importance for our patients.

Active surveillance of HAI and feedback of the information to those responsible for care is associated with a significant reduction in HAIs.4 The New Zealand Health Quality and Safety Commission (the Commission) recently sponsored a cost-benefit analysis of contemporary international studies on the benefit of surveillance and intervention programmes in reducing SSIs.5 This showed a reduction in SSIs when surveillance results are disseminated, with a mean reduction of approximately 8% a year.5 In addition there are well described interventions which reduce SSIs, eg, the correct timing of surgical antibiotic prophylaxis.6,7

We therefore began a programme with the aim of improving patient outcomes. The programme included surveillance and reporting of SSI rates to our hospitals’ senior management, nursing employees and credentialed medical specialists. From 2010 quality improvement actions were introduced to improve adherence to practices known to reduce the rate of SSIs. This report details the results of our surveillance, reporting and intervention programme over the 12-year period, 2004–2015.

Methods

The SSI surveillance programme was developed over 2002–2003 at three hospitals and involved a small numbers of procedures. In 2004, after education and training, all 10 network hospitals started surveillance for SSIs. Hospitals that joined the network in the latter part of the period were excluded from analysis as they were performing mainly orthopaedic procedures and their inclusion would have artificially reduced the SSI rate by changing the case mix. To ensure a consistent case mix small volume procedures with wide variations in the number performed each year, eg, vascular procedures, were excluded from analysis; as were procedures which were introduced in the later part of the period which would have significantly altered the case mix and/or SSI rate, eg, arthroscopic orthopaedic procedures.

The USA National Healthcare Safety Network (NHSN) definition for the occurrence of a SSI was used except that the assessment for infection was made 30 days after the procedure.8,9 Patients were informed during their stay that they would be contacted by either mail or phone to seek information on their wound. Responses suggesting a SSI were followed up with the patient’s primary care provider and/or surgeon to obtain relevant details. A SSI was only recorded if the signs and symptoms met the NHSN definition; eg, a stitch abscess (minimal inflammation and discharge confined to the points of suture penetration) did not meet the SSI definition. For cases when there was doubt about the presence of an SSI, authors experienced in applying the definitions (AJM, TMJ, AM) were contacted for advice. If patient feedback was not obtained, we recorded the procedure as not having a SSI.

Patient surgical risk score was calculated using the NHSN method; ie, ASA risk score (ASA >2, score 1) + surgical wound score (contaminated or dirty wounds, score 1) + operation duration score (procedure taking more than its cut off time, score 1).

Continuing education on NHSN definitions and surveillance methods was provided to hospital Infection Prevention and Control Nurses at yearly network infection control training workshops. Quality improvement training on using the Plan, Do, Study, Act (PDSA) improvement model to develop, test and implement changes leading to improvement was also provided at the workshops.

Data was collected prospectively on the procedures chosen to be included by the network hospital. Procedures reflected the hospital’s case mix and were consistent during the period. Details recorded included: patient demographics (including
smoking history and diabetes), procedure, date of procedure, details of surgical antimicrobial prophylaxis (the antibiotic, dose and timing), type of skin preparation used for the incision site, duration of surgery, American Society of Anaesthesiologists (ASA) physical status score, body mass index (BMI), presence of SSI, type of SSI (superficial, deep incisional or organ space), and from 2011 the infecting organism(s). All details were entered into the bespoke database. Six-monthly reports were produced and circulated to all participating hospitals and the National Infection Prevention and Control Committee. These reports presented the SSI rate by hospital and procedure type along with comments on antimicrobial prophylaxis and type of skin preparation used.

Procedures were classified into 10 groups (Table 1). Breast surgery included mastectomy, reduction and other procedures. Hysterectomy procedures included abdominal and vaginal approaches, the latter also including laparoscopic assisted operations. Orthopaedic surgery included hip, knee and other joint replacements and other procedures eg, pin or plate removal or insertion. Bowel procedures were mainly on the colon, eg, anterior resections 32% and right-sided colectomies 33%, and a minority were on the small bowel 14%.

The SSI rate and, from 2010, adherence to recommended surgical antimicrobial prophylaxis, eg, cefazolin dose and timing, and use of alcohol-based skin preparation for the incision site results were widely circulated within the network. This included each hospital's Infection Control and/or Safety, Quality and Risk Committee, the hospital General Manager and the Hospital Clinical Medical Committee. Articles on surgical prophylaxis were included in network newsletters to all credentialed medical specialists.

