Staphylococcus aureus bacteremia (SAB) is common and increasing worldwide. A retrospective review was undertaken to quantify the number of cases, their place of acquisition, and the proportions caused by methicillin-resistant S. aureus (MRSA) in 17 hospitals in Australia. Of 3,192 episodes, 1,571 (49%) were community onset. MRSA caused 40% of hospital-onset episodes and 12% of community-onset episodes. The median rate of SAB was 1.48/1,000 admissions (range 0.61–3.24; median rate for hospital-onset SAB was 0.7/1,000 and for community onset 0.8/1,000 admissions). Using these rates, we estimate that ≈6,900 episodes of SAB occur annually in Australia (35/100,000 population). SAB is common, and a substantial proportion of cases may be preventable. The epidemiology is evolving, with >10% of community-onset SAB now caused by MRSA. This is an emerging infectious disease concern and is likely to impact on empiric antimicrobial drug prescribing in suspected cases of SAB.

Bacteremia caused by Staphylococcus aureus continues to be a common problem worldwide. In the preantibiotic era, most cases occurred in young patients without underlying disease. The associated death rate was 82% (1). Even with antimicrobial drug treatment, death rates remain high; in a recent meta-analysis of 31 studies, estimates of death rates for methicillin-resistant strains (MRSA) varied from 0.0% to 83.3% (median 34.2%), while those for methicillin-sensitive strains (MSSA) varied from 3.6% to 51.7% (median 25.0%) (2). Many of these infections are healthcare associated and thus are potentially preventable.

Antimicrobial drug resistance in S. aureus arose early after the development of antimicrobial agents and continues to evolve. In Australia, hospital strains are frequently methicillin resistant and resistant to several other antimicrobial drugs (3). This resistance limits the choice of potentially efficacious agents and results in frequent use of glycopeptides, such as vancomycin. The reliance on vancomycin causes difficulties because vancomycin has been shown to be less effective than isoxazolyl penicillins (e.g., flucloxacillin) in treating severe infections caused by S. aureus (4,5). This may be 1 explanation for the higher death rate associated with bacteremia caused by MRSA, compared with that caused by MSSA (2,6). Although MRSA tends to be the bacterium discussed most often in relation to healthcare-associated infections, MSSA strains are responsible for the largest proportion of hospital-acquired infections (3).

S. aureus remains a common cause of bloodstream infections of community onset. Increasing numbers of these community-onset infections are being caused by MRSA. Some of these infections may be caused by hospital strains carried into the community by patients or healthcare workers, but others are caused by true community strains in patients who have had no recent healthcare contact (7–9). These strains have emerged in many countries, including Australia, New Zealand, the United States, Canada, France, Switzerland, Greece, Denmark, Finland, Scotland, and the Netherlands. They are susceptible to most or all non-β-lactam antimicrobial drugs, are highly pyogenic, and are often associated with indigenous populations (10,11).

Although S. aureus is a well-known major cause of bacteremia, population-based estimates of its incidence are lacking. This study used hospital data to estimate the incidence of S. aureus bacteremia in Australia. In addition, we

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1Australian Group on Antimicrobial Resistance contributors to this study were the following: Thomas Gottlieb, Concord Hospital; David McGechie, Denise Daley, Fremantle Hospital; John Ferguson, John Hunter Hospital; James Branley, Nepean Hospital; Graeme R. Nimmo, Princes Alexandria Hospital; Gary Lum, Royal Darwin Hospital; Alistair McGregor, Royal Hobart Hospital; Clarence Fernandes, Royal North Shore Hospital; Iain Gosbell, Archie Darbar, South West Area Health Service, New South Wales; Peter Collignon, Jan Roberts, Canberra Hospital.
Results

