Determinants of Vancomycin Use in Adult Intensive Care Units in 41 United States Hospitals


We analyzed data from a prospective observational cohort study that included 108 adult intensive care units (ICUs) in 41 United States hospitals. Use of vancomycin (defined daily doses per 1,000 patient-days), nosocomial infection rates, and proportion of all Staphylococcus aureus isolates resistant to methicillin (MRSA rate) were recorded from January 1996 through November 1997. The median rate of vancomycin use was lowest in coronary care ICUs and highest in general surgical ICUs. Prior approval before use of vancomycin was required in only 26 (24%) of the 108 ICUs. In a multivariate linear regression model, rates of MRSA, central line–associated bloodstream infection, and the type of ICU were independent predictors of vancomycin use. None of the vancomycin control practices was associated with lower rates of vancomycin use; however, it is important to recognize that this database was not designed to measure rates of inappropriate use. Vancomycin use is heavily determined by rates of endemic MRSA and central line–associated bloodstream infection. Efforts to reduce these rates through infection control activities should be included in hospitals’ efforts to reduce vancomycin use.

Strains of Staphylococcus aureus resistant to methicillin (MRSA) and to other antimicrobial agents have become commonplace in hospitals in the United States [1, 2]. S. aureus, together with coagulase-negative staphylococci, account for roughly half of nosocomial central line–associated bloodstream infections and are commonly resistant to methicillin and other drugs, leaving vancomycin as the only effective agent for treating infections caused by these types of organisms [3, 4]. Therefore, it is not surprising that the use of vancomycin has increased over the past decade [5–7]. Unfortunately, along with this increase in vancomycin use, resistance has increased among certain organisms. There has been a 20-fold increase in the proportion of enterococci reported as resistant to vancomycin in hospitals participating in the National Nosocomial Infections Surveillance (NNIS) system, with highest rates among isolates from patients in intensive care units (ICUs) [3, 8]. Vancomycin exposure has been shown to be a risk factor for infection with vancomycin-resistant enterococci [9–11] and was associated with decreased susceptibility to vancomycin of S. aureus from patients in the United States and Japan [12, 13]. Since the Centers for Disease Control and Prevention (CDC) published “Recommendations for Preventing the Spread of Vancomycin Resistance” in 1995, investigators have reported that 30%–80% of vancomycin used in hospitals was inappropriate according to the published criteria [14–21].


Efforts to improve antimicrobial use in hospitals have generally focused on cost-saving interventions [6, 22], although some studies have documented decreased rates of colonization or infection with antimicrobial-resistant bacteria after interventions [23–25]. National organizations, including the CDC, the National Foundation for Infectious Diseases, the Infectious Diseases Society of America, and the Society for Healthcare Epidemiology of America, have published consensus statements calling for a system to monitor and improve antimicrobial use in hospitals in the United States [26, 27]. Despite this consensus, the efficacy of specific aspects of programs to improve antimicrobial use remains unclear.

To evaluate the epidemiology of antimicrobial use, the Hospital Infections Program at the CDC, in cooperation with the Rollins School of Public Health of Emory University (Atlanta), began the second phase of Project ICARE (Intensive Care Antimicrobial Resistance Epidemiology) in 1996. Phase 1 of this study illustrated a higher rate of antimicrobial resistance in ICUs than in other hospital areas [3]. Using data from ICARE hospitals participating in phase 2, we studied the relationship

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between (1) existing programs to improve antimicrobial use and (2) the use of vancomycin in adult ICUs. Although preliminary analysis suggested some importance of clinical practice guidelines in optimizing vancomycin use [28], we present further analysis in this article that accounts for other influential factors that affected vancomycin use in ICUs of ICARE hospitals.

Methods

Hospitals that participate in the ICU surveillance component of the NNIS system were invited to participate in the second phase of Project ICARE, and 41 hospitals successfully implemented the ICARE component over the study period of January 1996 through November 1997. The surveillance methodology and definitions of the NNIS system have been previously described [29, 30]. Participating hospitals reported monthly nosocomial infection data from at least one ICU. These data included information on device-associated infections (i.e., central line–associated bloodstream infection, ventilator-associated pneumonia, and catheter-associated urinary tract infection) and the number of patient admissions, days of device utilization by patients (device-days), and total inpatient days for the ICU, allowing the calculation of device-associated infection rates (i.e., infections per 1,000 device-days), device utilization rates (percentage of patient-days in which specific devices were in use), and average length of stay.