Local quality improvement activities, using PDSA cycles and the model for improvement, included three key change projects designed to: improve adherence with prophylactic antibiotic dose of 2–3g of cefazolin, rather than 1gm when it was used, promoted from late 2009; administer prophylaxis ‘on time’, ie, within 60 minutes of knife to skin (KTS), and ideally not less than five minutes before KTS; and promote the use of an alcohol-based skin preparation for procedures with skin incisions, ie, alcohol with either chlorhexidine or povidone-iodine. All three interventions were promoted from 2010. When hair removal was needed its removal with clippers, not by shaving, was promoted.

From 2011 SSI culture results were recorded. In 2016 procedures using aqueous skin preparations were audited to record the types of procedures they were being used in.

Regression analysis was performed to test whether patient risk factors changed over time.

Run analysis is a common approach used to follow quality improvement processes, and based on probability theory, and was used to map the SSI rate change over time. It uses the ‘shift rule’ which states a statistically significant sustained change has taken place when a run of continuous points either side of the median line occur. At the shift point, a new median is drawn until another shift takes place. For our set of 24 data points a run of six was taken to indicate a shift. Contingency tables were used to determine Pearson's chi-squared functions, odds ratios and 95% confidence intervals (CI) were calculated, and regression analyses performed, using VassarStats (vassarstats.net). P values <0.05 were considered statistically significant.

The reduction in additional hospital days with a reduced SSI rate was estimated. A conservative estimate for the increase in length of stay for deep and organ space SSIs was taken as being 10 days. All admission days for the unknown proportion of readmitted superficial SSIs were ignored.

Results

Over the 12-year surveillance period, January 2004 to December 2015, 42,792 procedures were followed in the 10 network hospitals, Supplementary Table 1. There were 932 SSI, 2.2% (95% CI 2.0–2.3); 754 (81%) superficial, 129 (14%) deep and 49 (5%) organ space SSIs. Most SSIs, 874 (94%) declared themselves after patient discharge and were identified by our 30-day follow-up process. The median patient response rate at 30-days was 88% (range 81–97%), with a higher response rate later in the time period (p=0.02, data not shown). The SSI
rate by procedure type is shown in Table 1. The highest SSI rates were observed following abdominoplasty, breast and bowel procedures, the lowest following thyroid/parathyroid and orthopaedic surgery (Table 1). Most orthopaedic procedures, 85%, were joint replacements. Hip and knee arthroplasty revision procedures had higher SSI rates than primary arthroplasties; 2.3 vs 0.9%, p<0.01, and 4.6 vs. 1.6%, p<0.02, respectively.

There were two changes in the overall SSI rate from an initial median rate of 3.2% to December 2006, 2.4% to December 2010 and 1.6% to December 2015, see run chart analysis, Figure 1. The apparent shift points were tested using chi-square to test the difference in proportion of procedures that resulted in an infection before and after the apparent shift points in January 2007 and January 2011. The proportion of procedures that had an SSI, as indicated by the shift points, fell significantly, p<0.001 (Table 2). The decrease in mean SSI rate was 59%, approximately 5% a year. Regression analysis also showed a significant reduction in the SSI rate over time, 3.5% to 1.2%, r=−0.865 (95% CI−0.94−0.71), r²=0.748, p<0.0001, Figure 2. The SSI rates vary slightly between Figure 1 and Table 2 as the former is the median rate for the time period whereas the mean is calculated in Table 2.

A statistically significant decrease in the SSI rate occurred in seven of the ten hospitals performing surveillance and interventions, all p<0.02 (data not shown) and in 5 of the 10 procedure groups; bowel, breast, herniorrhaphy, orthopaedic, and varicose vein procedures (Table 1). There was a trend for a reduction in cholecystectomy procedures (p=0.08). Four of the procedure groups without a SSI rate reduction had the lowest numbers of procedures. For hysterectomy procedures an alcohol skin preparation was only used 38% of the time for abdominal hysterectomies vs. 73% for all other procedures, p<0.0002.