We detected 12,771 bloodstream infections in the 17 hospitals participating in this study (12 principal referral metropolitan, 3 large metropolitan, 1 private hospital, and 1 medium-sized public hospital, and 1 private hospital with 2,013,534 total separations; Table 1). There were 3,192 episodes of \textit{S. aureus} bacteremia identified (i.e., 25% of the total true bloodstream infections). The median rate of \textit{S. aureus} bacteremia was higher in the principal referral metropolitan hospitals (1.59/1000 admissions) than in large metropolitan hospitals (1.3) or the private hospital (0.6). The range varied from 0.60 to 3.24 (Table 2). The median rate of community-onset bacteremia episodes was 0.80/1000 admissions (range 0.11–0.99). The median rate of hospital-onset bacteremia was 0.72 episodes/1,000 admissions (range 0.13–1.30). The median rate of hospital-onset \textit{MRSA} episodes was 0.22/1,000 admissions (range 0–0.89). When expressed as MRSA episodes per 1,000 occupied bed days (OBDs), the rates varied from 0 to 0.30 with a median rate of 0.08. If day-only cases are removed from the denominator then the median rate was 0.10 per 1,000 OBDs (range 0–0.39).

Of these 3,192 SAB episodes, 1,621 (51%) were of hospital onset, and 1,571 (49%) had their onset in the community. Of those with a hospital onset, 40% were \textit{MRSA} in comparison to 12% with a community onset. Of all \textit{MRSA} bacteremia episodes, 23% had a community onset, and 77% had hospital onset. Of the 193 community-onset episodes of \textit{MRSA} that occurred, only 47 (24%) had a sensitivity pattern (sensitive to gentamicin and ciprofloxacin) that suggests that they were community acquired.

When both \textit{MRSA} and \textit{MSSA} were considered, data were available for 560 community-onset SAB infections (but only from 4 hospitals). The proportions of these episodes that were noninpatient, healthcare-associated were 35%, 42%, 18% and 16%, respectively (from hospitals A, D, E, and N). In those hospitals, the percentage of \textit{S. aureus} episodes that were healthcare associated overall (i.e., all hospital-onset cases and those community-onset cases associated with healthcare exposure) were 75%, 69%, 64%, and 36%, respectively.

Mortality data were available for 526 patients from 2 hospitals. At hospital E, the mortality rate at day 7 was 10% (27 of 267 patients). When a subgroup of these patients at hospital E (52 patients) was followed for a longer period (2001–2002), the mortality rate was 23% at 30 days and 35% at 6 months. For those 24 patients with a community-onset episode of bacteremia that was not healthcare associated, mortality rates were 6% at day 7, 17% at 1 month, and 21% at 6 months, respectively. At hospital H (259 patients), the mortality rate at 30 days was 19%. At hospital H, the mean length of stay for those with SAB was 25.6 days compared to 6.2 days in matched controls. The mean length of stay was longer for MRSA infections (39.2 days) than for MSSA infections (23.3 days).
The rates of *S. aureus* bacteremia in different hospital populations were used to estimate the incidence for Australia. Using our median bacteremia rate for *S. aureus* bacteremia in different types of public hospitals (1.27/1,000 admissions, range 0.68–3.24) and in private hospitals (0.6/1,000 admissions), we estimated ≈6,900 episodes per year nationally (range 3,826–20,658) or 35/100,000 per year (Tables 3 and 4). Some data are available from other countries for comparison; the lowest annual rates are in Northern Ireland (23/100,000) and the highest in the United States (56/100,000; Table 4). However only 2 countries, Denmark and England, appeared to have comprehensive collection systems, and their rates were 29/100,000 and 37/100,000, respectively (17,20,22).

**Discussion**

*S. aureus* bacteremia is very common. Approximately one fourth (26%) of all *S. aureus* bacteremia episodes were caused by MRSA, and, as expected, the onset of most of
these episodes was in hospitals (77%). Notably, however, 12% of all community-onset *S. aureus* infections were MRSA, which was 23% of all MRSA bloodstream infection episodes. A recent study from the United States similarly showed that 15% of community-onset SAB episodes were MRSA (14). Most of the community-onset strains in our study were multiresistant or phenotypically consistent with UK EMRSA-15 (15) and thus most likely to have been acquired by patients who had previous hospital contact, with nursing home contact a major factor in at least 1 of the hospitals in this study (hospital G). However, approximately one fourth of these community-onset MRSA infections were caused by other phenotypes of non–multiresistant MRSA and thus more likely to be true community-acquired episodes of MRSA bacteremia.

Severe cases of MRSA bacteremia not associated with prior healthcare contact have been reported previously in Australia (7,9,16).

