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Journal of Preventive Medicine & Healthcare

Original Research Article

Organizational Characteristics of Infection Control Processes and Antimicrobial Resistance Rates in US Hospitals

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Submitted: 23 January 2017

Accepted: 23 March 2017

Published: 18 April 2017

Keywords

- Hospital acquired infections
- Antimicrobial resistance
- Patient safety
- Organizations

Abstract

Objective: Several antimicrobial resistance (AMR) surveillance programs have illustrated the extent of increased rates of AMR, but there is little information examining variations by organizational characteristics. This study describes relevant organizational practices, differentiated by AMR rates of Methicillin-resistant *Staphylococcus aureus* (MRSA), Vancomycin-resistant enterococci (VRE), Ceftazidime-resistant *Klebsiella* species (K-ESBL), and Quinolone-resistant *Escherichia coli* (QREC).

Methods: We used survey responses from 448 Infection Control Professionals and the American Hospital Association Annual Survey. Point estimates for AMR rates were calculated using the ridit method, and validated via antibiograms. AMR rates were compared across factors describing organizational structure, processes, and resources using the Jonckheere-Terpstra test. Hospital characteristics such as teaching, profit, and Veterans Administration (VA) Hospital status were compared using the Cochran-Mantel-Haenszel mean score statistic.

Results: Lower MRSA and K-ESBL rates were significantly associated with increased hospital implementation of infection control measures, resources allocation, and leadership. Lower VRE rates were associated with increased hospital implementation of infection control measures while lower QREC rates were observed with better resources. Higher AMR rates were associated with a greater number of beds. Urban hospitals reported higher MRSA and VRE rates and teaching institutions had higher MRSA, VRE, and QREC rates. VA hospitals reported higher MRSA and K-ESBL rates.

Conclusions: Lower AMR rates were associated with hospitals that had implemented processes, dedicated resources, and demonstrated leadership for infection control. Identifying organizational characteristics associated with lower AMR rates may offer some concrete strategies in which hospitals can evaluate their current capabilities to implement effective processes or practices to foster and sustain a culture of patient safety.

Abbreviations: AMR: Antimicrobial resistance; **MRSA:** Methicillin-resistant *Staphylococcus aureus*; **VRE:** Vancomycin-resistant enterococci; **K-ESBL:** Ceftazidime-resistant *Klebsiella* species; **QREC:** Quinolone-resistant *Escherichia coli*; **VAMC:** Veterans Administration Medical Center; **CDC:** Centers for Disease Control and Prevention; **HICPAC:** Healthcare Infection Control Practices Advisory Committee; **AHA:** American Hospital Association; **IT:** Information technology; **MAR:** Missing at random

INTRODUCTION

The use of antibiotics against bacterial illnesses in the 1940s marked a new era in health care. In the 21st Century, however, the growing presence of antimicrobial resistance (AMR) has brought new challenges to the health care system [1-3]. In a recent White House press release [4], the Centers for Disease Control and Prevention (CDC) estimated that hospital acquired infections affect two million patients annually in acute care facilities alone and 23,000 deaths at a projected cost of approximately $3.5 billion per year in direct patient care [2,5,6]. The most recent data from over 5,000 acute care hospitals, long-term care hospitals, and inpatient rehabilitation facilities, that were reported in 2014 showed that among all health care acquired infections, 48% of *Staphylococcus aureus* infections were resistant to methicillin, 30% of enterococci were resistant to vancomycin, and 18% of Enterobacteriaceae were extended-spectrum beta-lactamase phenotype [7]. While the overall cost estimates of AMR have varied widely, it can range as high as $20 billion. The economic impact of AMR has received significant attention from hospital administrators [8-10], particularly as it has become a focus of health care reform and has implications on reimbursement [11].

Specifically, the Healthcare Infection Control Practices

Advisory Committee (HICPAC) identified methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), and certain gram-negative bacilli with extended-spectrum-beta-lactamases (ESBLs) or resistance to quinolones (such as *Klebsiella* species) as high priority organisms in need of increased control [5,12]. Furthermore, AMR has serious implications not only on patient safety, but also on quality improvement efforts that many hospitals have initiated in the past decade. Although several existing AMR surveillance programs have provided data, such as resistance rates, illustrating the extent of problems in U.S. hospitals, there has been very limited information on how organizational characteristics affect strategies for infection control.

As the White House calls for innovative practice design to improve antimicrobial use, a greater understanding of organizational factors that are associated with either high or low AMR rates can provide tremendous insight into this challenging issue. In particular, identifying these organizational characteristics may facilitate the implementation of evidence-based care or prevention strategies in these hospitals. Although limited, some current literature has documented difficulties that hospitals encounter in implementing safety measures to control AMR spread. In a case study, a major U.S. hospital described barriers to their efforts in implementing and sustaining a culture of patient safety. A number of barriers related to organizational characteristics, such as a decentralized decision-making hierarchy, which limited the flow of ideas, practices, and cultures; a lack of interdisciplinary integration and effective communication among provider teams; limited leadership support; and the need for further development of valid and meaningful safety-related measurement and data collection methodologies to provide feedback, often impeded infection control [13,14]. Flach and colleagues, surveying a sample of laboratory directors, found that U.S. hospitals did not effectively apply existing organizational procedures to monitor AMR spread [15].