The use of an alcohol-based skin preparation increased from 63% in 2004–05 to 84% in 2014–15, r=0.847, r²=0.72, p<0.0001, Supplementary Figure 1. The use of alcohol-based skin preparations was associated with a reduction in the SSI rate, OR 0.54 (95% CI (0.47–0.61) (Table 3).

In 2016 there were 703 procedures where an aqueous skin preparation was used to prepare the incision site; while 280 involved a mucosal surface there were 423 (60%) procedures without a contraindication to using an alcohol-based agent.

Timing of prophylaxis was known for 40,221 (94%) procedures. On time surgical prophylaxis steadily improved over the 12 years from 72% to 95%, r=0.953 (95% CI

<table>
<thead>
<tr>
<th>Procedure group</th>
<th>n</th>
<th>SSIs</th>
<th>Rate % 2004–15</th>
<th>95%CI</th>
<th>Rate % 2004/5</th>
<th>Rate % 2014/15</th>
<th>SSI decrease, p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominoplasty</td>
<td>369</td>
<td>35</td>
<td>9.5</td>
<td>6.8–13.1</td>
<td>7.9</td>
<td>11.1</td>
<td>No, p=0.64</td>
</tr>
<tr>
<td>Bowel surgery</td>
<td>1,300</td>
<td>88</td>
<td>6.8</td>
<td>5.5–8.3</td>
<td>9.5</td>
<td>3.8</td>
<td>Yes, p=0.02</td>
</tr>
<tr>
<td>Breast</td>
<td>3,027</td>
<td>143</td>
<td>4.7</td>
<td>4.0–5.6</td>
<td>8.4</td>
<td>2.2</td>
<td>Yes, p=0.01</td>
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<tr>
<td>Cholecystectomy</td>
<td>502</td>
<td>11</td>
<td>2.2</td>
<td>1.2–4.0</td>
<td>2.6</td>
<td>0</td>
<td>No, p=0.08</td>
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<tr>
<td>General surgery — Other</td>
<td>477</td>
<td>8</td>
<td>1.7</td>
<td>0.8–3.4</td>
<td>0</td>
<td>0</td>
<td>No, p=0.19</td>
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<tr>
<td>Herniorrhaphy</td>
<td>4,768</td>
<td>74</td>
<td>1.6</td>
<td>1.2–1.9</td>
<td>1.6</td>
<td>0.98</td>
<td>Yes, p=0.02</td>
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<tr>
<td>Hysterectomy</td>
<td>4,967</td>
<td>164</td>
<td>3.3</td>
<td>2.8–3.8</td>
<td>4.2</td>
<td>1.7</td>
<td>No, p= 0.22</td>
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<tr>
<td>Orthopaedic</td>
<td>24,770</td>
<td>318</td>
<td>1.3</td>
<td>1.2–1.4</td>
<td>1.8</td>
<td>0.9</td>
<td>Yes, p&lt;0.0001</td>
</tr>
<tr>
<td>Thyroid/parathyroid</td>
<td>499</td>
<td>3</td>
<td>0.6</td>
<td>0.2–1.1</td>
<td>0</td>
<td>1.5</td>
<td>No, p=0.18</td>
</tr>
<tr>
<td>Varicose veins</td>
<td>2,113</td>
<td>88</td>
<td>4.2</td>
<td>3.4–5.1</td>
<td>7.9</td>
<td>3.6</td>
<td>Yes, p=0.002</td>
</tr>
<tr>
<td></td>
<td>42,792</td>
<td>932</td>
<td>2.2</td>
<td>2.0–2.3</td>
<td>3.5</td>
<td>1.2</td>
<td>Yes, p&lt;0.0001</td>
</tr>
</tbody>
</table>
Figure 1: Run chart analysis of SSI rate in Southern Cross Hospitals 2004–2015.

Figure 2: Regression analysis of SSI rate in Southern Cross Hospitals 2004–2015.

Table 2: Southern Cross Hospitals SSI rate over three time periods detected by run chart analysis.