Under the ICARE component, hospitals reported the amount (in grams) of vancomycin administered intravenously to patients and the proportion of S. aureus isolates from clinical specimens that were resistant to methicillin (MRSA rate). Microbiological data were reported for each ICU, all non-ICU inpatient wards combined, and all outpatient areas combined. Pharmacy data were reported for the same hospital strata, but outpatient areas were omitted. All S. aureus isolates, whether associated with hospital- or community-acquired infection or colonization, were reported. Duplicate isolates were excluded; these were defined as isolates of the same organism with the same antimicrobial resistance pattern that were recovered from the same patient, regardless of the site of isolation. Amounts of parenteral vancomycin were standardized by conversion to defined daily doses (DDDs), where 1 DDD is equivalent to 2 g.

For each ICU, pooled mean rates for the study period were calculated for device-associated infection, device utilization, average length of stay, MRSA, and vancomycin use. For example, the pooled mean rate of vancomycin use was calculated by dividing the total number of DDDs by the total number of patient-days reported over the study period and was expressed as DDDS per 1,000 patient-days. MRSA rates were calculated for each ICU and for all non-ICU inpatient areas combined. If <10 S. aureus isolates were tested for susceptibility during the study period, then the MRSA rate was not calculated in that hospital area.

As participants in the NNIS system, hospital personnel had previously categorized each ICU at their hospital by the types of patients served: coronary (CCU), medical (MICU), general surgical (SICU), cardiothoracic, combined medical-surgical (MSU), respiratory, trauma, burn, neurosurgical, or other. For this analysis, respiratory, trauma, burn, and neurosurgical units were grouped with “other” ICUs.

To evaluate antimicrobial control practices, additional information was obtained from participating hospitals in a May 1997 survey of their antimicrobial formularies and prescribing-control practices (e.g., automatic stop orders, antibiotic order forms, and a formal approval process for vancomycin use), whether pharmacy personnel participated in clinical rounds, and use of clinical practice guidelines. Likewise, information was collected in a November 1997 survey on their use of diagnosis-based guidelines (e.g., community-acquired pneumonia, fever in neutropenic patients, and nosocomial pneumonia), criteria-based guidelines (i.e., indications for appropriate vs. inappropriate vancomycin use), and surgical prophylaxis. Preliminary analysis suggested that the placement of clinical practice guidelines in patients’ charts was important [28]. Therefore, the four hospitals that initially had not returned the survey were contacted regarding clinical practice guidelines, and their responses were included in this analysis.

Data were analyzed with SAS Release 6.12 software (SAS Institute, Cary, NC). Selected factors potentially associated with increased or decreased use of vancomycin (e.g., ICU or hospital characteristic, device utilization rates, nosocomial infection rates, MRSA rates, or antimicrobial control practices) were evaluated. The relationship between continuous variables and vancomycin use was assessed by means of Spearman’s rank correlation coefficient, while for categorical variables the medians were compared with the Kruskal-Wallis test. All reported P values are two-tailed. To assess the joint influence of these factors, we used stepwise linear regression techniques to develop a model for vancomycin use, identifying the most important main effects and first-order interaction terms.

Results

Description of sites. During the study period, 41 hospitals reported a median of 12 months’ worth of data from a total of 108 adult ICUs. The hospitals were in 19 states and had a median capacity of 385 beds (range, 147–1,206); 28 (68%) were affiliated with a teaching institution, and 4 (10%) were Veterans Affairs medical centers. The ICUs included 27 MSUs, 20 CCUs, 19 MICUs, 19 general SICUs, 12 cardiothoracic ICUs, and 11 “other” ICUs. The number of beds in the ICU, median length of stay, and rates of central line–associated bloodstream infection, catheter-associated urinary tract infection, and central line utilization each varied significantly among the different types of ICUs (table 1).