Use of the >48 hours postadmission definition of hospital onset underestimates the number of episodes of bacteremia that are healthcare associated. Many patients with chronic conditions are now treated in the community or on a day-only basis. Vascular lines are increasingly used in the community and outpatient settings, providing a potential source of bacteremia. The collection of data on the true association of episodes of bacteremia to healthcare is time-consuming and was not done by most institutions participating in this study. However, 3 principal referral hospitals (hospitals A, D, and E) did collect these data for 971 episodes, and 64%–75% of their total *S. aureus* bacteremia episodes were healthcare associated. Only 46%–61% of the episodes were acquired while the patient was an inpatient (i.e., >48 h in hospital). This finding means that in these larger hospitals approximately one third of healthcare-associated episodes were acquired by either outpatients or short-stay patients. These episodes are better defined as “nonpatient, healthcare-associated.” In a recent study in the United States, 62% of their community-onset SAB infections were healthcare related (with intravenous [IV] catheters the most common clinically apparent site of infection) (14). On the basis of our data, we conclude that in Australia approximately two thirds of all SAB episodes were associated with healthcare or medical procedures (i.e., all hospital-onset and approximately one third of community-onset episodes). A similar situation is evident in Denmark (17), where in 2002, at least 59% of all *S. aureus* infections were associated with healthcare procedures. Clearly, substantial scope exists internationally for interventions in healthcare settings to decrease the numbers of these episodes (especially those related to IV catheters). Interventions to reduce *S. aureus* bacteremia need to target healthcare-associated infections in the broadest sense and include those following non–inpatient-related medical procedures.

*Table 2. Staphylococcus aureus* bacteremia at individual hospitals*

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Incidence†</th>
<th>Community-onset infections†</th>
<th>Hospital-onset <em>S. aureus</em> infection†</th>
<th>Hospital-onset MSSA‡</th>
<th>Hospital-onset MRSA‡</th>
<th>SAB sepsis§ (including 1 day only)</th>
<th>MRSA SAB§ (excluding 1 day only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.29</td>
<td>0.51</td>
<td>0.78</td>
<td>0.54</td>
<td>0.24</td>
<td>0.34</td>
<td>0.08</td>
</tr>
<tr>
<td>B</td>
<td>1.80</td>
<td>0.74</td>
<td>1.05</td>
<td>0.58</td>
<td>0.48</td>
<td>0.52</td>
<td>0.17</td>
</tr>
<tr>
<td>C</td>
<td>2.21</td>
<td>0.94</td>
<td>1.27</td>
<td>0.74</td>
<td>0.53</td>
<td>0.58</td>
<td>0.18</td>
</tr>
<tr>
<td>D</td>
<td>1.83</td>
<td>0.99</td>
<td>0.84</td>
<td>0.64</td>
<td>0.20</td>
<td>0.48</td>
<td>0.08</td>
</tr>
<tr>
<td>E</td>
<td>1.37</td>
<td>0.66</td>
<td>0.72</td>
<td>0.46</td>
<td>0.26</td>
<td>0.40</td>
<td>0.09</td>
</tr>
<tr>
<td>F</td>
<td>0.80</td>
<td>0.35</td>
<td>0.46</td>
<td>0.42</td>
<td>0.04</td>
<td>0.21</td>
<td>0.01</td>
</tr>
<tr>
<td>G</td>
<td>2.29</td>
<td>0.99</td>
<td>1.30</td>
<td>0.41</td>
<td>0.89</td>
<td>0.64</td>
<td>0.30</td>
</tr>
<tr>
<td>H</td>
<td>1.48</td>
<td>0.83</td>
<td>0.65</td>
<td>0.55</td>
<td>0.10</td>
<td>0.44</td>
<td>0.05</td>
</tr>
<tr>
<td>I</td>
<td>1.69</td>
<td>0.77</td>
<td>0.93</td>
<td>0.49</td>
<td>0.44</td>
<td>0.40</td>
<td>0.14</td>
</tr>
<tr>
<td>J</td>
<td>1.48</td>
<td>0.88</td>
<td>0.60</td>
<td>0.25</td>
<td>0.35</td>
<td>0.35</td>
<td>0.15</td>
</tr>
<tr>
<td>K</td>
<td>2.10</td>
<td>1.06</td>
<td>1.04</td>
<td>0.59</td>
<td>0.44</td>
<td>0.47</td>
<td>0.13</td>
</tr>
<tr>
<td>L</td>
<td>0.78</td>
<td>0.58</td>
<td>0.21</td>
<td>0.10</td>
<td>0.11</td>
<td>0.26</td>
<td>0.05</td>
</tr>
<tr>
<td>M</td>
<td>0.68</td>
<td>0.48</td>
<td>0.20</td>
<td>0.08</td>
<td>0.12</td>
<td>0.20</td>
<td>0.05</td>
</tr>
<tr>
<td>N</td>
<td>3.24</td>
<td>2.40</td>
<td>0.84</td>
<td>0.62</td>
<td>0.22</td>
<td>0.60</td>
<td>0.06</td>
</tr>
<tr>
<td>O</td>
<td>1.27</td>
<td>0.80</td>
<td>0.47</td>
<td>0.41</td>
<td>0.06</td>
<td>0.35</td>
<td>0.02</td>
</tr>
<tr>
<td>P</td>
<td>0.60</td>
<td>0.11</td>
<td>0.49</td>
<td>0.44</td>
<td>0.05</td>
<td>0.12</td>
<td>0.01</td>
</tr>
<tr>
<td>Q</td>
<td>0.93</td>
<td>0.80</td>
<td>0.13</td>
<td>0.13</td>
<td>0.00</td>
<td>0.32</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>1.59</td>
<td>0.78</td>
<td>0.81</td>
<td>0.49</td>
<td>0.32</td>
<td>0.43</td>
<td>0.11</td>
</tr>
</tbody>
</table>