<table>
<thead>
<tr>
<th>Period</th>
<th>Dates</th>
<th>Procedures</th>
<th>SSIs</th>
<th>SSI (%)</th>
<th>95% CI</th>
<th>P value, chi-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Jan 2004–Dec 2006</td>
<td>9,814</td>
<td>316</td>
<td>3.2</td>
<td>2.9–3.6</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Jan 2007–Dec 2010</td>
<td>21,533</td>
<td>466</td>
<td>2.2</td>
<td>1.9–2.4</td>
<td>A vs. B,&lt;0.0001</td>
</tr>
<tr>
<td>C</td>
<td>Jan 2011–Dec 2015</td>
<td>11,445</td>
<td>150</td>
<td>1.3</td>
<td>1.1–1.5</td>
<td>A vs C,&lt;0.0001; B vs. C,&lt;0.0001</td>
</tr>
</tbody>
</table>
The proportion of prophylaxis given <5 minutes before KTS decreased from 14% to 6%, r=−0.81 (95% CI −0.92−−0.61), r²=0.66, p<0.0001. The SSI rate for those receiving prophylaxis on time, 730/36224 (2%, 95% CI 1.8−2.2%) was lower from those not on time, 129/3,997 (3.2%, 95% CI 2.7−3.8), OR 0.62 (95% CI 0.52−0.75), p<0.0001 (Table 3).

Cefazolin was used as prophylaxis in 30,047 (70%) procedures. One gram doses were used until the end of 2009 then the proportion of procedures where 2–3g doses were used increased from 13% in 2010 to 80% in 2015, r=0.971, r²=0.97, p<0.0001, Supplementary Figure 3. While patient weight was not recorded the BMI was for 9,906 procedures using 1g of cefazolin; 2,886 (29%) patients were obese, BMI ≥30, with 667 (9.3%) and 259 (2.6%) having a BMI ≥35 and ≥40 respectively suggesting underdosing in these patients.

During 2010 to 2015 the proportion of procedures complying with all three key interventions, ie. ≥2g of cefazolin when cefazolin was used, on time prophylaxis and an alcohol-based skin preparation increased from 6% to 57%, r=0.966 (95% CI 0.72−0.99), r²=0.933, p<0.0002. Over this time period the SSI rate for procedures meeting all three interventions was lower than other procedures not meeting all three, 1.2% (83/7130) vs. 1.9% (282/15,099) respectively, OR 0.62 (95% CI 0.48−0.79), p<0.0002 (Table 3).

For the period 2011 to 2015, there were 288 SSIs and 153 (53%) had positive cultures; Staphylococcus aureus was the most common pathogen and was isolated from 82 SSIs (28% overall, 54% of those with a positive culture), 69 in pure culture and 13 in mixed cultures. Only one S. aureus was known to be methicillin resistant (MRSA).

The BMI was recorded for 18,451 (43%) patients. Diabetic, obese (BMI ≥30) and patients with higher surgical risk scores had higher rates of SSIs, smokers did not (Table 3).

Regression analysis found the proportion of patients who smoked decreased over time r=−0.687 (95% CI −0.85−−0.39), r²=0.468, p=0.0002. All three characteristics with higher SSI risk increased over time: diabetes 3.8% to 5.4%, r=0.652 (95% CI 0.34−0.84), r²=0.423, p=0.0006; obesity (BMI ≥30) 29% to 36%, r=0.805 (95% CI 0.59−0.91), r²=0.648, p<0.0001; and surgical risk score ≥1 10% to 15%, r=0.621 (0.29−0.82), r²=0.385, p=0.0012.

If there had been no reduction in the SSI rate the number of SSIs in 2015 would have been 124 (3,560 procedures at 3.5%, the SSI rate in 2004), ie, an additional 81 SSIs over the 43 observed in 2015. Overall 19% of our SSIs are deep or organ space meaning 15 of the 81 would have been deep or organ space SSIs which would have been readmitted. Taking a conservative estimate of 10 additional days for such SSIs there were at least 150 additional hospital days, and their attendant costs, prevented as well as significant patient harm avoided.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SSI rate (%)</th>
<th>Odds ratio (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol-based skin preparation vs aqueous</td>
<td>1.8 vs 3.2</td>
<td>0.54 (0.47−0.61)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>On time prophylaxis vs early/late prophylaxis</td>
<td>2.0 vs 3.2</td>
<td>0.62 (0.51−0.75)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>On time prophylaxis, 2g of cefazolin and alcohol-based skin preparation vs less than three interventions</td>
<td>1.2 vs 1.9</td>
<td>0.62 (0.48−0.79)</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>Diabetic vs non-diabetic</td>
<td>3.0 vs 2.1</td>
<td>1.4 (1.1−1.9)</td>
<td>0.006</td>
</tr>
<tr>
<td>Obese (BMI ≥30) vs non-obese</td>
<td>3.1 vs 1.6</td>
<td>2.0 (1.6−2.4)</td>
<td>0.001</td>
</tr>
<tr>
<td>Surgical risk score ≥1 vs score &lt;1</td>
<td>2.7 vs 2.1</td>
<td>1.3 (1.12−1.59)</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>Smoker vs non-smoker</td>
<td>2.6 vs 2.1</td>
<td>1.2 (0.98−1.54)</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Discussion

