Relationship of Antimicrobial Control Policies and Hospital and Infection Control Characteristics to Antimicrobial Resistance Rates

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• BACKGROUND *Antibiotic misuse and noncompliance with infection control precautions have contributed to increasing levels of antimicrobial resistance in hospitals.*
• OBJECTIVES *To assess the extent to which resistance is monitored in infection control programs and to correlate resistance rates with characteristics of antimicrobial control policies, provider attitudes and practices, and systems-level indicators of implementation of the hand hygiene guideline of the Centers for Disease Control and Prevention.*
• METHODS *An on-site survey of intensive care unit staff and infection control directors of 33 hospitals in the United States was conducted. The following data were collected: antimicrobial control policies; rates during the previous 12 months of methicillin-resistant* Staphylococcus aureus, *vancomycin-resistant enterococci, and ceftazidime-resistant* Klebsiella pneumoniae; *an implementation score of systems-level efforts to implement the guideline; staff attitudes toward practice guidelines; and observations of staff hand hygiene. Variables associated with resistance rates were examined for independent effects by using logistic regression.*
• RESULTS *Resistance rates for* S aureus, *enterococci, and* K pneumoniae *were 52.5%, 18.2%, and 16.0%, respectively. Ten (30.3%) hospitals had an antibiotic control policy. No statistically significant correlation was observed between staff attitudes toward practice guidelines, observed hand hygiene behavior, or having an antibiotic use policy and resistance rates. In logistic regression analysis, higher scores on measures of systems-level efforts to implement the guideline were associated with lower rates of resistant* S aureus *and enterococci (*P = .046*).*
• CONCLUSIONS *Organizational-level factors independent of the practices of individual clinicians may be associated with rates of antimicrobial resistance. (American Journal of Critical Care. 2007;16:109-119)*

The growing problem of antimicrobial resistance has been attributed in part to inappropriate use of antibiotics and failure among healthcare providers to comply with infection control precautions.[1-3] Despite increased knowledge among healthcare providers about the spread of resistant pathogens and the publication of antimicrobial prescribing guidelines by the Healthcare Infection Control Practices Advisory Committee and professional organizations, antibiotics continue to be prescribed in excess or inappropriately.[4,5] Most likely the rapid emergence of organisms such as methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) also is associated with institution-wide factors such as administrative enforcement of recommendations among staff.[1]

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Because providing care to patients infected by antimicrobial-resistant organisms contributes to the continued increase in healthcare expenditures, administrative strategies are being implemented to reduce resistance in acute and long-term care facilities. These strategies include automatic stop orders for use of antibiotics, required pharmacy or infectious disease consultations for prescription of certain antibiotics, surveillance of pathogen-specific resistance rates, and the development of in-house antimicrobial control policies and guidelines.[1,5-7] In a recent study[7] of 120 Canadian hospitals, among institutions in which surveillance for antimicrobial-resistant organisms was conducted and healthcare-associated infection rates were reported, rates of MRSA were significantly lower than in institutions without such surveillance and reporting.

Nevertheless, many questions about the relationship between institutional policies and practices and antimicrobial resistance remain. For example, the extent to which hospitals have designed specific methods for tracking resistance and limiting prescribing of antibiotics is unknown. Furthermore, hand hygiene is the mainstay of preventing the transmission of antimicrobial-resistant pathogens, yet it is unclear whether staff attitudes toward and practices of hand hygiene are associated with rates of antimicrobial resistance.[8] The purposes of this study were to determine the extent to which hospital infection control programs include surveillance of antimicrobial-resistant pathogens and to correlate rates of antimicrobial resistance with characteristics of infection control policies and programs and attitudes toward and practices of healthcare workers regarding hand hygiene.

Methods

Sampling Procedures

This project was a component of a larger study, Impact of Hand Hygiene Guideline on Infections and Costs (National Institute of Nursing Research). The participants in the study were recruited from among hospitals that were members of the National Nosocomial Infection Surveillance (NNIS) System, a voluntary reporting network of more than 300 acute care hospitals representing nearly every state in the United States and coordinated by the Centers for Disease Control and Prevention (CDC).[9] The target sample size of hospitals (n=36) was based on the number of hospitals needed to detect a difference in infection rates among those implementing or not implementing the CDC hand hygiene guideline.[8] To recruit hospitals for the larger study, a letter describing the study was sent by mail and e-mail from CDC to NNIS hospitals. Interested individuals were asked to contact the investigators and the individuals' eligibility then was determined.