*MSA, methicillin-susceptible *S. aureus*; MRSA, methicillin-resistant *S. aureus*; SAB, *S. aureus* bacteremia.

†Per hospital admission (1,000).

§Per occupied bed days (1,000).
respectively). How best to intervene to decrease these infections is difficult to determine. Vaccination is a possibility for the future; a recent trial of a conjugated capsular polysaccharide vaccine in renal dialysis patients estimated efficacy at ≈60% (18). However, vaccination for the general population is unlikely to be available soon. We should therefore concentrate on reducing the number of deaths from established infections. Because the mortality rate associated with community-acquired bacteremia increases with inadequate empiric therapy (19), all efforts should be made to promote compliance with published guidelines for treatment of severe staphylococcal sepsis, including adequate duration of therapy.

Available data suggest that staphylococcal bacteremia is a major global health problem. The median death rate for MSSA infections is 25%, and for MRSA infections, 34% (20). Thus, >1,700 deaths in Australia are likely associated with *S. aureus* bacteremia per year (assuming 6,900 episodes or a bacteremia rate of 35/100,000/year). This estimate of the rate of SAB is similar to England (20,22) but much lower than in the United States on the basis of the rate derived from the figures available in the only comparative study (55/100,000) (14). Our estimated rate in Australia is higher than that in Denmark (17,21). It is also higher that those reported from Wales (22) and Ireland (23) (Table 4); however, all episodes from these last 2 countries likely were not reported in their voluntary reporting schemes. England changed recently from a similar voluntary reporting scheme to a compulsory scheme, and the numbers of reported episodes increased by almost 50% (24).

The rate of MRSA bacteremia in England was higher per 1,000 OBDs than in our figures from Australia (0.17 compared to 0.10 episodes per 1,000 OBDs, respectively). MRSA was a substantial cause of episodes of SAB in this study (26%). However, this percentage was lower than that seen in most other countries (e.g., Wales, 47%; Table 4) with the notable exception of Denmark (0.6% in 2002) (17).

We may have overestimated the number of cases of bacteremia occurring in Australia because of the overrepresentation of larger hospitals in our survey. However, these hospitals participated because they had in place surveillance systems for measuring all episodes of bacteremia. The rates of SAB may have been relatively lower in these hospitals because they were also more likely than were hospitals without surveillance systems to have infection control programs in place to try to decrease the numbers of these episodes. If systems were in place that better captured and reported on all bacteremia episodes in well-defined populations (e.g., all of Australia or a state), then this would give a more accurate rate. Such systems appear only to be in place in Denmark and England (17,21,24). Currently, no such systems are operating in Australia. Limited data are available from a voluntary surveillance

