Getting surgical antibiotic prophylaxis right, lessons from the National Orthopaedic Surgical Site Infection Improvement Programme: a call for action!

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Joint replacement greatly improves quality of life and with an ageing population the number of procedures is increasing. A feared complication is subsequent surgical site infection (SSI), especially deep periprosthetic joint infection (PJI), which results in significant patient morbidity and healthcare costs.[1,2] In New Zealand each PJI adds an excess mean treatment cost of $40k and an additional 42 days in hospital.[3] Similar costs and excess hospital stays occur following deep spinal SSIs and *Staphylococcus aureus* mediastinitis after sternotomy.[4,5]

The National Orthopaedic Surgical Site Infection Improvement Programme (the Programme) was started in 2013 to promote adherence with evidence-based practices known to reduce SSI.[6,7] The Programme has resulted in significantly improved use of alcohol-based skin preparations and the timing and dosing of surgical antibiotic prophylaxis.[7,8] The national surveillance, intervention and quality improvement-based Programme has been associated with a reduction in the median SSI rate following hip and knee arthroplasties from 1.36% to 0.91% ($p<0.01$).[8]

In 2014 early observations of the Programme and the publication of a report from Scotland on the use of gentamicin in orthopaedic procedures led to further recommendations on surgical prophylaxis. A change to Scotland prophylaxis in 2009, in an effort to reduce the burden of *Clostridium difficile* disease which was an epidemic at the time, from a cephalosporin alone to flucloxacillin (two 1g doses) with gentamicin (single dose at 4mg/kg) was associated with a 94% increase in acute renal injury.[9] The authors concluded that "gentamicin should be avoided in orthopaedic patients in the perioperative period".[9] In early 2015 the Programme wrote to the clinical heads of all DHB orthopaedic surgery services with several recommendations concerning surgical prophylaxis, including; that the use of gentamicin for prophylaxis should stop, a second dose of prophylaxis be given before the second side of bilateral arthroplasty procedures, to use clindamycin in preference to vancomycin in cases of cephalosporin allergy because of better compliance with timing, and to stop prophylaxis within 24 hours of surgery.

This report examines in more detail the relationship between the timing of surgical antibiotic prophylaxis and the SSI rate and the changes in practice following the Programme's March 2015 recommendations. Full details of the Programme's methods, data collection and reporting have been published previously.[6–8] The US National Healthcare Safety Network SSI definitions were used.[6]

Results and discussion

From 1 July 2013 to 31 December 2017, 46,360 publicly funded hip and knee arthroplasties were performed. There were 498 SSIs, a rate of 1.07% (95% CI 0.98–1.17%). Prophylaxis was defined as "on time" if given ≤60 minutes of knife to skin (KTS),

Table 1: Surgical site infection rates by timing, dose and type of prophylaxis: July 2013 to December 2017.

Prophylaxis	SSI rates	Odds ratio	p value	Comment
On time prophylaxis vs late/early	1.05% (95% CI 0.96–1.15) vs 2.0% (95% CI 1.3–3.0)	0.52 (95% CI 0.34–0.78)	<0.003	On-time prophylaxis reduces SSI rate.
Gentamicin and cephalosporin prophylaxis vs cephalosporin alone	0.85% (95% CI 0.51–1.2) vs 1.08% (95% CI 0.99–1.18)	0.78 (95% CI 0.51–1.2)	p=0.29	Combination prophylaxis does not reduce SSI rate.

early if given >60 minutes before KTS and late when given after KTS.[6,10]

There was no difference in the SSI rate depending on the antibiotic used, ie, cefazolin, cefuroxime, clindamycin, vancomycin or other agents (data not shown). On-time prophylaxis halved the SSI rate (Table 1).

Following the 2015 recommendations, significant improvements in prophylaxis were achieved (Table 2). Combination prophylaxis continued to decline significantly (Table 2 and Figure 1). Combination prophylaxis did not reduce the SSI rate (Table 1) another reason to stop its use.