We conducted a large representative survey of U.S. hospitals, stratified by bed size, status as teaching facilities, and geographic region. This study described relevant organizational practices, differentiated by AMR rates of MRSA, VRE, K-ESBL, and QREC.

MATERIALS AND METHODS

Data and Sample

This study constructed an analytic dataset, using both primary and secondary data, by combining survey responses from the Infection Control Professionals portion of the Epidemiology and Control of AMR Study [6], and hospital characteristics obtained from the American Hospital Association (AHA) Annual Survey. The AHA Annual Survey Database contains information on over 6,000 hospitals in the U.S., with an average response rate of 83%. Annual institutional variables in five areas are obtained: organizational structure (type of organization, overall hospital operations, and affiliations); facilities and services; community orientation; size, utilization, finances and staffing; and revenue and expenses [16].

We sampled from the AHA Survey Database for participating hospitals in the Epidemiology and Control of AMR Study. As hospital size and affiliation have been shown to be related to availability of infection control programs, hospitals were stratified according to bed-size (1-49, 50-99, 100-199, 200 beds or more), teaching status (membership in the Council of Teaching Hospitals), and geographic region (Table 1). Exclusion criteria eliminated hospitals that (a) have fewer than 50 beds; (b) are other than general medical and surgical hospitals; and (c) did not receive accreditation from the Joint Commission. Moreover, geographic variations were controlled at the sampling level. For each Veterans Affairs Medical Center (VAMC) in a given geographic region, four to five non-VAMC hospitals were selected from the same stratum based on size and teaching status to ensure adequate power in detecting AMR rates. The final sampling pool retained 670 hospitals.

Survey

The development of the survey instrument was informed by two pilot studies, where respondents were asked for feedback on clarity of questions. Both qualitative and quantitative data from the pilot study were analyzed for instrument refinement, and the instrument was retested in a large sample of hospitals [15,18].

Infection control professionals responding to the survey documented prevalence of MRSA, VRE, K-ESBL, and QREC, which were then compared to the hospital laboratories' antibiograms for consistency. In addition, the survey captured items focusing on areas such as policies and practices within the hospital for dealing with AMR, infection control practice and guideline implementation, hospital culture and structure, as well as demographic data of the responder [6,18].

Sample Recruitment and Survey

We identified 670 infection control professionals from 670 hospitals (one from each hospital) and contacted them for participation. A recruitment letter, the survey questionnaire, and letters of support from national professional organizations and experts were sent to each participant. After the initial mailing, the study team employed a modified Dillman approach [17] to recruit non-responders with the following protocol: (a) a postcard reminder was mailed to non-responders 3.5 weeks after the initial survey mailing; (b) a second mailing took place six weeks following the postcard reminders; (c) 222 non-responders were invited to participate via telephone contact six weeks following the second mailing; and (d) a final letter, another survey, and an incentive were sent to non-responders 14 weeks after the telephone call [6,18]. At the time of the final mailing, participants also received the incentive, in a form of a gift card, and a letter of appreciation for their participation. The final study sample included infection control professionals from 448 hospitals (response rate=67%).

Measures

There are three organizational domains derived from the survey: structure, processes, and resources [19]. To examine structural factors, we asked respondents to rate items that measured the extent to which their hospitals had formalized protocols, standardized practices for infection control, and leadership structure/centralized hierarchy for decision-making. Formalized protocol is characterized by four items; the extent to which hospitals implemented guidelines for antibiotic use, measures to improve compliance with hand hygiene, feedback on the impact of antibiotic resistance, and compliance with hand hygiene guidelines. Practices were standardized via the dissemination of guidelines to providers in treating infectious diseases, use of antimicrobial order forms and formularies. Leadership and centralized structures were measured by assessing the extent of administrators' participation in decision-making for service improvement, nurse managers' enforcement of infection control policies, and leadership support for infection control activities.

To assess processes for antimicrobial control, the survey captured evidence-based recommendations, such as appropriate use of preoperative antimicrobial prophylaxis, best practices in empiric antimicrobial therapy, reporting changes in AMR, rapid change of therapy upon AMR reporting, and assessment of hand hygiene compliance [20]. Resource adequacy was determined by both overall appropriate resources (e.g., materials and personnel) to prevent AMR, and information technology (IT) capabilities and integration to support evidence-based practices.

