**Staphylococcus aureus** bacteraemia as a quality indicator for hospital infection control

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**ABSTRACT**

**Objective:** To evaluate the practicality and effectiveness of a new program that made health care-associated *Staphylococcus aureus* bacteraemia (SAB) a quality indicator at Austin Health.

**Design and setting:** Roll-out of the program over 9 months and review over 27 months from January 2006. Every episode of SAB at Austin Health was promptly reviewed, and classified as community- or health care-associated and as inpatient- or non-inpatient-related. Feedback was provided to treating clinicians for every SAB episode considered potentially preventable, and education-based interventions were introduced where appropriate.

**Main outcome measure:** Episodes of SAB associated with health care at Austin Health per 1000 separations (hospital discharges) per month.

**Results:** We identified 131 episodes of health care-associated SAB, of which 90 (68.7%) were caused by methicillin-susceptible *S. aureus*, 96 (73.3%) occurred in inpatients, and 65 (49.6%) were associated with a vascular access device. The health care-associated SAB rate was 1.1 per 1000 separations in the first 9 months, and fell by 55% to 0.51 per 1000 separations in the subsequent 18 months. We estimated that there were 80 fewer SAB episodes (95% CI, 20–140) than expected had the initial rate remained unchanged, a notional saving of $1.75 million to Austin Health over 27 months. About 16 hours per month of clinical nurse consultant time was required to maintain the program, representing a 0.1 equivalent full-time position, or a cost of $7000–$9000 per year.

**Conclusion:** Introducing a structured program to investigate all health care-associated SABs, rather than only infections with methicillin-resistant *S. aureus*, revealed a large under-recognised burden of potentially preventable infections. The program was simple and low-cost, and the rate of health care-associated SAB has fallen significantly since its introduction.

**METHODS**

The AuSABs program was designed and introduced at Austin Health, a large University of Melbourne teaching health service with three separate hospital campuses, but a single, central microbiology laboratory service. The program was progressively developed and rolled out over 9 months from January 2006, and we continued to review the impact over the subsequent 18 months. Every SAB detected in our microbiology laboratory that was linked to an Austin Health patient triggered a review of the case (when possible, on the same day or next normal working day) by an infection control clinical nurse consultant and/or infectious diseases registrar. This review was separate from the immediate clinical management of the patient, which remained the responsibility of the unit under which the patient was admitted. We recorded the likely place of acquisition (community or hospital), admitting unit, likely source, presence of any vascular access device and, if applicable, details of device insertion and management. Any potential system errors that may have contributed to the episode were noted.

An episode of SAB, including its association with a vascular device, was defined according to published criteria (Box 1).9,10 As part of our program, we introduced the term “AuSAB” (meaning SAB associated with health care at Austin Health), instead of “health care-associated SAB”, to encourage a sense of ownership and responsibility for these adverse events at Austin Health. Where possible, the source of bacteraemia was determined by identification of a primary focus, which was confirmed where possible by isolating *S. aureus* with the same antibiogram from that site.
Patients were followed until hospital discharge or 30 days after the episode of SAB. In the event of a patient’s death, the AuSAB was retrospectively categorised as “contributory” or “non-contributory” to the death by consensus among a panel of infectious diseases physicians and registrars who were presented with de-identified patient information that included the admission diagnosis, underlying comorbidities, clinical history, and timing of the AuSAB episode in relation to the time of death.

Blood cultures were ordered as clinically indicated, and MRSA and MSSA isolates were identified by standard techniques. Isolates from episodes of AuSAB were examined for clonality by means of pulsed-field gel electrophoresis (PFGE) of Smal digests of chromosomal DNA. The resulting PFGE pattern was analysed using GelCompar II, version 3.5 (Applied Maths NV, Sint-Martens-Latem, Belgium), as described previously. PFGE digestion patterns were considered clonal if GelCompar estimated a similarity of $\geq 80\%$. During the initial 9 months of the program, infection control staff publicised and explained the new program to hospital staff in the high-risk clinical areas. Reassessments were performed to monitor adherence to recommended interventions, and to provide further assistance as required.

### Statistical analysis

The main outcome measure was the rate of SAB associated with health care at Austin Health (AuSAB), expressed as the number of patient-episodes of S. aureus bacteraemia per 1000 total separations per month. Separations were obtained from “total separations” for Austin Health, an accounting statistic that measures all completed episodes of care, including day cases, and is equivalent to the number of discharges of all day-patients and overnight-patients of Austin Health.