Vancomycin use. For all ICUs, the median rate of vancomycin use (DDDS per 1,000 patient-days) was 62.6. However, use varied considerably by type of ICU (table 1). Significantly
higher rates \( (P = .003) \) of vancomycin use were reported in
general surgical (87.6), cardiothoracic (85.6), and “other”
(90.6) units than in MSUs (53.2) and MICUs (59.1), while
significantly lower \( (P = .001) \) rates were reported in CCUs
(25.6). Correlations between the rate of vancomycin use in an
ICU and the ICU-specific MRSA rate \( (r = 0.36, P < .001) \),
the total inpatient MRSA rate \( (r = 0.34, P < .001) \), the central
line–associated bloodstream infection rate \( (r = 0.26, P = .01) \),
the central line utilization rate \( (r = 0.34, P < .001) \), the average
length of stay \( (r = 0.20, P = .04) \), and the total number of hospital beds \( (r = 0.34, P < .001) \) were significant. There was
no association between vancomycin use and the ICU-specific
rate of ventilator-associated pneumonia, catheter-associated
urinary tract infection, number of ICU beds, or rate of MRSA
in outpatient areas only. However, vancomycin use was higher
in hospitals with a teaching affiliation (table 2).

Two ICUs (ICU “A” and ICU “B”) at the same hospital
reported extremely high rates of vancomycin use (313.2 and
227.3 DDDs per 1,000 patient-days, respectively). These high
rates were partially explained by the reported high rates of central
line–associated bloodstream infection (7.3 and 9.8 in-
fecions per 1,000 central line days, respectively) and MRSA
(50% and 53%, respectively) in these ICUs. However, these
rates were so extreme that we considered the potential effect of
these ICUs in the linear-regression-model building process
described below.

Impact of antimicrobial use practices. Information on
some practices to improve antimicrobial use was obtained from
all hospitals. Of the 41 hospitals, 26 (63%) reported use of a
diagnosis-based guideline for antimicrobial selection (e.g., for
community-acquired pneumonia \( n = 26 \), fever in neutropenic
patients \( n = 5 \), and nosocomial pneumonia \( n = 3 \)), 20
(51%) used guidelines on antimicrobial selection for surgical
prophylaxis, 14 (34%) reported having written criteria concern-
ing appropriate vs. inappropriate use of vancomycin, and only
7 (17.1%) reported a requirement for preapproval before use
of vancomycin in their ICUs. Additional control practices were
reported by 38 hospitals (95%), and these included automatic

### Table 1. Median values of selected intensive care unit (ICU) characteristics, by type of ICU (Project ICARE, January 1996 through November 1997).

<table>
<thead>
<tr>
<th>Characteristic of ICU</th>
<th>Coronary ((n = 20))</th>
<th>Medical/surgical ((n = 27))</th>
<th>Medical ((n = 19))</th>
<th>General surgical ((n = 19))</th>
<th>Cardiothoracic ((n = 12))</th>
<th>Other ((n = 11))</th>
<th>(P) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of beds (n)</td>
<td>10.0</td>
<td>12.0</td>
<td>2.9</td>
<td>10.0</td>
<td>10</td>
<td>8.5</td>
<td>.03</td>
</tr>
<tr>
<td>Average length of stay (d)</td>
<td>11.5</td>
<td>4.5</td>
<td>4.5</td>
<td>3.6</td>
<td>2.4</td>
<td>4.6</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>MRSA rate</td>
<td>28.0</td>
<td>40.3</td>
<td>25.0</td>
<td>42.2</td>
<td>25.4</td>
<td>35.3</td>
<td>.12</td>
</tr>
<tr>
<td>Central line–associated bloodstream infection rate(n)</td>
<td>3.9</td>
<td>4.8</td>
<td>5.1</td>
<td>1.5</td>
<td>5.8</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Catheter-associated urinary tract infection rate(n)</td>
<td>10.3</td>
<td>7.94</td>
<td>14.4</td>
<td>8.94</td>
<td>14.5</td>
<td>.12</td>
<td></td>
</tr>
<tr>
<td>Central line utilization rate(n)</td>
<td>6.6</td>
<td>6.5</td>
<td>5.6</td>
<td>1.0</td>
<td>6.5</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td>Vancomycin use(n)</td>
<td>28.0</td>
<td>52.6</td>
<td>60.2</td>
<td>79.1</td>
<td>50.0</td>
<td>&lt;.001</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE.** ICARE = Intensive Care Antimicrobial Resistance Epidemiology; MRSA rate = proportion of *Staphylococcus aureus* strains resistant to methicillin.
* No. of infections per 1,000 days of device utilization [30].
† No. of central-line days per 1,000 patient-days [30].
‡ No. of defined daily doses per 1,000 patient-days.