Private surgical hospitals perform more than 170,000 operations a year representing approximately 50% of elective procedures in New Zealand.12 Approximately one-third of Southern Cross Hospitals procedures are at times funded by DHBs and the Accident Compensation Corporation usually through contracting arrangements. Despite this significant proportion of elective procedures, most local reports on SSIs and their costs are DHB focused.13–15 To the best of our knowledge this is the first large prospective study reporting on patient outcome following procedures performed in New Zealand private surgical hospitals.

Our major finding was a significant reduction in SSIs over the 12-year period. The run chart is a commonly used quality improvement tool and provides a simple representation of change over time.10,11 The ‘shift’ rule identified two occasions where our rate improved. The proportion of procedures that had an infection fell from 3.5% to 1.2%, a 59% reduction, p<0.0001, approximately 5% a year. The time to our first shift, three years, is similar to the two and a half years observed in the Commission sponsored national orthopaedic programme.16 The initial fall in SSIs followed surveillance and SSI result reporting to those responsible for care. The second decrease, after 2010, coincided with the promotion of best practices, for surgical antibiotic prophylaxis and use of an alcohol based surgical site skin preparation, and associated quality improvement projects.

The reduction occurred despite the three identified patient risk factors for higher SSIs, ie, diabetes, obesity and surgical risk score, all increasing over the 12-year period.

The reduction in SSIs was not due to a change in just a small number of hospitals or procedures. We observed a reduction in seven hospitals and five procedure groups. This implies a general change within the hospital network. The reason why a reduction was not observed in five procedure groups is not known but four of these procedure groups had low numbers of procedures performed and abdominal hysterectomies had significantly less use of alcohol-based skin preparations. While the rate reduction is in part due to the uptake of the key interventions, eg, alcohol-based skin preparation, and prophylaxis timing other changes may have had impact as well, eg, home-use of chlorhexidine wipes before orthopaedic surgery, surgical safety check list sign in and time out prompts for antibiotic prophylaxis and timing, wound dressing protocols, blood glucose and patient temperature control, and theatre traffic control. Another contributor could have been the hand hygiene programme which started in 2011, which raised the compliance rate for the ‘5 moments’ from 65% to 75% at the end of 2015 (data not shown) and currently sits at 83%.18

In a prospective study at the Mayo Clinic the SSI rate was more than halved after the rapid deployment of 28 interventions associated with SSI reduction.17 It appears that numerous small adjustments are required in a patient’s pathway to achieve the lowest possible SSI rate. There is no single solution.

The SSI rate was determined using a 30-day review involving patient feedback. Most SSIs declare themselves after hospital discharge.19–21 While it is recognised that post-discharge surveillance is required to estimate the true SSI rate there are no well validated accepted methods for how this surveillance should be conducted.19,20,22 Without our 30-day review more than 90% of our SSIs would have been missed. Before recording a SSI we obtained as much information as possible and applied the NHSN definitions. We acknowledge that we have not recorded deep or organ space SSIs which occurred beyond 30 days. Regular educational updates for employees collecting the data and applying the definitions were in place to build consistency in the surveillance programme. Resource intensive validation processes in other surveillance programmes seldom find errors in applying definitions by hospital teams.23 We believe that the 30-day protocol, with consistent application of the NHSN definitions, gives a reliable estimation of the network SSI rate. The process has been constant over the 12-year period and therefore allows us to draw valid conclusions about the SSI rate and its reduction over time.