Rates of AuSAB per 1000 separations in the initial 9 months and subsequent 18 months were compared by two-tailed $\chi^2$ tests (Stata statistical software, release 5.0; StataCorp, College Station, Tex, USA). To calculate “cases prevented”, a linear regression line was fitted to the entire 27-month dataset using GraphPad Prism 4 software (GraphPad Software, San Diego, Calif, USA), which also calculated the slope of the regression line (Box 2) and upper and lower 95% confidence limits of the slope. Using Excel (Microsoft, Redmond, Wash, USA), the area under the observed regression curve (AUC) was compared with the AUC obtained assuming the initial rate of 1.1 per 1000 separations had remained unchanged.

### Laboratory and clonality findings

As shown in Box 3, MSSA was isolated in 90 (68.7%) and MRSA was isolated in 41 (31.3%) of the 131 AuSABs. All but one of the AuSAB isolates were typed by PFGE. The 41 MRSA isolates could be clustered by PFGE into eight groups, with one main group comprising 27 isolates and seven smaller groups with four or fewer isolates. In contrast, the 90 AuSAB MSSA isolates clustered into 33 different groups, 25 of which were comprised of only one or two isolates. Of the other eight MSSA PFGE groups, the
two largest had 18 and 11 isolates, respectively, which were identified from AuSAB episodes throughout the 27-month period, and did not seem to predominate in any particular month or location.

**Source of AuSABs**

A proven or suspected source was identified in 116 (88.5%) of the 131 AuSABs, and 65 (49.6%) were associated with a vascular access device. Sources of infection for the other 51 AuSABs were surgical site (19; 14.5%), endocarditis (6; 4.6%), bone and joint (5; 3.8%), skin and soft tissue (3; 3.8%), urosepsis (6; 4.6%), pneumonia (2; 1.5%), intra-abdominal (2; 1.5%), and other sources (6; 4.6%). Of the 65 vascular access device infections, 45 (69%) were in inpatients and 20 (31%) in non-inpatients. Twelve (9.2%) of the 131 AuSABs occurred in patients in the intensive care unit and, of these, three were associated with a vascular access device. Devices involved in the 65 line-associated AuSABs included 18 central access devices (centrally venous catheters, Hickman catheters, Infus-A-Ports [AngioDynamics, Vilvoorde, Belgium]; 28%), 28 peripherally inserted devices (peripherally inserted central catheters, intravenous cannulae; 43%), 18 renal access devices (vascath and permcath catheters; 28%) and one case in which the identity of the device was unclear (1%).

During the 27-month program, there were six occasions when the monthly AuSAB rate exceeded 1.0 per 1000 separations (Box 2). On one occasion (November 2007), the cases could not be linked to a particular area, and were a mixture of line-associated and non-line-associated infections. The other five occasions when the monthly rate was high were within the 9-month roll-out period and, of the 68 AuSABs that occurred, 33 (49%) were line-associated. Of these 33, 17 were associated with “clinical area A” and nine with “clinical area B”. Although it is difficult to establish with certainty, the infections seemed to be linked to issues with line insertion in clinical area A and accessing lines in clinical area B.

In clinical area A, we observed inadequate insertion techniques for percutaneous intravenous central catheter insertion, including a modified rather than full surgical scrub, poor patient skin preparation, inadequate training of new staff and poor environmental conditions. Staff from infection control and clinical area A responded as soon as they became aware of AuSABs in that clinical area by organising staff education, improving techniques, introducing checklists and holding progress and review sessions with infection control staff. Similar AuSAB auditing in clinical area B conducted with active support from clinical area B nurses suggested poor technique in accessing lines, including staff not disinfecting ports before administering intravenous therapy, lines being left unconnected, and use of inappropriate dressings. In collaboration with the staff of clinical area B, education forums were conducted, and improved line-accessing practices were instituted. During the subsequent 18 months of the program, there were 63 AuSABs; 32 (51%) of these were line-associated, of which 14 (44%) were associated with clinical area A and seven (22%) with clinical area B.

**Program resources**

The staff time necessary for data collection, investigation, interventions and feedback varied according to the number of SABs and AuSABS per month. However, assuming that there were up to 1.5 SABs per 1000 separations (<10 cases per month) and up to 0.7 AuSABS per 1000 separations (<5 AuSABS per month), we calculated that about 16 hours per month of infection control clinical nurse consultant time (representing a 0.1 equivalent full-time [EFT] position) was required to maintain the program. This labour cost would be about $7000–$9000 annually.