### Table 2. Rate of vancomycin use in 108 adult intensive care units (ICUs), by hospital or ICU characteristic (Project ICARE, January 1996 through November 1997).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Vancomycin use(n) in ICUs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With characteristic ((n))</td>
</tr>
<tr>
<td>Teaching affiliation</td>
<td>69.2 (87)</td>
</tr>
<tr>
<td>Vancomycin control measure</td>
<td>83.0 (26)</td>
</tr>
<tr>
<td>Automatic stop order(n)</td>
<td>81.9 (62)</td>
</tr>
<tr>
<td>Antibiotic order form(n)</td>
<td>83.0 (22)</td>
</tr>
<tr>
<td>Pharmacists on rounds with ICU (n)</td>
<td>82.1 (37)</td>
</tr>
<tr>
<td>Clinical practice guidelines used</td>
<td>77.0 (56)</td>
</tr>
<tr>
<td>Surgical prophylaxis</td>
<td>59.3 (40)</td>
</tr>
<tr>
<td>Diagnosis-based guideline</td>
<td>82.1 (47)</td>
</tr>
<tr>
<td>Criteria for appropriate use (n)</td>
<td>58.5 (43)</td>
</tr>
<tr>
<td>Dissemination of guidelines</td>
<td>54.8 (41)</td>
</tr>
<tr>
<td>Form in patients’ charts</td>
<td>110.0 (29)</td>
</tr>
<tr>
<td>Mailing or newsletter to clinician</td>
<td>45.1 (11)</td>
</tr>
</tbody>
</table>

**NOTE.** ICARE = Intensive Care Antimicrobial Resistance Epidemiology.
* Median no. of defined daily doses per 1,000 patient-days. In parentheses
next to these values are the numbers of ICUs with or without the characteristic.
† Only 98 ICUs provided information on these vancomycin control measures.
Table 3. Median inpatient rates of methicillin-resistant \textit{S. aureus} (MRSA rate) and central line–associated bloodstream infection (BSI rate), by vancomycin control measure (Project ICARE, January 1996 through November 1997).

<table>
<thead>
<tr>
<th>Vancomycin control practice</th>
<th>MRSA rate*</th>
<th>BSI rate²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice present</td>
<td>Practice present</td>
<td></td>
</tr>
<tr>
<td>Pharmacists on rounds with ICU clinicians</td>
<td>Yes</td>
<td>31.5</td>
</tr>
<tr>
<td>Approval needed for use in ICU</td>
<td>Yes</td>
<td>46.8</td>
</tr>
<tr>
<td>Automatic stop order</td>
<td>Yes</td>
<td>41.3</td>
</tr>
<tr>
<td>Criteria for appropriate use</td>
<td>Yes</td>
<td>43.3</td>
</tr>
<tr>
<td>Pocket guides for physicians</td>
<td>Yes</td>
<td>52.3</td>
</tr>
<tr>
<td>Form in patients’ charts</td>
<td>Yes</td>
<td>35.4</td>
</tr>
</tbody>
</table>

NOTE. ICARE = Intensive Care Antimicrobial Resistance Epidemiology; ICU = intensive care unit.

* Proportion of \textit{S. aureus} isolates resistant to methicillin, for all inpatient areas combined, in 108 ICUs (except for ‘‘pharmacists on rounds’’ and ‘‘stop orders,’’ for which both vancomycin control measures and MRSA rates were known at only 98 ICUs).

² No. of infections per 1,000 central-line days for indicated ICU category, among 98 ICUs (except for ‘‘pharmacists on rounds’’ and ‘‘stop orders,’’ for which both vancomycin central measures and infection rates were known at only 91 ICUs).

stop orders for vancomycin (at 24 [63%]), participation of pharmacists on rounds with ICU clinicians in at least one ICU (at 18 [47%]), and use of an antibiotic order form (at only 8 [21%]).

When we compared the median rate of vancomycin use for the ICUs that each had various vancomycin control practices and a method of disseminating guidelines to the median rate for those ICUs that did not have such practices and methods, no control practice or method of dissemination was associated with lower rates of vancomycin use (table 2). However, several control practices (i.e., automatic stop orders, participation of pharmacists on rounds with ICU clinicians, use of criteria for appropriate use, and use of pocket guides by physicians) were associated with significantly higher rates of vancomycin use (table 2). These counterintuitive findings (i.e., of higher use in ICUs using control practices) are partially explained by higher rates of MRSA and/or of central line–associated bloodstream infection at hospitals using these control measures (table 3). Because MRSA rates and bloodstream infection rates are related to both vancomycin use and control policies, these rates confound the effect of the vancomycin control policy on vancomycin use and must be controlled for to determine the independent effect of antimicrobial control practices on vancomycin use.

