



The Hospital Infection Standardised Surveillance (HISS) programme: analysis of a two-year pilot

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Summary: In 1998 the New South Wales (NSW) Health Department funded the development and implementation of the State's first standardized methodology for the surveillance of healthcare-associated infection for public hospitals. Fifteen pilot hospitals targeted inpatient groups considered to represent their core patient groups to act as sentinel measurements of patient safety. The aggregated rates of surgical site infection for coronary artery bypass graft (CABG) (chest & leg) surgery was 1.7% (95%CI: 1.1–2.5), CABG (chest only) 2.1% (95%CI: 1.0–3.7), vascular 7.1% (95%CI: 4.6–10.3), hip prosthesis 1.3% (95%CI: 0.5–2.7), knee prosthesis 6.1% (95%CI: 2.8–11.2) and colorectal 12.5% (95%CI: 9.5–16.1). The development of a bloodstream infection (BSI) associated with a central venous catheter (CVC) was not significantly ($P=0.6$) different when examined by duration of exposure with 3.7 BSI per 1000 line-days for CVC in situ six or more days compared with 4.0 BSI per 1000 line-days for CVC in situ for five or less days. A significantly ($P<0.0001$) greater proportion of patients whose CVC was in situ six or more days (6.8 per 100 patients, 95%CI: 4.2–10.2) developed a BSI compared with the proportion of patients whose CVC was in situ for five or fewer days (0.6 per 100 patients, 95%CI: 0.3–1.3). Significantly ($P<0.0001$) different rates of patients acquiring a new methicillin-resistant *Staphylococcus aureus* infection were found when hospital type was examined with rates ranging from 0.2 to 5.0 per 10 000 occupied acute-care bed-days. The pilot highlighted that the collection of data for aggregation of some procedures and intravascular catheters may take many years before a reliable benchmark can be identified and many hospitals may not achieve reliable local rates annually. For surveillance to provide timely measures of patient safety we should consider surveillance methods for many small to medium sized hospitals that includes active surveillance only for infections with concurrent passive surveillance of the relevant denominators.

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Keywords: Surveillance; infections; surgical; bloodstream; methicillin-resistant *Staphylococcus aureus*; multiple-resistant micro-organisms.

Introduction

In 1984 prevalence rates of hospital-acquired infections in Australia were established from

a standard methodology.^{1,2} Six in every 100 patients from 269 hospitals were found to have a hospital-acquired infection (HAI).^{1,2} In 1993 one of Australia's voluntary accrediting bodies for healthcare facilities, the Australian Council for Healthcare Standards (ACHS), developed clinical indicators for surgical site infections (SSI) and bloodstream infections (BSI) recently updated to accommodate the national adoption of standardized definitions.³ Australia now has 249 accredited public hospitals⁴ that perform surveillance, but not all participate or contribute to the ACHS database. Hence our

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current knowledge of the rates of HAIs in Australia has most often been derived from research and experience of a single hospital.⁵⁻⁹ Reports from several hospitals have provided rates of HAI for a limited number of patient groups including coronary artery bypass surgery (1.9-8.9%⁷⁻⁹) and BSI associated with central venous catheters, (CVCs; five to six infections per 1000 line-days^{5,6}).

In June 1998 the New South Wales (NSW) Health Department funded the development and implementation of the Hospital Infection Standardised Surveillance (HISS) programme for surgery, intensive care, paediatrics and endemic microorganisms. This pilot was the first attempt to develop a standardized, valid surveillance approach for NSW public hospitals. The programme received advice from a reference group with expertise in infection control for surgery, intensive care, epidemiology, infectious diseases and microbiology, the NSW Infection Control Association, the Royal Australian College of Surgeons and the software programmer. This paper discusses the aggregated rates of SSI, BSI and methicillin-resistant *Staphylococcus aureus* (MRSA) identified from the standardized surveillance efforts of Infection Control Practitioners in 15 hospitals over a two-year period.

Methods

The Executive Directors of public hospitals, with at least 100 acute-care beds and an infection control practitioner (ICP), were invited by the NSW Health Department to express interest in participating in the pilot. Participation was voluntary and hospitals were assured of confidentiality of their quality assurance data. Forty-six responding hospitals represented 73.8% (13 664/18 520) of all acute-care beds in the State and 25.8% in Australia. The selection of hospitals was based on the Health Department's requirement that principal referral, metropolitan and non-metropolitan and district hospitals were represented.