### Table 3. Estimated numbers of *Staphylococcus aureus* bacteremia in Australia*

<table>
<thead>
<tr>
<th>Published data for Australia 2001–2002 (13)</th>
<th>Total hospitals†</th>
<th>Acute public‡</th>
<th>Private§</th>
<th>Australia-wide</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. hospitals</td>
<td>724</td>
<td>537</td>
<td>1,306</td>
<td></td>
</tr>
<tr>
<td>No. beds</td>
<td>49,004</td>
<td>27,407</td>
<td>75,516</td>
<td></td>
</tr>
<tr>
<td>Total admissions (x1,000)</td>
<td>3,950</td>
<td>2,426</td>
<td>8,376</td>
<td></td>
</tr>
<tr>
<td>Same day separations (x1,000)</td>
<td>1,886</td>
<td>1,453</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Average length of stay</td>
<td>4.1</td>
<td>2.9</td>
<td>3.5</td>
<td></td>
</tr>
</tbody>
</table>

*S. aureus* BSI episodes; (calculated rates from data in this study)

- *S. aureus* BSI rate/1,000 admissions 0.68–3.24 0.6 0.6–3.24
- Estimated episodes/y 2,370–12,798 1,456 3,826–20,658
- Median rate/1,000 admissions 1.37 0.6 NA
- Estimated episodes/y (based on median) 5,412 1,456 6,867

Hospital-onset MSSA

- Rate/1,000 admissions 0.08–0.74 0.44 0.10–0.97
- Estimated episodes/y 316–2,923 1,067 638–4,718
- Median rate/1,000 admissions 0.47 0.44 NA
- Estimated episodes/y (based on median) 1,769 1,067 2,836

Hospital-onset MRSA

- Rate/1,000 admissions 0.05–0.89 0.05 0.05–0.89
- Estimated episodes/y 198–3,516 121 255–5,675
- Median rate/1,000 admissions 0.25 0.05 NA
- Estimate episodes/y (based on median) 868 121 1,015

*BSI, bloodstream infection; MSSA, methicillin-sensitive *S. aureus*; MRSA, methicillin-resistant *S. aureus*; NA, not applicable.
†For full details for individual hospitals in this study and hospital grouping, see Table 3 at [http://www.cdc.gov/ncidod/eid/vol11no04/04-0772.htm#table3](http://www.cdc.gov/ncidod/eid/vol11no04/04-0772.htm#table3)
‡Acute public hospitals exclude psychiatric hospitals.
§Of private hospitals, 246 were day only, 314 others had admissions for >24 h.
system in Victoria (25) that captures an estimated two thirds of bacteremic episodes that occur in that state. The extrapolated rate (27 episodes/100,000 persons/year; Table 4) was slightly lower than what we estimated for all of Australia in this study.

Substantial illness and increased medical costs are also associated with staphylococcal bacteremia. *S. aureus* bacteremia is often related to serious infections, including endocarditis, osteomyelitis, and septic arthritis. It frequently results in prolonged hospital admission and increased costs. In hospital H, the average length of stay for patients with *S. aureus* bacteremia was 26.5 days. In South Australia, the estimated additional cost of each episode of hospital-acquired *S. aureus* infection was $22,000 in 1998 (26). Nationally, these South Australian costs translate to additional hospital costs of ≈$150 million dollars ($22,000 x 6,900 episodes).

Treatment of *S. aureus* infections is complicated by the high prevalence of antimicrobial drug resistance. Although this has long been the case with multiresistant strains of MRSA in hospitals, the spread of hospital strains into the community, as well as the emergence of unique strains of MRSA unrelated to health care, have made this an issue of general importance. At least 3 community strains of MRSA are currently circulating in Australia (10,27,28). Two of these 3 community strains carry the gene for Panton-Valentine leukocidin, which is associated with subcutaneous abscess formation and necrotizing pneumonia. A number of reports have already highlighted the clinical impact of infection due to these strains (9,28–30). Surveillance data show that their prevalence is increasing in our capital cities, but the situation in rural Australia is not well documented (3). This increase will inevitably affect guidelines for empirical antimicrobial drug prescribing for staphylococcal infections and for patients in the community with suspected SAB. Further surveillance of staphylococcal infections, including bacteremia, is warranted to guide recommendations for empirical therapy and infection control interventions.