Eligibility criteria for participation in the study included being an NNIS hospital or using NNIS methods and definitions since at least 1999, having reported data by using the intensive care unit (ICU) surveillance component since at least 2000 (to ensure that sufficient, standardized data were available), and not using alcohol-based products for hand hygiene before June 2002. All hospitals participating in the larger study were later invited by e-mail to take part in this supplemental component to assess antimicrobial control policies and rates of antimicrobial resistance.

> *Where surveillance for antimicrobial-resistant organisms occurs, methicillin-resistant* Staphylococcus aureus *rates are decreased.*

Instruments

Four instruments were used for the study. The Implementation Assessment Survey was used to measure implementation and diffusion of the CDC hand hygiene guideline at the hospital systems level. This instrument consisted of 3 parts: (1) introduction of the guideline within the hospital (eg, where copies were kept, the extent to which the guideline had been discussed and disseminated), (2) presence of the recommended products on clinical units in the year before and after publication of the guideline, and (3) written institutional policies and procedures regarding hand hygiene. In addition, information about infection control staff and the hospital was recorded (eg, education and years of experience of staff, number of hospital beds, geographic location of the hospital).

The survey included 12 items to assess the implementation of recommendations from the guideline, such as whether special sessions were conducted to educate staff about the CDC guideline and whether a formalized plan was in place to monitor compliance with hand hygiene. Possible scores on the Implementation Assessment Survey ranged from 0 to 12; higher scores indicate greater hospital-wide administrative efforts to implement the guideline. Before final use in this study, the survey form was pilot tested among the infection control staff in 5 hospitals in New York City for content validity and clarity; interrater reliability was 0.92.

The Hand Hygiene Observation Instrument was used for direct observations of hand hygiene behavior. The tool lists the 8 indications for hand hygiene from the CDC guideline:

1. before direct contact with a patient;
2. before donning sterile gloves when inserting a central venous catheter;
3. before inserting invasive devices;
4. after touching a patient's intact skin;
5. after touching body fluids, wounds, or nonintact skin;
6. before moving from a contaminated body site to a clean body site in the same patient;
7. after contact with inanimate objects in the vicinity of a patient; and
8. after removing gloves.

While directly observing a care provider, the observer checked when one of the indications occurred, then whether hand hygiene also occurred, either with soap and water or with an alcohol-based product. Based on these observations, an overall hand hygiene rate (number of hand hygiene episodes per number of indications) and the proportion of hand hygiene episodes that occurred with either soap and water or with alcohol were calculated. Before the instrument was used, it was pilot tested by 4 research assistants who independently conducted observations in 3 different ICUs; the interrater agreement was 0.98.

The Attitudes Regarding Practice Guidelines survey was adapted from instruments originally developed by Cabana and colleagues.[10-12] Preliminary psychometric testing of the tool has been described.[13] The tool uses a 6-point Likert scale and has 2 sections: section 1 included 18 attitudinal statements about practice guidelines in general; section 2 included 18 parallel statements specifically about the CDC hand hygiene guideline. Possible scores ranged from 0 to 180; higher scores indicate fewer perceived barriers to use of clinical practice guidelines in general and the CDC hand hygiene guideline specifically. Additionally, respondents were asked to (1) name the most important factors that would either facilitate or prevent the respondents' use of the guideline and (2) self-report the proportion of time when they used an alcohol-based hand hygiene product.

To assess antimicrobial control policies, an 8-item survey was completed by the director of infection control in each hospital. The first item determined whether the hospital had a policy for restricting use of antibiotics. For those hospitals with a policy, the remaining items were used to determine which antibiotics were restricted, justification requirements for prescribing antibiotics, requirements for approval by the infectious disease department before antibiotics could be prescribed, implementation of stop orders for use of antibiotics, suggestions for use of alternative drugs, recommended route of antibiotic administration, and whether the policy indicated that the hospital had a pharmacy and therapeutics committee.