Each hospital provided six-monthly data, collected using active surveillance for infection and the associated denominator for patients they considered representative of their core patient group, that included surgical site infection (SSI) and/or intravascular catheter associated BSI in intensive care unit (ICU) patients. Details of the seasonal monitoring by two paediatric facilities of respiratory syncytial virus (RSV)¹⁰ and rotavirus are not reported in this paper for purposes of anonymity,

because these were the only institutions collecting these data. It was mandatory for participating hospitals to monitor endemicity (prevalence of infection and colonization) and acquisition (incidence of infection and colonization) of MRSA.

Data collection began in 10 hospitals in November 1998 and in May 2000 an additional five hospitals were enrolled continuing surveillance until December 2000. Before data collection ICPs attended two one-day workshops for the methodology of case finding, the application of case definitions and the use of the eICAT¹¹ software for entry, management and analysis of data. Training and guideline manuals were provided.^{12,13} Surgical patients were monitored daily for evidence of a SSI, until a SSI developed, or the patient was discharged, whichever came first. Post-discharge surveillance was not performed during the pilot. All data were categorical, except duration of procedure, which was discrete. Data were collected at the patient's bedside using a handheld computer programmed with software¹¹ with a pull-down lists for clinical signs and symptoms of infection in accordance with the National Nosocomial Infection Surveillance (NNIS) system.¹⁴ Patients were given a unique identifier and data collected included date of birth, sex, admission and discharge date. Data were electronically downloaded on to a personal computer. The full methodology has been detailed elsewhere.¹⁵

In December 1999 the Australian Infection Control National Advisory Board (AICA-NAB) published NNIS definitions¹⁴ modified for ease of application, and recommended their application for SSI and BSI surveillance in Australia.³ All ICPs responsible for HISS data collection were notified of these modifications and applied them from May 2000.

Analysis of sentinel surgical procedure data

Specific colorectal procedures and vascular surgical procedures were performed infrequently and relevant procedures within these two categories were aggregated into colorectal and vascular. The rate of infection associated with primary and graft site for coronary artery bypass graft (CABG) (chest and leg) were expected to occur infrequently during the pilot phase and so data were collected for these two potential infection sites as an aggregate. Data were examined for frequency of the procedure, the proportion of patients receiving antimicrobial

prophylaxis, the proportion of emergency or unplanned procedures, classification of American Society for Anesthesiology (ASA) score,¹⁶ quartiles of duration of procedure in minutes, and then further classified as ≤ 75 th centile or > 75 th centile for duration of procedure. The rate of SSI was calculated from aggregated data monitored by two or more hospitals to ensure hospital anonymity.

As the number of core surgical procedures performed by individual hospitals would be small and adversely affect the statistical analysis, only one rate was reported for each group of procedures and compared with an equivalent NNIS risk index rate. The equivalent rate was identified from scoring the majority of our patients, not individual patients, using NNIS risk criteria.¹⁴ Only surgical procedures assessed preoperatively by the surgeon as having the degree of contamination most commonly encountered were monitored. Therefore, all CABG (chest and leg, and chest only), vascular, hip, knee and lower segment caesarean section operations (LSCS) which were clean procedures were monitored and scored a NNIS arithmetic score of 0; all colorectal procedures monitored were clean-contaminated and scored 1. Any procedure that did not comply was excluded from surveillance. Procedures were further scored according to ASA criteria and duration of procedure. An arithmetic score of 1 was given to all CABG and vascular procedures, as the ASA score for the majority of these patients was 3 or more. Knee, hip and LSCS procedures were given an arithmetic score of 0 as the majority of patients had an ASA score less than 3. For similar reasons, all procedures were given an arithmetic score of 0 for duration. As a result, our procedures acquired a risk index of either 0 or 1.