### Acknowledgments

We greatly appreciate the assistance of the many laboratory staff members at each of the participating hospitals and as well as many infection control practitioners who assisted in the collection of the data.

The Australian Group for Antimicrobial Resistance is currently funded by a grant from the Department of Health and Aging of the Australian Government with funding in the past from Eli Lilly (no funds received for 3 years).

The Australian Group on Antimicrobial Resistance (AGAR) is a group that represents 21 teaching hospital microbiology laboratories and 5 private laboratories. AGAR meets every 6 months. At these meetings, Drs. Gottlieb and Collignon made the initial proposal for this project. All members of AGAR were able to participate in the discussion of the project and

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**Table 4. International rates and numbers of *Staphylococcus aureus* bacteremia (SAB)*

<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>Population</th>
<th>SAB/y</th>
<th>SAB/10^5/y</th>
<th>% MRSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Present report</td>
<td>1998–2002</td>
<td>19,500,000</td>
<td>6,900</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Victoria (25)†</td>
<td>1990–1999</td>
<td>4,502,000</td>
<td>804</td>
<td>27</td>
</tr>
<tr>
<td>Denmark</td>
<td>Northern Jutland (21)</td>
<td>1996–1998</td>
<td>493,000</td>
<td>155</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Whole of Denmark (17)‡</td>
<td>2002</td>
<td>5,350,000</td>
<td>1,488</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Ireland (23)§</td>
<td>1999</td>
<td>3,700,000</td>
<td>ND*</td>
<td>25</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>England (20,22)¶</td>
<td>2002–2003</td>
<td>49,200,000</td>
<td>18,403</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2003</td>
<td>19,244</td>
<td>39</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Northern Ireland (22,24)#</td>
<td>2002</td>
<td>1,697,000</td>
<td>397</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2003</td>
<td>569</td>
<td>34</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Wales (22)#</td>
<td>2003</td>
<td>2,920,000</td>
<td>742</td>
<td>25</td>
</tr>
<tr>
<td>USA</td>
<td>Connecticut (14)**</td>
<td>1988</td>
<td>1,124,337</td>
<td>634</td>
<td>56</td>
</tr>
</tbody>
</table>

*MRSA, methicillin-resistant *Staphylococcus aureus*; ND, no data given.
† In Victoria, 8,036 SAB episodes were reported, resulting in a rate of 17.8/100,000. The final rate (27.0) for the entire state was extrapolated from this figure. The Victorian scheme is estimated to capture about two thirds of all bacteremia episodes that occur in that state per year.
‡ System in place in Denmark since 1960, with numbers of episodes continually rising (e.g., in 1966, 400 per year and total population 4.8 million or 8/100,000). Collection data based on reviewing all discharge summaries and laboratory samples (15 of 16 counties). Associated 23% mortality rate in 2002, and 22% of these deaths were directly related to sepsis.
¶ Rates in different regions varied from 8.9 to 37.1 per 100,000. Likely underreporting (22).
# Compulsory reporting system. Unclear if all community onset episodes were included. In England, underreporting occurred when a voluntary system was in place (only 13,770 episodes reported for 2003; thus, a 50% increase with compulsory system) (22).
# This rate is based on voluntary reporting system. Real rate might be 50% higher (22,24).
**Retrospective case analysis. Rate increased with age, urban areas, and African American ethnicity. 15% of community-onset SAB episodes were MRSA.
suggest modifications of the project design. Only 10 hospital laboratories had collected details on all their *S. aureus* bacteremia data prospectively, and these formed the AGAR participants able to participate in this study. Archie Darbar and Denise Daley were involved in the collection of data at their hospitals. Jan Roberts was involved in the collection of data at her hospital and also in the spreadsheet analysis of the data of all the participating hospitals.

Dr s. Collignon, Nimmo, Gottlieb, and Gosbell were involved in the writing of the manuscript. They made substantial contributions to the conception and design of the study, as well as to the acquisition, analysis, and interpretation of data. They also drafted the article and revised it critically for intellectual content. Additionally, all of the other participants in this AGAR project provided comment and feedback on numerous drafts over a 6-month period. All authors have reviewed this version and given final approval for publication.

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References


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