**DISCUSSION**

The AuSABS quality improvement program was associated with a 55% reduction in hospital-acquired SABs, probably preventing 80 costly and potentially fatal infections. From the outset, we deliberately named the program “AuSABS” for Austin-associated *S. aureus* bacteraemias to remind us and other Austin Health departments that these adverse events occur on our watch, are frequently preventable and are our responsibility. By refocusing our existing MRSA bacteraemia surveillance system to include all SABs, we uncovered a large, under-recognised burden of health care-associated bloodstream infection at our institution. A caveat to our report on this program is that it is a quality improvement project, and not research. The interventions were introduced progressively, and there was no application of randomised controlled methods. Therefore, we cannot assess the relative effectiveness of any one intervention, nor be certain that the improvement we observed was causally linked to our interventions. However, the program has several merits.

Episodes of SAB are an unambiguous marker of invasive infection, and more than half of the episodes we observed were health care-related. By monitoring all health care-associated SABs and not just MRSA, as with our previous strategy,8 we detected 90 additional health care-associated SABs (of a total 131 [68.7%]) that were caused by MSSA. We also detected 35 health care-associated SABs in non-inpatients (26.7%), which may have been missed by a ward-based surveillance program, and even more may have been missed if we had aimed the surveillance program at high-risk wards, such as the intensive care unit, only. Our program showed that vascular access device-related bacteraemias accounted for 49.6% of AuSABs, and many of these were associated with system errors that were previously undetected, and were potentially preventable. Others have also suggested there is great potential within hospitals to reduce or nearly eliminate nosocomial infections, in particular catheter-related bacteraemias.13-23
Furthermore, the multifaceted interventions used in our program, including staff education, nurse empowerment, intervention bundles and checklists, are relatively simple to implement in busy hospitals, and have proved to be sustainable. The PFGE typing of our AuSAB isolates showed an expected pattern for MRSA, with a restricted number of previously recognised hospital-endemic clones. However, for the MSSA isolates, the PFGE showed a much greater diversity of clones, implicating varied sources and modes of transmission. These data suggest that many of these infections arise from strains already colonising patients at the time of admission, and are not the result of cross-transmission. However, we cannot exclude some degree of cross-transmission of MSSA. Hence, to prevent MSSA AuSAB infections, we needed to not only focus on staff hand hygiene, as we had for controlling endemic MRSA, but to review protocols and practices for inserting devices that breach skin, or accessing existing lines. This quality improvement program was simple to perform and required relatively little time to maintain, at an estimated annual cost of $7000–$9000 (a proportion of 0.1 of an infection control clinical nurse consultant salary). Our findings mirror results obtained with a similar program at Canberra Hospital. Compared with the small cost of establishing the program, the economic costs of health care-associated SABs are huge. Estimates vary, but in the United States, the cost of an episode of SAB ranges from US$20 000 to US$50 000. Financial data for Australia are scarce, but assuming a cost of A$22 000 per episode, the total AuSAB cost at our institution for 27 months was almost $3 million. So, the annual cost of running the program ($7000–$9000) was less than half the cost of one episode of SAB. By preventing an estimated 80 AuSAB infections, the program may have saved our institution $1.75 million, and prevented 5–6 deaths over 27 months.

The AuSAB program is now core business for our infection control team, with investigation and feedback integrated into the team's daily activities. Results are reported to the hospital executive, and are used as a performance indicator by the Infection Control Committee. The data generated from our program are also useful for comparison with other Australian hospitals, and the AuSAB rate has fallen below the previously published national median of 0.7 per 1000 admissions. At Austin Health, our overall performance target is now less than 0.5 AuSABs per 1000 separations, but our target for those that are line-related should be close to zero. The introduction of institution-wide SAB surveillance and feedback is a first step towards this goal.

ACKNOWLEDGEMENTS

We thank the staff of the Austin Health Microbiology Laboratory for isolating, identifying and reporting SABs; Shirley Xie and Wei Gao from the Microbiology Department for technical assistance with PFGE; Sandi Gamon and the staff of the Radiology Department for interventions in the Radiology Department; and the medical and nursing teams of Austin Health who willingly contributed to the review of each AuSAB.

COMPETING INTERESTS

None identified.

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(RECEIVED 12 Mar 2009, accepted 11 Aug 2009)