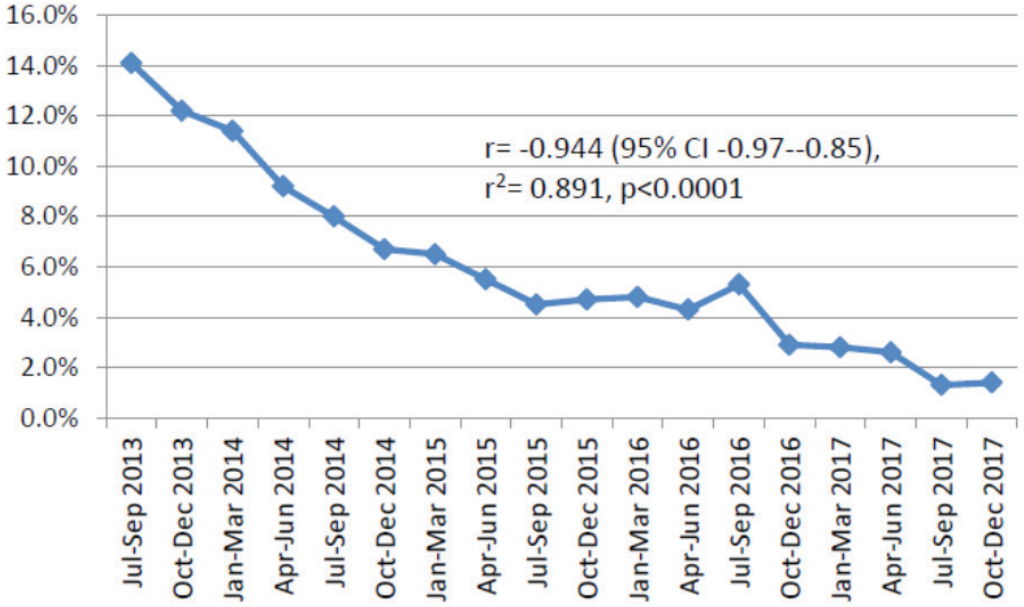
Timing for bilateral procedures improved, use of clindamycin increased and excess duration of prophylaxis reduced (Table 2).

The Progamme has recently started an identical process for cardiac surgery.[11] While the adherence with recommended interventions is higher than that at the start of the orthopaedic Programme there are ~3–5% of cardiac surgery patients who do not receive either the correct antibiotic dose on time or have an alcohol-based skin preparation used.[12] It is probable that the practice gaps identified in both orthopaedic and cardiac surgery exist in other surgical disciplines as well.

Table 2: Change in antimicrobial surgical prophylaxis practice following Programme recommendations in March 2015.

2015 recommendations	Change in practice	Comments
The routine/common use of gentamicin for prophylaxis in orthopaedic surgery should stop.	Gentamicin, in combination with a cephalosporin, dropped from >6% to <1.5%, p=0.0002, see Figure 1.	In 2013 five DHBs used it >20%. In 2017 five DHBs never used combination prophylaxis and only one used it >10% (14.5%). For 2017 and 2018 this means >3,000 fewer patients were exposed to gentamicin and its toxicity.
A second dose of prophylaxis is given before the second side of a bilateral procedure is commenced.	Prophylaxis timing has improved from 76% to 90%, p=0.002, due to a second dose being given more frequently.	10% of bilateral procedures still not getting prophylaxis on time. A second dose is not required if vancomycin is used because of its long half-life.
Clindamycin to be used in preference to vancomycin when there is cephalosporin allergy because it is associated with better on time compliance.	Clindamycin is given on time 96% vs 70% for vancomycin. When either is used the proportion of clindamycin has increased from <50% to 75%, p<0.0001.	In cases of cephalosporin allergy there is still scope to increase clindamycin use to achieve higher on time prophylaxis.
Prophylaxis should stop within 24hrs of a procedure.	Stopping prophylaxis within 24hrs has increased from <80% to >97%, p<0.0001.	Standing orders can assist in ensuring prophylaxis is stopped within 24hrs. Continuing prophylaxis until drains or catheters have been removed is unproven and not recommended.

Figure 1: Proportion of procedures receiving combination prophylaxis of gentamicin and a cephalosporin: July 2013–December 2017.