Procedure

The study was reviewed and approved by the institutional review board of each participating hospital. During a 2-day site visit to each hospital, the study project director collected data from the director of the infection control department, including the Implementation Assessment Survey; written hand hygiene policies and procedures; documents on staff education, infection control policies and procedures, product usage, and multidisciplinary meetings on hand hygiene; and rates of healthcare-associated infections within the ICUs studied.

During the site visit, the project director also made rounds in one or more ICUs in each hospital to record the proportion of rooms for patients' care and general areas in which alcohol products were available, to directly observe staff hand hygiene, and to administer the Attitudes Regarding Practice Guidelines Survey to ICU staff working during that shift (ie, physicians, nurses, and any ancillary direct care staff such as respiratory therapists). From 2 to 5 hours of observation during 1 to 2 days were completed until at least 24 hand hygiene episodes were recorded. To ensure that the practices of a single staff member did not bias the results, each staff member was observed a maximum of 3 times.

For infection control staff who also agreed to provide data on antimicrobial resistance, participants provided copies of their antimicrobial control policies and procedures in addition to hospital-wide rates of 3 organisms, if available: MRSA, VRE, and ceftazidime-resistant *Klebsiella pneumoniae.* Antimicrobial resistance data were obtained for the most recent 12 months. The time between implementation of the CDC guideline and calculation of rates of resistant strains was 2 to 3 years for each hospital.

Hospitals with hand hygiene compliance of 59% or more had lower vancomycin-resistant enterococci rates.

Data Analysis

Content analysis was performed to describe each hospital's antimicrobial control policies. Rates of MRSA, VRE, and ceftazidime-resistant *K pneumoniae* were obtained from each hospital. Rates were calculated as the number of isolates that were resistant divided by the total number of isolates of each species (eg, number of isolates of MRSA/total number of isolates of *S aureus*). The median rate of resistance was calculated across all participating hospitals. For the purposes of the analyses, rates of each of the 3 resistant organisms were dichotomized as high or low, defined as at or greater than the median (high resistance rates) or less than the median (low resistance rates), respectively, for each hospital. Bivariate analyses with χ^2 or t tests were then used to examine correlations between institutional characteristics and high or low rates of MRSA, VRE, or ceftazidime-resistant *K pneumoniae.* Variables examined in these analyses included hospital characteristics (affiliation with an academic health center, geographic region, number of beds), characteristics of the infection control department (number of years staff had worked in infection control, number and professional disciplines of infection control staff, educational preparation), presence of antibiotic-restriction policies, scores from the Attitudes Regarding Practice Guidelines survey and Implementation Assessment Survey, and observed rates of hand hygiene. For variables significantly associated with resistance rates in the bivariate analyses ($P<.05$), logistic regression models were fit to examine the independent effects of each variable.

Hospitals with higher implementation rates of hand hygiene guidelines had lower methicillin-resistant Staphylococcus aureus *and vancomycin-resistant enterococci rates.*

Table 1 Characteristics of hospitals and infection control departments (N = 33)

Characteristic	Value*
Hospitals	
No. of active beds, mean (range)	398.9 (128-894)
Affiliated with academic health center	57.6
Geographic region	
Eastern (Mid-Atlantic, South Atlantic, East North Central, East South Central)	69.7
Western (Mountain, Pacific, West North Central, West South Central)	30.3
Infection control departments	
No. of full-time infection control employees, mean (SD)	2.7 (2.0)
Discipline	
Nurse/nurse practitioner	87.9
Physician	6.1
Pharmacist	3.0
Medical technician	3.0
Highest level of education	
Diploma or bachelor's degree	39.4
Master's degree or doctorate	60.6
Time worked in infection control	
2-5 y	9.1
6-9 y	6.1
>9 y	84.8

* Values are percentages unless otherwise indicated.