Although the SSI rate has reduced significantly there are still improvements that can be made. While an alcohol-based skin preparation was used 84% of the time; the
A 2016 audit found that when an aqueous skin preparation was used an alcohol product should have been, 60% of the time. Five percent of patients do not get prophylaxis on time and six percent of those that do receive it on time get it <5 minutes before KTS. This, challenges the aim of having adequate tissue levels at the time of incision. Our updated surgical antimicrobial prophylaxis guideline suggests prophylaxis be given at least 10 minutes before KTS. Too many patients receiving cefazolin only get 1g and a significant proportion of these are obese. While we do not remove hair from surgical sites by shaving, occasionally patients present for admission having shaved their operation site. A co-design approach is proposed, ie, empowering patients to be engaged in their care, to improve our current pre-admission advice regarding not shaving. There is also a need to understand why the SSI rate did not drop in some procedure groups and ensure that other best practice interventions are applied to reduce SSIs, eg, patient normothermia, perioperative supplemental oxygen, triclosan-coated sutures where appropriate as well as engaging clinical pharmacological advisory services.

Almost 60% of procedures in the surveillance programme are orthopaedic and there is scope to reduce their SSI rate further. *S. aureus* is our most common isolate and a recent literature review concluded that a bundle comprising nasal and skin agents could reduce orthopaedic SSIs by approximately 50%. The Commission has recently started a collaborative to evaluate the benefit of an ‘anti-staph bundle’ and Southern Cross Hospitals are involved in this initiative.

The Commission has recently reported the successful reduction of SSIs in orthopaedic surgery. Our report confirms and extends the Commission’s findings. We also show that a network of hospitals can successfully institute interventions to reduce SSIs and extend the observation by showing that SSIs can be reduced in several procedural groups. The Commission’s Orthopaedic Programme has reported that BMI is a key risk factor for deep SSIs following primary hip and knee arthroplasty. We extend this by reporting the impact of obesity in a wider range of procedure groups.

In summary we have shown that surveillance and reporting SSIs and the introduction of an intervention programme can make a significant contribution to the reduction of SSIs resulting in reduced healthcare costs and patient morbidity. There is scope however to reduce the rate further by greater adherence to our surgical prophylaxis and skin antisepsis interventions. The integration of an ‘anti-staph bundle’ into our patient pathway for orthopaedic surgery offers another opportunity to reduce SSIs.
### Appendix

**Supplementary Table 1**: Number of procedures included in SSI surveillance in Southern Cross Hospitals, by hospital 2004-2015.

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>110</td>
<td>20</td>
<td>110</td>
<td>36</td>
<td>269</td>
<td>81</td>
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<td>190</td>
<td>129</td>
<td>94</td>
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<td>61</td>
</tr>
<tr>
<td>B</td>
<td>406</td>
<td>436</td>
<td>387</td>
<td>430</td>
<td>409</td>
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<td>453</td>
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<td>135</td>
<td>144</td>
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Supplementary Figure 1: Increase in the use of alcohol-based skin preparations in Southern Cross Hospitals 2004–2015.

Supplementary Figure 2: Increase in “on time” prophylaxis in Southern Cross Hospitals 2004–2015.
Supplementary Figure 3: Increase in the use of 2–3g doses of cefazolin in Southern Cross Hospitals January 2010 to December 2015.


Competing interests:
Adrienne Morgan and Tanya Jackways report payment for Infection Control advice to Southern Cross Hospitals. Rosaleen Robertson is employed by Southern Cross Hospitals as Chief of Clinical Governance, and is a member of the Health Quality and Safety Commission Safe Surgery NZ Advisory Group. Dr Morris is a Trustee of the Southern Cross Trust and a director for Southern Cross Hospitals. He also received payment for infection control advice to Southern Cross Hospitals. Muriel McIntyre is employed by Southern Cross Hospitals as National Quality and Risk Coordinator.

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We recognise the committed involvement of the Infection Prevention and Control Nurses in the network who have collected data, introduced interventions and monitored change in practice. We also acknowledge the contributions of the surgical teams, who have adopted the changes and interventions. We acknowledge all the network hospital General Managers who have supported and resourced the programme and interventions. They have been assisted by their Infection Control and/or Safety, Quality and Risk Committee, as well as their Hospital Clinical Medical Committee. The involvement of a wide range of employees has been an important enabling factor for this surveillance and quality improvement project. We thank the large number of patients who participated in the surveillance programme and the feedback they provided on their wound. This valuable feedback continues to inform quality improvements for future patient care.

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