The Programme's experience to date suggests the following steps be undertaken by all surgical service providers, public and private, to generalise the lessons from the orthopaedic and cardiac Programmes to all surgical specialties to reduce their SSI rate. These should include:

- Ensuring an agreed up-to-date evidence based surgical prophylaxis guideline is in place[10]
- Performing snap audits of an adequate number of procedures in a sub-specialty/theatre to measure compliance with the prophylaxis guideline, ie, choice, dose, timing, and duration
- When used, recommending 2g of cefazolin for all adults as our experience shows that weight-based dosing is inadequately adhered to
- Not using gentamicin in prophylactic regimes unless its use is included in authoritative prophylaxis guidelines, eg, for certain abdominal or pelvic procedures[10]
- Surgeons utilise the surgical safety checklist to ensure prophylaxis has been given on time
- Ensuring that prophylaxis is not continued after surgery unless recommended in authoritative guidelines, eg, cardiac surgery.[10] Consider the use of pharmacy stop orders
- Ensuring alcohol-based skin preparations are used for procedures involving skin incisions
- Asking those undergoing elective procedures about possible previous *S. aureus* infections and, if a history is confirmed, implement an "anti-staph" protocol
- Ensuring adequate infection prevention and control resources are in place and utilised to reduce SSI
- That the relevant infection control committee has input into, and audit of, the surgical prophylaxis guideline and regularly reviews local SSI data.

The significant strides made in the improvement in orthopaedic prophylaxis compliance, with its attendant reduction in SSIs, are transferrable to other surgical specialities. If the lessons learned from the national orthopaedic Programme were applied across all surgical sub-specialties a reduction in SSI rates will occur. Surgeons and anaesthetists should take the lead to ensure indicated surgical prophylaxis is administered correctly to maximise its ability to reduce SSIs and their often significant human and financial costs.

Competing interests:
Arthur Morris states he is the Clinical Lead for the NZ Surgical Site Infection Improvement Programme. Sally Roberts is the National Clinical Lead for the Health Quality and Safety Commission Infection Prevention and Control Programme.

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REFERENCES:

1. Zimmerli W, Trampuz A, Ochsner P. Prosthetic-joint infections. N Engl J Med. 2004; 351:1645–54.
2. Tande A, Patel R. Prosthetic joint infection. Clin Microbiol Rev. 2014; 27:302–345.
3. Gow N, McGuinness C, Morris A, et al. 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. NZ Med J. 2016; 129(1432):51–8.
4. Barnacle J, Wilson D, Little C, Hoffman C, Raymond N. Excess cost and inpatient stay of treating deep spinal surgical site infections. NZ Med J. 2018; 131(1475):27–34.
5. Upton A, Smith P, Roberts S. Excess cost associated with Staphylococcus aureus poststernotomy mediastinitis. NZ Med J. 2005; 118: URL:http://www.nzma.org.nz.journal/118-1210/1316/
6. Health Quality and Safety Commission New Zealand. Surgical Site Infection Improvement Programme Orthopaedics Surgery Implementation Manual v 1.4. 2015.
7. Morris A, Panting A, Roberts S, Shuker C. A new surgical site infection improvement programme for New Zealand: early progress. NZ Med J. 2015; 128(1414):51–9.
8. Morris AJ, Roberts SA, Hamblin R, et al. The New Zealand Surgical Site Infection Improvement Programme: a national quality improvement programme reducing orthopaedic surgical site infections. NZ Med J. 2018; 131(1479):45–56.
9. Bell S, Davey P, Nathwani D, et al. Risk of AKI with gentamicin as surgical prophylaxis. J Am Soc Nephrol. 2014; 25:2625–32.
10. Bratzler DW, Dellinger EP, Olsen KM, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. Am J Health-Syst Pharm. 2013; 70:195–283.
11. Health Quality and safety Commission. National cardiac surgery report, 1 October - 31 December 2017. https://www.hqsc.govt.nz/our-programmes/infection-prevention-and-control/publications-and-resources/publication/3401/
12. Health Quality and Safety Commission. SSIIP Cardiac Surgery. Summary findings for current quarter - April to June 2018. https://wwwpublic.tableau.com/profile/hqi2803#!/vizhome/SSIcardiacdashboard/SSIIPcardiacsurgery?-publish=yes