Results

A total of 33 infection control directors provided data on antibiotic policies and resistance rates. Characteristics of the infection control directors and their hospitals are described in Table 1. Of the 33 hospitals, 10 (30.3%) had an antimicrobial restriction policy. Six restricted only vancomycin use, whereas 4 restricted use of vancomycin as well as use of other antibiotics, including linezolid, cefotaxime, aztreonam, ticarcillin/clavulanate, and amphotericin B. Of the 10 policies, 7 required that the prescribing clinician provide justification when ordering a restricted antibiotic and 7 required that an infectious disease physician approve the order before it was filled by the pharmacy. Six of the policies specified automatic stop orders for restricted antibiotics, usually 72 hours for vancomycin, and 6 specified a route of administration (eg, oral, intravenous). Only 3 of the policies suggested alternative drugs to commonly prescribed antibiotics. Half of the policies noted the existence of a pharmacy and therapeutics committee.

Rates of MRSA, VRE, and ceftazidime-resistant *K pneumoniae* were 52.5%, 18.2%, and 16.0%, respectively (Table 2). Susceptibility patterns from 9 hospitals (27.3%) indicated low rates of resistance (ie, <median resistance rates for all hospitals) for all 3 organisms tested. A total of 9 hospitals (27.3%) had high rates for 1 of the 3 organisms, 9 (27.3%) had high rates for 2 of the 3 organisms, and 6 (18.2%) had high rates for all 3 organisms.

In bivariate analyses, hospitals that scored high (11 or 12) on the Implementation Assessment Survey had significantly lower rates of MRSA than did hospitals with lower implementation scores ($P<.05$). Four variables correlated with VRE rates in bivariate analyses: geographic region of the hospital, score on the Implementation Assessment Survey, hand hygiene observation score, and number of active beds. Hospitals located in the western region of the United States had significantly lower rates of VRE than did hospitals located in the eastern region ($P=.049$). Hospitals that scored high on the Implementation Assessment Survey also had significantly lower rates of VRE ($P<.001$) than did hospitals with lower scores. Hospitals with

Table 2 Number of isolates tested and mean rates of methicillin-resistant *Staphylococcus aureus,* vancomycin-resistant enterococci, and ceftazidime-resistant *Klebsiella pneumoniae* (N = 33 hospitals)

Characteristic	*Staphylococcus aureus*	Enterococci	*K pneumoniae*
Total No. of isolates tested (range per hospital)	38 085 (198-3489)	15 775 (73-1553)	8814 (0-1035)
Mean rate of resistance, % (range per hospital)*	52.5 (16-71)	18.2 (1-79)	16 (0-83)

* For each organism, rate was calculated as number of isolates resistant/total number of isolates of that species (eg, number of isolates of methicillin-resistant *S aureus*/total number of isolates of *S aureus*).

observed hand hygiene compliance rates of 59.0% or greater had significantly lower rates of VRE than did hospitals with lower compliance rates ($P = .05$), and hospitals with 471 or more active beds had significantly higher levels of VRE than did hospitals with fewer beds ($P = .01$). Only geographic location of the hospital was significantly correlated with rates of resistant *K pneumoniae.* Hospitals in the eastern region of the United States had significantly higher rates than did hospitals in the western region ($P = .003$). Hospitals in which the proportion of hand hygiene with an alcohol product was higher and in which the infection control department routinely monitored hand hygiene had lower rates of resistance for all 3 organisms, although results were not significant (Tables 3 and 4).

In the logistic regression analysis, implementation score was the only significant predictor of higher rates of MRSA and VRE. That is, compared with hospitals with low implementation scores, hospitals with high implementation scores had significantly lower rates of MRSA and VRE (Table 5). None of these variables were associated with rates of resistance in *K pneumoniae.*

Discussion

The rates of resistance reported by our study participants were lower than, but consistent with, rates reported in the latest published NNIS summary of 2004: for MRSA, 52.5% in our study and 59.5% in the NNIS; for VRE, 18.2% and 28.5% respectively; and for *K pneumoniae* resistant to ceftazidime, 16.0% and 20.6% respectively.[14] Strategies that have been used to minimize the emergence of antimicrobial resistance in healthcare settings have included admission screening and isolation of carriers, antibiotic restriction policies, education of clinicians, feedback, implementation of guidelines, and vaccination.[15] The admission screening and isolation of carriers, referred to as the "search-and-destroy" approach, has become routine in several European countries, including the Netherlands, Denmark, and Germany, and has been recommended by some in the United States.[16-20] Low rates of healthcare-associated MRSA acquisition and reduced costs have been attributed to this strategy.[18,20,21]

In a systematic review of 43 studies designed to assess the effectiveness of strategies to reduce resistance rates, Wilton et al[15] identified the need to develop and evaluate "macro" strategies such as the search-and-destroy approach that involve entire systems of care or institutional management. In our study, we attempted to examine the impact of some of these macro factors (characteristics of hospitals and infection control departments) and staff attitudes toward practice guidelines and hand hygiene behavior on rates of 3 antibiotic-resistant organisms.