Intravascular catheter data from ICU were examined for frequency of patients by catheter type, number of in situ catheter days for CVC inserted by direct skin puncture into the jugular or subclavian veins. Although the primary aim of ICU surveillance was for the purpose of BSI associated with CVC, rates were also calculated for those hospitals which extended their surveillance to include peripheral, arterial, vascular (dialysis) catheters, peripherally inserted central catheters (PICC) and Hickman catheters. The rate of BSI by catheter type is expressed per 1000 catheter-days and per 100 patients stratified by catheter-day exposure for ≤ 75 th and > 75 th centiles of duration in situ.

Three rates for MRSA were calculated: newly diagnosed infection collected from patients with

admission of ≥ 48 h with presenting clinical signs and symptoms which had not previously been diagnosed as MRSA infection; the acquisition rate for newly diagnosed infections and newly colonized patients; and the prevalence of previously and newly diagnosed infection and colonization. The number of occupied acute-care bed-days available from the State Health Department's homepage¹⁷ was the denominator used for each of the three rates. Data were then categorized into three types of hospital: principal referral, major referral and major non-metropolitan.

Descriptive statistics for active surveillance data were performed using SPSS 10.0.7 and alpha was set at the 5% level.

Results

Participation

Responses to the call for participation in the trial were received from 67% (8/12) of the principal referral hospitals, 67.0% (4/6) of the specialist hospitals, 46.0% (6/13) of major metropolitan, 44.0% (4/9) of major non-metropolitan and 38.0% (3/8) of district hospitals. The 15 selected hospitals represented all types; six principal referral, one specialist (paediatric), one major metropolitan and two major non metropolitan hospitals.

Surgical procedures

Ten hospitals monitored one or more of eight surgical procedures for SSI; three monitored CABG (chest and leg) procedures, three monitored CABG (chest only) procedures, four monitored vascular procedures, eight monitored hip prosthesis procedures, five monitored knee prosthesis procedures, two LSCS procedures and five colorectal procedures. Abdominal hysterectomy was omitted from this report as it was surveyed by one hospital only. The completion of the potential risk factor data as shown in Table I was high except for ASA scores, missing for hip prosthesis (30.2%) and LSCS (31.6%) procedures. The ASA scores were homogenous for risk of death in patient groups undergoing all procedures other than hip prosthesis insertion LSCS (58.9%) and hip prosthesis (42.1%) procedures were two operations performed frequently under emergency or unplanned conditions. The majority, 90% or more, of patients received antibiotic prophylaxis before surgery, although

Table 1 Infection rates for HISS sentinel surgical procedures and the distribution of risk factors

Operative procedure	N	Number and type of contributing hospitals		ASA(%)			Unplanned (%)	Prophylaxis given (%)	75th centile duration of procedure in minutes (25th, 50th) [difference between HISS 75th & NNIS 75th]	HISS SSI rate (%) (95% CI)	NNIS SSI rate (%) by [*NNIS risk index]
		1-2	3-5	Missing							
CABG (chest & leg)	1293	3	PR	0.3	98.2	1.5	1.0	99.0	229 (170, 199) [-11]	1.7 (1.0-2.5)	3.6 [1]
CABG (chest only)	519	3	PR	2.5	96.1	1.3	4.6	98.5	215 (150, 178) [-85]	2.1 (1.0-3.7)	2.2 [1]
Vascular	352	3	PR, 1 MNM	19.3	65.1	15.6	11.6	81.3	180 (79, 135) [0]	7.1 (4.6-10.3)	1.8 [1]
Hip prosthesis	478	4	PR, 2 MM, 2 MNM	35.1	34.8	30.2	42.1	91.6	124 (67, 94) [+4]	1.3 (0.5-2.7)	1.5 [1]
Knee prosthesis	148	4	PR, 1 MM	54.7	31.1	14.2	2.7	93.9	149 (100, 119) [+29]	6.1 (2.8-11.2)	0.8 [0]
Lower segment caesarean section	596	1	PR, 1 MNM	63.6	4.9	31.6	58.9	79.9	49 (30, 40) [-11]	2.3 (1.3-3.9)	3.4 [0]
Colorectal	408	3	PR, 1 MM, 1 MNM	58.6	30.4	11.0	17.4	86.8	183 (106, 145) [+3]	12.5 (9.5-16.1)	7.1 [1]

Principal referral (PR), major metropolitan (MM), major non-metropolitan (MNM).