To assess the independent importance of factors identified in univariate analysis, a stepwise linear regression analysis was performed. Because the rate of MRSA was calculated only if $\geq 10$ isolates were reported, no MRSA rate was available for some ICUs. Therefore, we used the total inpatient MRSA rate in the final modeling process. The final model included only the 98 ICUs that reported sufficient data concerning all factors under investigation. Including ICU ‘‘A’’ and ICU ‘‘B’’ (both at the same hospital) in the model significantly changed the main effect parameters. To control for the effect these two ICUs have on the other main effect variables, indicator variables for these ICUs were left in the final model. Because of inclusion of indicator variables for these ICUs in the final model, the importance of the remaining variables depended entirely on their relationship with vancomycin use in the remaining 96 ICUs.

An interaction between central line–associated bloodstream infection and type of ICU (i.e., cardiovascular ICUs) was found to be significant and remained in the final model. The final model showed that an increased central line–associated bloodstream infection rate in any type of ICU except cardiothoracic ICUs, an increased rate of MRSA among all inpatient isolates of \textit{S. aureus}, and cardiothoracic ICUs (regardless of central line–associated bloodstream infection rate) were associated with significantly higher vancomycin use, while CCUs were the only factor associated with lower vancomycin use (table 4). In addition, the final model controlled for the effects of ICU ‘‘A’’ and ICU ‘‘B,’’ which used vancomycin at extremely high rates.

Discussion

The concern that improved antimicrobial use should be a public health priority has been intensified since the isolation of \textit{S. aureus} with decreased susceptibility to vancomycin in patients in the United States and Japan [12, 13, 31]. Determining effective mechanisms to decrease vancomycin use at hospitals has been a great challenge to pharmacy and infection control personnel [25, 32, 33]. In our study, rates of MRSA, rates of central line–associated bloodstream infection, and type of ICU were independent predictors of vancomycin use in adult ICUs. After controlling for these factors, our study did not
Table 4. Independent predictors of vancomycin use, per a linear regression model of the square root of vancomycin use among 98 intensive care units (ICUs) reporting vancomycin use and nosocomial infection data to the Centers for Disease Control and Prevention (Project ICARE, January 1996 through November 1997).

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Parameter estimate</th>
<th>SE</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>5.685</td>
<td>0.86</td>
<td>.0001</td>
</tr>
<tr>
<td>Coronary ICU</td>
<td>-3.301</td>
<td>0.74</td>
<td>.0001</td>
</tr>
<tr>
<td>Cardiothoracic ICU</td>
<td>2.685</td>
<td>0.95</td>
<td>.0056</td>
</tr>
<tr>
<td>MRSA rate (inpatient)</td>
<td>0.047</td>
<td>0.02</td>
<td>.0187</td>
</tr>
<tr>
<td>Central line–associated bloodstream infection rate (in all except cardiothoracic ICUs)</td>
<td>0.283</td>
<td>0.09</td>
<td>.0015</td>
</tr>
<tr>
<td>ICU ‘A’</td>
<td>6.258</td>
<td>2.72</td>
<td>.0234</td>
</tr>
<tr>
<td>ICU ‘B’</td>
<td>5.915</td>
<td>2.75</td>
<td>.0340</td>
</tr>
</tbody>
</table>

NOTE. ICU ‘A’ and ICU ‘B’ are at the same hospital. ICARE = Intensive Care Antimicrobial Resistance Epidemiology; MRSA rate = proportion of S. aureus isolates resistant to methicillin.

identify a specific antimicrobial control practice that was associated with lower rates of vancomycin use.

Effective methods of reducing vancomycin use at one institution may be ineffective at others. The reasons for this may be multifactorial and difficult to assess. Our data illustrate some of the difficulties involved in evaluating the effectiveness of antimicrobial control programs at multiple institutions. First, we observed that vancomycin use varied by the ICU type, reflecting the types of patients cared for in the ICU. Any surveillance system of antibiotic use should account for differences in patient type. In addition, vancomycin use was directly related to ICU or microbiological characteristics that differ from hospital to hospital, such as the rate of MRSA or central line–associated bloodstream infections. This observation is supported by data reported from NNIS hospitals, which showed that 60% of pathogens isolated from patients with central line–associated bloodstream infections are pathogens commonly treated with vancomycin (i.e., coagulase-negative staphylococci, enterococci, and S. aureus) [4, 34].