Fewer than one third of US hospitals have antibiotic control policies.

Impact of Antibiotic Use Policies

One of the fundamental strategies to reduce antimicrobial resistance has been the implementation of policies for antibiotic use and prescribing restrictions.[22] Several studies have indicated significant reductions in inappropriate antibiotic prescribing[23] and in rates of multiresistant infections[24-28] associated with such policies, but these studies to date have generally been small, restricted to a single institution or even a single unit within an institution. In a review of evidence of a relationship between antibiotic policies and control of resistance, Gould[29] noted that much of the evidence did not meet current standards for evidence-based practice, and others[30,31] have confirmed that additional research is needed to establish a causal relationship between antibiotic use policies and changes in rates of resistance.

In an Italian study[32] conducted in 2000, only 9.6% of hospitals reported having a surveillance system for antimicrobial-resistant organisms, and 18% had an antibiotic policy committee that met at least yearly.

Table 3 Association between hospital characteristics and rates of methicillin-resistant *Staphylococcus aureus,* vancomycin-resistant enterococci, and ceftazidime-resistant *Klebsiella pneumoniae,* bivariate analysis, χ^2 analysis

Characteristic	Methicillin-resistant *Staphylococcus aureus* (n = 33 hospitals) Rate, %	*P*	Vancomycin-resistant enterococci (n = 32 hospitals) Rate, %	*P*	Ceftazidime-resistant *Klebsiella pneumoniae* (n = 30 hospitals) Rate, %	*P*
Affiliated with an academic health center		.21		.29		.14
Yes	57.8		61.1		57.9	
No	35.7		35.7		27.3	
Geographic region		.71		.049		.003
Eastern	52.2		63.6		63.6	
Western	40		20		0	
Years of experience in infection control		.66		>.99		.60
<9	60		60		25	
≥9	46.4		48.1		50	
Director's educational preparation		.73		.47		.72
Bachelor's degree or diploma	53.8		38.5		41.7	
Master's degree or doctorate	45		57.9		50	
No. of full-time infection control practitioners		.73		>.99		.46
<2	52.6		47.4		38.9	
≥2	42.8		53.8		58.3	
Policy restricting antibiotics		>.99		.25		.12
Yes	50		70		70	
No	47.8		40.9		35	
Routinely monitor hand hygiene		.49		.08		>.99
Yes	41.2		31.3		43.7	
No	56.2		68.8		50	

The authors[32] concluded that intensive efforts are needed to better understand how to adopt uniform policies to reduce antimicrobial resistance. In our study, fewer than one third (10/33) of hospitals surveyed reported having antibiotic control policies. This low rate is surprising because the participants were members of the NNIS network of hospitals, which might be more likely than nonparticipating hospitals to be early adapters and/or current in their policies and practices. This rate is also lower than that reported in a recent survey[33] of 494 US hospital laboratories in which 60% reported that they had implemented antimicrobial use guidelines and 53% reported that they provided sufficient resources to prevent resistance. Possibly the infection control directors in the hospitals we surveyed were unaware of antibiotic control policies in the hospital, but that explanation seems unlikely.

Even among those hospitals that have antibiotic control policies, the extent to which the policies have been enforced is unknown. Implementation of antibiotic control policies may be an important potential source of intervention to reduce resistance. In our sample of hospitals we found no correlation between having standardized, written antibiotic stewardship policies and hospital-wide rates of MRSA, VRE, or ceftazidime-resistant *K pneumoniae;* however, we had no data on the extent to which these policies were actually implemented. A similar lack of such data occurred in the large national survey by Diekema et al.[33] Hence, these studies cannot be used to determine whether such policies might have an impact if the policies were actually practiced.