* The NNIS SSI rate is provided for the NNIS risk index [] that reflected the risk index for the majority of HISS patients within each surgical procedure.

patients received prophylaxis significantly ($P < 0.00001$) less often if they had colorectal (86.8%), vascular (81.3%) and LCSC (79.9%) procedures.

The observed 75th centiles for duration of surgical procedure monitored during the pilot were contrasted with those established from data contributed by 257 NNIS hospitals where duration were rounded to 'the nearest whole number of hours'.¹⁸ The most notable difference in 75th centiles was the shorter duration by HISS hospitals for CABG (chest-only) procedures. The observed HISS 75th percentiles for duration of CABG (chest only) operations was 85 min shorter than those established by NNIS and the HISS 75th percentile for knee surgery was 29 min longer.

Of the orthopaedic procedures, knee prosthesis insertions were 4.84 times (Chi-square 9.28, $P = 0.0025$) more likely to become infected post-operatively compared with hip prosthesis procedures. No surgical procedure monitored, including knee prosthesis insertion, differed significantly for rate of SSI when examined by emergency/unplanned procedures, for procedures that extended past the 75th percentile for duration or for exposure to prophylaxis. Colorectal surgery was the only procedure where the SSI rate was significantly ($P = 0.027$) influenced by the risk factors that contribute to the NNIS Risk Index. The SSI rate for colorectal patients (18%, 95%CI: 11.7–26.0) with an ASA ≥ 3 was twice that for patients with ASA score < 3 (9.0%, 95%CI: 6.7–14.0) (Table I).

In Table I the NNIS Risk Index level indicates the risk level for the majority of HISS patients and the corresponding SSI rate. Infection rates for vascular, colorectal, and knee prosthesis procedures were higher than the latest reported rate for the respective NNIS Risk Index group.¹⁹ The majority of colorectal procedures (63%) did not score higher than NNIS score 1 due to the usual degree of contamination and the absence of other risk factors.

Intravascular catheters

Over a 21 month period 32 953 line-days were monitored in seven ICUs (Table II). Three catheter types contributed the majority (97.3%) of surveillance line-days: peripheral cannulae (16 500 line-days), arterial lines (9746 line-days) and CVCs (5814 line-days). The 75th centile for duration of exposure to the same peripheral cannula was 48 hours or less and four days for arterial lines.

The rate of BSI for all peripheral lines was 0.2 (95%CI: 0.0–0.5) per 1000 line-days, with no difference ($P = 0.06$) in the rate of BSI for peripheral lines in situ for longer than 48 h or ≤ 48 h. The proportion of patients with a BSI was significantly ($P < 0.0001$) greater for those whose peripheral line was in situ for more than 48 h (0.6 per 100 patients, 95%CI: 0.1–1.6) compared with (95%CI: 0.0–0.2) patients whose line was in situ for 48 h or less. Similarly, a significantly ($P < 0.0001$) greater proportion of patients had a BSI associated with an arterial line in situ for five or more days (1.9 per 100 patients, 95%CI: 0.8–3.9) compared with 0 per 100 (95%CI: 0.0–0.4) the patients whose arterial line was in situ for four or less days.

Seventy-five percent of CVC catheters were in situ for up to five days. The rate of BSI for patients exposed to CVC for five or less days (4.0 per 1000 line-days, 95%CI: 2.0–8.0) was not significantly ($P = 0.6$) higher than the rate for those exposed for six or more days (3.7 per 1000 line-days, 95%CI: 2.0–6.0). The distribution of exposure to CVC line-days was skewed to the right with the majority, 76.4% (5640/7381), of line-days being contributed by a minority (22.5%, 310/1375) of patients. When BSI rate was examined by the proportion of patients within the two exposure categories, a significantly ($P < 0.001$) greater proportion of patients (6.8%, 95%CI: 4.2–10.2) had a BSI associated with a CVC whose catheter was in situ for six or more days compared with the proportion exposed for five or less days (0.6%, 95%CI: 0.3–1.3).

Few BSIs (20.0%, 8/40) were diagnosed using clinical signs and symptoms alone in the absence of a positive blood culture. When a BSI was diagnosed with a positive blood culture the causative micro-organism was MRSA in 41% of CVC, 40% of arterial line and 33% of peripheral catheter culture infections.