Of interest is the finding that the bloodstream infection rate was an independent predictor of vancomycin use in all types of ICUs except cardiothoracic units. Why there is a lack of dependence between vancomycin use and the bloodstream infection rate in cardiothoracic ICUs is unclear. Two factors to be considered are that these patients may commonly receive prophylactic vancomycin, which would suppress bloodstream infections. In addition, the length of stay of patients in these units tends to be short, and the bloodstream infections may go undiagnosed during their stays in the cardiothoracic ICU. Regardless, efforts to reduce vancomycin usage in ICUs may require that hospitals focus increased attention on the prevention of central line–associated bloodstream infection and cross-transmission of MRSA between patients [35, 36]. Once these factors with major impact are dealt with, the relative importance of antimicrobial control practices may be assessed.

Many of the commonly cited policies to improve antimicrobial use (i.e., formulary restrictions, educational efforts, written hospital guidelines, and automatic stop orders) [25, 32, 37, 38] were in use at ICARE hospitals. However, the methods used to improve the use of vancomycin varied widely. Although 63% of hospitals implemented diagnosis-based clinical practice guidelines before 1996, less common were participation of pharmacists on clinical rounds with physicians in the ICU (47%), written guidelines specific for vancomycin (34%), written guidelines for surgical prophylaxis (34%), reported use of antibiotic order forms (21%), and required approval for vancomycin use in the ICUs (17%). This lack of agreement may be a reflection of the absence of data on the efficacy of each policy to reduce vancomycin use.

We were not able to detect a single antimicrobial control practice associated with lower rates of vancomycin use when controlling for independent predictors of vancomycin use. Although the implementation of clinical practice guidelines initially appeared to be associated with lower vancomycin use (table 2) [28], the influence of two ICUs (‘‘A’’ and ‘‘B’’) at the same hospital, a hospital that did not use such guidelines, may have confounded the preliminary analysis. The role of influential data points has been illustrated in other analyses of NNIS data [39] and highlights the importance of examining data from multicenter studies for these effects.

The lack of association between decreased vancomycin use and antimicrobial control practices must be interpreted with caution. Our survey instrument did not record all aspects of antimicrobial control practices; possible aspects of control practices not included in our analysis include curbside consultation with infectious diseases physicians, attitudes of ICU directors and ICU attending physicians, and local expert opinions. This was not an intervention study, and we did not assess the effect of antimicrobial-use control programs on vancomycin use within each individual ICU. Therefore, this analysis did not assess the change in vancomycin use over time in a specific ICU, but rather differences in use based on differing ICU or hospital characteristics. Comparison of use in an ICU before and after intervention is needed to assess the importance of specific aspects of antimicrobial control practices. Likewise, these data did not incorporate a measure of inappropriate use, which, while ideal, would be very labor-intensive in a study of this magnitude. Although the hospitals participating in NNIS and specifically in Project ICARE tend to be larger than the typical hospital in the United States, because we limited the analysis to adult ICUs this difference will unlikely limit the generalizability of our findings to adult ICUs throughout the United States.

In addition, we controlled for ICU and hospital-specific characteristics associated with vancomycin use in our multivariate model; therefore, we believe the demonstration by our data that vancomycin use was linked to rates of endemic MRSA and central line–associated bloodstream infection is applicable to most adult ICUs at hospitals in the United States. If hospitals can recognize this link, we believe our data will help hospitals
in their efforts to improve vancomycin use by incorporating aspects of guidelines for the prevention of central line–associated bloodstream infections and for isolation precautions [35, 36].

There has been increasing interest in involving the infectious diseases community in efforts by institutions to reduce costs of antimicrobials used in hospitals [6, 24, 40, 41]. This interest needs to go beyond cost-savings to include reducing the incidence of antimicrobial resistance [23, 26]. Some studies have already attempted this and have demonstrated that reducing the use of certain antimicrobial agents can reduce the incidence of antimicrobial-resistant pathogens, although it may take 2–3 years to observe the effect [24, 42–44].

Implementing an effective program will require a multidisciplinary approach among infectious disease, medical, surgical, and pharmacy personnel. This study highlights the importance of controlling for other factors associated with antimicrobial use or resistance when evaluating measures to reduce antimicrobial-resistant pathogens.

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References