Impact of Hospital-Wide Indicators of Guideline Implementation

Although the data used to assess the level of guideline implementation were obtained in large part from an interview with the directors of infection control, we

Table 4 Association between hospital characteristics and rates of methicillin-resistant *Staphylococcus aureus,* vancomycin-resistant enterococci, and ceftazidime-resistant *Klebsiella pneumoniae,* bivariate analysis, *t* test

	Methicillin-resistant *Staphylococcus aureus* (n = 33 hospitals)			Vancomycin-resistant enterococci (n = 32 hospitals)			Ceftazidime-resistant *Klebsiella pneumoniae* (n = 30 hospitals)		
	Resistance rate*			Resistance rate*			Resistance rate*		
Characteristic	High	Low	*P*	High	Low	*P*	High	Low	*P*
No. of active beds	452	348	.08	471	319	.01	433	371	.35
Attitude score, mean	139	137	.40	139	137	.35	139	138	.67
Implementation assessment score, mean	9.81	10.76	.03	9.56	11	<.001	10.28	10.43	.75
Mean rate of use of alcohol hand hygiene products, %	31	35	.48	28	38	.11	29	38	.16
Total mean hand hygiene compliance rate, %	55	56	.78	50	59	.05	55	56	.84

* High rate indicates ≥ median rate for all hospitals; low rate indicates <median rate for all hospitals.

verified facts by reviewing minutes, educational records, and administrative data and by direct observation on units (eg, to confirm the presence of products). Hence, we believe the implementation score was an accurate reflection of systems-level practices. The implementation score most likely is a surrogate for the extent to which the infection control program in general is current and effective and/or the level of administrative support for the implementation of new guidelines.

Our findings indicate a strong relationship between this implementation score and rates of 2 of the 3 resistant organisms we examined. For example, although number of hospital beds, geographic location in the eastern United States, and lower rates of staff hand hygiene, along with the implementation score, were significantly associated with higher rates of VRE in bivariate analyses, the only significant predictor of higher VRE rates in the logistic regression analysis was the extent to which the hospital had implemented the CDC guideline.

The finding that hospitals with higher implementation scores also had lower rates of MRSA and VRE is consistent with the hypothesis that administrative and organizational factors such as improved infection prevention and control programs play an important role in preventing the spread of resistance. In the classic Study of the Efficacy of Nosocomial Infection Control conducted in the 1970s, infection prevention strategies implemented in a systematic way were associated with reduced rates of infection.[34] Our study provides evidence that these same strategies may also have a significant impact on rates of antibiotic resistance. This interpretation is consistent with the results of a survey[35] of 172 acute care Canadian hospitals in which deficits in various components of infection control programs were identified. The authors[35] suggested that greater investment in resources to support these programs might be associated with reduced rates of infection and resistance. Smith et al[36] developed conceptual mathematical models that indicated that regional coordination and planning across hospitals might be an essential element in ultimately preventing interinstitutional epidemics of antimicrobial resistance.

For *K pneumoniae,* only geographic location of the hospital (eastern half of the United States) was significantly associated with higher rates of resistance. Although we found no association between any of the other factors we examined and rates of resistance, Patterson et al[37] reported a significant reduction in rates of resistance among *Klebsiella* isolates after an intervention that included emphasis on contact precautions and education about use of antibiotics.

Impact of Staff Attitudes and Observed Hand Hygiene Practices

We found no association between staff self-reported knowledge of or attitudes toward practice guidelines or hand hygiene and rates of antibiotic resistance. The lack of such a relationship is not surprising because little evidence exists for a link between self-reported attitudes and actual hand hygiene behavior.[38-41] For that reason, most likely little reason exists to obtain self-report data from staff except perhaps to measure changes in knowledge and attitudes after a specific intervention.