MRSA

Eleven hospitals monitored MRSA acquisition and prevalence during the pilot. Of all newly acquired MRSA isolates 77% were associated with infection and 23% with colonization. The mean incidence rate for new infection and new colonization isolates was significantly ($P < 0.001$) different for the three types of hospitals with the major metropolitan hospitals having the highest mean acquisition rate at 7.3 per 1000 occupied acute-care bed-days (Table III). The rate for new infections alone was significantly

Table II Type of intravascular catheters in intensive care unit patients and the rate of catheter associated BSI

Catheter type	Total patients	Total catheters	Total catheter line-days	Duration of catheter line-days 75th centile	Rate/1000 catheter line days (95% confidence interval)		
					≤75th centile	>75th centile	Total
Arterial	1547	1549	9746	4	0 (0.0-0.2)	0.9 (0.3-1.8)	0.7 (0.3-1.5)
Peripheral cannula	2285	2566	16 500	2	0 (0.0-0.2)	0.2 (0.0-0.7)	0.2 (0.0-0.5)
Central venous catheters (CVC)	1375	1384	5814	5	4.0 (2.0-8.0)	3.7 (2.0-6.0)	5.0 (3.0-7.0)
Vascular catheters	56	56	140	2	0 (0.0-80.0)	21.0 (2.5-73.0)	14.0 (1.7-51.0)
Hickman	17	17	54	1	0 (0.0-25.0)	0 (0.0-86.0)	0 (0.0-66.0)
Peripherally inserted central catheters (PICC)	162	162	431	2	0 (0.0-23.0)	0 (0.0-13.0)	0 (0.0-8.0)
Other	95	100	268	1	12.7 (3.2-68.5)	0 (0.0-19.0)	0.4 (0.0-21.0)

Table III Aggregate rates of MRSA acquisition by type of hospital

Hospital category (number of contributing hospitals to each category)	Contributing hospitals' total occupied acute-care bed-days (Median)	Prevalence rate* per 10 000 occupied acute-care bed-days	Total incidence rate † per 10 000 occupied acute-care bed-days	New infection rate ‡ per 10 000 occupied acute-care bed-days
Principal referral (7)	1 139 487 (172 615)	19.6	3.3	0.7
Major metropolitan (2)	1 06 098 (53 049)	45.9	7.3	5.0
Major non-metropolitan (2)	96 618 (48 309)	20.1	0.2	0.2

*Old + new cases of infection isolates & old + new colonization isolates (one isolate per patient), $P < 0.0001$.

†New infection isolate + new colonisation isolate (one isolate per patient), $P < 0.0001$.

‡New infection (one isolate per patient), $P < 0.0001$.

higher ($P < 0.0001$) for this hospital type compared with that of the two other hospital types.

Discussion

The occurrence of healthcare-associated infection is perceived by patients and healthcare professionals as a frequent event. Rather, our pilot highlighted that the occurrence of SSI and BSI is statistically rare requiring hundreds of procedures and thousands of catheter-days to be collected before a reliable rate is produced rather than one influenced greatly by chance. The wide 95% confidence interval around many of our SSI or BSI rates confirm their statistical 'rare' distribution and bear testimony to the necessity for both continuous standardized data collection and national aggregation when a rate for benchmarking is the object of surveillance.

In 1984, we reported an SSI rate for 2495 orthopaedic procedures of 7.0% (95%CI: 6.1–8.0) which was significantly ($P < 0.0001$) higher than NNIS knee and hip prosthesis data even when the higher rate of Infection risk index levels 2 and 3 were used in the comparison.² This difference persisted when we compared our recent HISS knee prosthesis rate with those of the UK Public Health Laboratory Service (PHLS) rate, 2.1%,²⁰ and the latest NNIS rate,¹⁹ 2.2%, for a higher risk index, 2 and 3 ($P = 0.004$). The discrepancy between HISS, NNIS and PHLS begs several questions: does our rate reflect less than acceptable patient management skills in our contributing hospitals and are the NNIS and PHLS rates artificially low due to small data sets contributed by a large number of hospitals in which the probability of detecting infection is low?