The lack of a relationship between observed hand hygiene rates and rates of resistance may be related to changes in behavior associated with the Hawthorne effect; because staff members were aware that their hand hygiene behavior was being observed by an outside

Table 5 Predictors of rates of methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococci, logistic regression

Organism	Variable	*P*	Odds ratio	95% CI
Methicillin-resistant *Staphylococcus aureus*	Implementation score	.046	0.501	0.254-0.987
Vancomycin-resistant enterococci	No. of active beds	.10	1.005	0 .999-1.010
	Implementation score	.046	0.472	0.226-0.988
	Hand hygiene compliance rate	.47	1.023	0.963-1.086

observer, the observations most likely were not representative of usual practice. The availability of valid measures of hand hygiene continues to be a major deterrent to studies to examine the relationship between hand hygiene and patients' outcomes such as rates of multiresistant infections. Even though self-reported attitudes and practices may have little correlation with outcomes, evidence suggests that low nurse staffing and other organizational factors such as high nurse turnover rates do have an effect on rates of infection. Investigators[42-44] have speculated that one intervening factor could be that inadequate numbers of trained staff result in inadequate infection control practices. No data are available on a potential relationship between such factors and resistance rates.

System-wide infection control strategies can reduce antibiotic resistance rates.

Limitations

This study had several limitations. Episodes of hand hygiene were directly observed by a trained researcher, a situation that most likely resulted in behavior change among staff members who knew that they were being observed. Furthermore, the observations took place over a short time: 1 or 2 days. Hence, the hand hygiene rates probably are biased. Of particular concern is the fact that the rates were so low even though most staff members were aware their hand hygiene practices were being observed.

Our sample of 33 hospitals was not large, even though it was geographically dispersed. Although we noted a consistent trend toward reduced rates of resistance among hospitals that had processes to routinely monitor hand hygiene and hospitals with higher rates of use of an alcohol hand product, the lack of statistical significance in these relationships may have been due to insufficient statistical power. Because the NNIS system is voluntary, it is not representative of all US hospitals. Still, an advantage of NNIS hospitals is that their surveillance systems and definitions are comparable and conform to rigorous standards. Resistance data were obtained from the microbiology laboratory at each participating hospital and did not include a single isolate per patient per admission. Therefore, multiple cultures from the same patient might have been included in both the numerator and denominator of these rates.

Two inconsistent findings in this study warrant discussion. First, if a relationship exists between implementation score and resistance, one would expect to see the relationship consistently for all 3 organisms studied rather than 2 of the 3 only. A possible reason for the lack of a significant association between implementation score and rates of resistant *K pneumoniae* is that fewer than half the number of isolates of this species were available for analysis, hence the statistical power was considerably less. In addition, compared with resistant *K pneumoniae,* MRSA and VRE may be more sensitive indicators of systems-level factors such as staffing, because MRSA and VRE are more likely to be transmitted on the hands of healthcare personnel.

The second inconsistent finding is that observed rates of hand hygiene were consistently low across all hospitals, regardless of the systems-level implementation score. Only for VRE did hospitals with low rates of resistance have both significantly higher implementation scores and significantly higher hand hygiene rates. (Even then, however, the differences in rates of observed hand hygiene probably were not clinically important, because they were only 50% and 59% in hospitals with high and low levels of resistance, respectively.) Although one would hope that improved implementation of a guideline would be directly associated with improved practice, the implementation score was not designed to measure changes in practice. Instead, it was a marker of organizational-level characteristics that may have had an impact on other important predictors such as staffing and administrative commitment.

On the one hand, these findings are discouraging because making administrative changes and providing materials needed to implement a guideline are perhaps necessary but clearly are not sufficient to effect any discernible practice change at the staff level, at least in the short term. On the other hand, these data suggest that organizational factors in addition to individual staff practices may have a direct impact on important clinical outcomes such as antibiotic resistance. These intriguing findings warrant further study.

Summary and Recommendations

This study was one of the first attempts to correlate organizational characteristics with antimicrobial resistance rates across a number of hospitals. Hospitals that had antibiotic use policies did not have significantly lower rates of resistance. Clearly, simply having such a written policy is insufficient to have an impact without administrative measures to implement the policy. The extent to which hospitals had implemented the CDC hand hygiene guideline was the only factor significantly associated with lower rates of MRSA and VRE. We conclude that prevention efforts administered through system-wide infection control programs may be an important contributor to minimizing rates of antimicrobial resistance.

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JOURNAL CLUB ARTICLE DISCUSSION POINTS

In a journal club, research articles are reviewed and critiqued. General and specific questions help to aid journal club participants in probing the quality of the research study, the appropriateness of the study design and methods, the validity of the conclusions, and the implications of the article for clinical practice.