Programmes such as those of the PHLS²⁰ and NNIS¹⁹ accept small samples for aggregation; some

programme requirements begin with hospitals contributing at least 20 procedures.¹⁹ The probability of identifying an infrequent risk of infection, say 2%, in a small dataset of 100 procedures is low ($P = 0.27$) and contribution to an aggregated database by hospitals with low probabilities for the accurate identification of infection may thus contribute to the perceived differences between the HISS, NNIS and PHLS infection rates. Had standardized post-discharge surveillance methodology been included in the pilot, the difference between HISS, PHLS and NNIS data may have been greater for several procedures, but this activity was outside scope of the pilot with standardized methods yet to be established.^{21–23}

Monitoring catheter-associated BSIs highlighted the unsuitability of prospective surveillance of line-days for most hospitals. The choice of ICU patients to trial routine active surveillance for infection and line-days was driven by the serious nature of CVC-associated BSI and the reduced likelihood of identifying BSI from peripheral lines as a result of adherence to the guidelines²⁴ for line removal. Active surveillance for all line types, however, was permitted during the trial. Yet, with the removal of 75% of peripheral lines after two days, and arterial ones after four days, active surveillance of line-days provided little insight. Line-day surveillance is arduous and we conclude that such surveillance can safely be restricted to CVC and rates expressed per 1000 line-days with an examination of the proportion of patients by exposure periods for the group most burdened by BSI. Cost-effective active monitoring of other catheters should begin with the laboratory identification of a BSI followed up in the ward for verification of infection, with a periodic audit for the estimate of line days. All cases of BSI can then be plotted on a process control chart without the need for line-day surveillance.²⁵

The difference between the acquisition rates of MSRA in the metropolitan and principal referral hospitals is highly suggestive of differences in undisclosed risk factors in the two types of hospitals, such as long inpatient stays by elderly patients in the smaller hospitals that deserve exploration of future databases. To establish a quarterly endemic or constant level, a healthcare facility may be inclined to use their prevalence rate; however, this rate may be subject to misinterpretation due to the insensitivity of measuring colonization which is dependent on choice of patient groups to screen. This may also be compounded where enrichment culture techniques are applied, increasing the yield by up to 30%.²⁶ Difficulties with standardized methodology reinforced our position that these rates are only interpretable at the local level and should not be aggregated for a rate or used for inter-hospital comparison.

In 1984 we demonstrated that larger Australian hospitals had significantly ($P < 0.001$) more healthcare-associated infections.¹ Hospitals of more than 500 beds were 20% more likely to report a SSI than hospitals with 200–499 beds, and had twice the proportion of infected surgical patients than hospitals with fewer than 200 beds.² The reason for this is of no surprise to healthcare professionals—larger teaching hospitals serviced sicker patients with longer in-hospital stay. In general, Australian patients are served by small to medium sized healthcare facilities⁴ and we should be mindful that the HISS rates and the 1984 survey¹ results serve as a reminder that a one-size-fits-all approach to active surveillance of both infection and denominator does not provide the majority of hospitals with meaningful real-time rates. Piloting the system in the varying size and type of HISS hospitals provided evidence that active surveillance requires an inordinate amount of time before there is a practical return to contributors. For most hospitals active surveillance of both infection and the denominator, for the purpose of calculating an infection rate, will not provide immediate or even annual benefits. Most hospitals will have to aggregate their data for several years before achieving reliable rates. The practice of data aggregation over several years at a state or national level makes sense for many surgical procedures and medical interventions that remain the same. But data aggregation by hospitals over years will not provide regular insight for change in clinical practice.

However, for all the difficulties and limitations involved with active surveillance it can not be replaced when the aim is the establishment of a national benchmark rate of infection and for the identification of potential predictors of infection. Active surveillance could, however, for smaller and medium size hospitals, be limited to the identification of infection using the laboratory and ward follow-up to seek and verify cases and employ passive identification of the number of procedures performed from theatre listings or admission and a quarterly audit of line-days. We need to rethink the monitoring of smaller to medium size patient groups to incorporate cost-effective and rapid assessments of the endemicity of SSI, BSI and MRSA, such as monthly process control charts,²⁵ for the purpose of effective communication with clinicians while participating in national benchmarking.

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