When critically appraising this issue's journal club article, "Relationship of Antimicrobial Control Policies and Hospital and Infection Control Characteristics to Antimicrobial Resistance Rates," consider the questions and discussion points listed below. To begin a discussion thread about the article online, visit **www.ajcconline.org,** read the article in either its full-text or .pdf format, and click on "Respond to This Article" (the link appears in bright blue in a list on the right-hand side of the page).

Study Synopsis: The purpose of this study was to examine the infection control practices of hospitals; specifically, how infection control programs monitored resistance, providers' attitudes and practices, and implementation of the Centers for Disease Control and Prevention (CDC) hand hygiene guidelines. Thirty-three hospitals were assessed using on-site surveys of intensive care unit (ICU) staff and interviews with infection control directors. Data were collected on antimicrobial control policies, resistance infection rates during the previous 12 months, ICU staff attitudes toward practice guidelines, and through direct observations of staff hand hygiene. Of the 33 hospitals, only 10 had an antibiotic control policy. Rates of antimicrobial resistance were lower but consistent with national rates, at 52.5% for methicillin-resistant *Staphylococcus aureus* (MRSA), 18.2% for vancomycin-resistant enterococci (VRE), and 16.0% for ceftazidime-resistant *Klebsiella pneumonia* rates. In analyzing factors associated with rates of antimicrobial resistance, higher scores on measures of system-level efforts to implement the CDC guidelines were associated with lower rates of MRSA and VRE.

A. Description of the Study

- What was the purpose of the research?
- Why is the problem significant for those working in critical and high acuity care environments?

B. Literature Evaluation

- What strategies have been identified as beneficial for reducing antimicrobial resistance in previous research on antimicrobial resistance?

C. Sample

- How were hospitals selected for study participation?

D. Methods and Design

- How were the data collected?

E. Results

- What were the findings of the research?
- What was the impact of staff attitudes and observed hand hygiene practices?

F. Clinical Significance

- What are implications of the study for clinical practice?

Information From the Authors: Elaine Larson, RN, PhD, lead author of this journal club article, provided additional information about the study. She shares that the study was conducted by a research team that was formed to study the topic of antimicrobial resistance as part of an official center funded by the National Institute of Nursing Research and the National Center for Research Resources. She notes: "We are very interested in antimicrobial resistance because it has become such a global problem and because I am the principal investigator on the Center for Interdisciplinary Research on Antimicrobial Resistance (http://www.cumc.columbia.edu/dept/nursing/CIRAR). It is clear that many of the actions being taken to reduce resistance are not working. We believe that part of the reason is because a more 'systems' approach rather than focusing solely on individual providers may be needed."

Dr Larson further relates that the hospitals that participated in the study were open to sharing their data on antimicrobial resistance rates and antimicrobial control policies. "Since the data are presented without identifiers and since the infection control staff members are as eager and committed as we are to deal effectively with resistance," she states, "we did not encounter any resistance. However, keep in mind that each hospital volunteered to be in the study—those that were resistant would simply not have volunteered." She adds that the most surprising finding of the study related to the number of hospitals with formal policies guiding antibiotic prescribing. "I was completely surprised to learn that so few institutions had formal antibiotic prescribing or restriction policies," she notes. "I would have guessed that most would."

Dr Larson indicates that the research team is planning additional studies related to infection prevention. "We have just submitted a large project grant to the National Institutes of Health that includes 9 related studies, but we won't know until August 2007 whether we receive funding. In the meantime, through our center we will continue to work with a large interdisciplinary team to identify important research questions related to resistance."

Implications for Practice: According to the study results, hospitals that had implemented the CDC hand hygiene guidelines had lower rates of MRSA and VRE infections. The results highlight the impact of the basics of infection prevention with hand hygiene measures. Dr Larson outlines several implications of the study results for readers of the *American Journal of Critical Care.* "It is likely to be impossible to stem the increasing tide of antibiotic resistance without system-wide, multidisciplinary collaboration and without strong administrative support and commitment," she points out. "Although infection control departments have been given primary 'responsibility' for controlling and preventing infections, they can only put processes and structures in place—they cannot, on their own, change practice."

Journal Club feature commentary is provided by Ruth Kleinpell.