Respondents were asked to rank all items on a five-point Likert scale with the following response categories: 1) "not at all;" 2) "to a very little extent;" 3) "to some extent;" 4) "to a great extent;" and 5) "to a very great extent."

Hospital characteristics derived from the AHA survey included bedsize, teaching facility status, profit status, rural/urban location, hospital type (VA vs. non-VA), and geographic regions. Respondents were asked to estimate the proportion of antimicrobial resistant isolates, which were unique patient strains, into the following categories: "none," "1-3%," "4-10%," "11-25%," "26-50%," and ">50%."

Statistical Analysis

Descriptive statistics of hospital characteristics were computed. Although the number of "don't know" or missing responses was minimal, we imputed these values using multiple imputation, which assumes that missing values are Missing at Random (MAR). The MAR structure suggests that missing values are conditional on the observed values, and not the missing values themselves [21]. We also compared characteristics of responding and non-responding facilities to assess potential response bias.

We calculated point estimates for AMR rates using the ridit method in which the infection control professional's response was the index measure and the antibiogram was the referent measure. The response categories "not at all" and "to a very little extent" were collapsed, as were "to a great extent" and "to a very great extent." AMR rates were compared across organizational factors and size using the Jonckheere-Terpstra test. Hospital characteristics such as teaching, profit, and VA status were compared using the Cochran-Mantel-Haenszel mean score statistic.

RESULTS

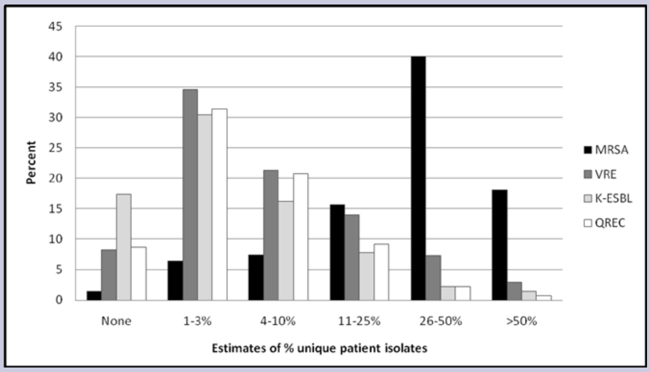
Table 1 describes characteristics of the 448 hospitals in the study sample. Sixty-six-percent of the hospitals in the sample were classified as large, with greater than 200 beds in size; another 22% were classified as medium, at 100-199 beds. Teaching hospitals made up 38% while VA hospitals constituted 20% of the study sample. Twenty-one percent were rural hospitals. The geographic distribution showed most participating hospitals were located in the South Atlantic/East-South-Central/West-South Central region (38%). On average, participating hospitals had two full-time employees devoted to infection control (range: 0–12.5). Respondents had a mean of 12.1 years of infection control experience and overall 80% were nurses, while 9% had medical degrees with infection control training. Responding facilities were representative of U.S. hospitals by geographic region [6,22].

Table 1. Characteristics of acute care hospitals in the sample(1)

Characteristic	Responding Hospitals (n=448)	All US Hospitals (n=6451)	p-value
	n (%)	n (%)	
Number of beds			
1-49*	2 (0.4%)	1468 (24.4%)	≤0.01
50-99	51 (11.4%)	1389 (23.1%)	
100-199	98 (21.9%)	1463 (24.4%)	
≥ 200	297 (66.3%)	1683 (28.0%)	
Member of Council of Teaching Hospitals	170 (37.9%)	369 (6.1%)	≤0.01
Surrounding area with non-metropolitan population base	95 (21.2%)	2383 (39.7%)	≤0.01
Veterans Affairs hospital	91 (20.3%)	138 (2.3%)	≤0.01
Region			
New England/Mid-Atlantic	76 (17.0%)	887 (14.9%)	0.66
East-North-Central/West-North-Central	123 (27.4%)	1616 (27.2%)	
South Atlantic/East-South-Central/West-South-Central	171 (38.2%)	2333 (39.3%)	
Mountain/Pacific	78 (17.4%)	1103 (18.6%)	

[1]Based on American Hospital Association Survey data
*Excluded from all analyses.

Among the antimicrobial pathogens we studied, MRSA was the most prevalent. The distribution of unique patient isolates was similar for VRE, K-ESBL, and QREC in that ≥75% of the hospitals reported ≤10% of isolates were unique. In contrast, a much greater proportion of MRSA isolates were unique (i.e., 60% of hospitals estimated ≥26% of MRSA isolates were unique patient isolates) (Figure 1). Moreover, AMR rates increased in hospitals that were larger, VA, teaching, and located in urban areas. Urban hospitals reported higher MRSA, VRE, and QREC rates. Larger, teaching institutions had higher MRSA, VRE, and K-ESBL rates. VA hospitals reported higher MRSA and QREC rates. Geographic regions showed no difference (Table 2).



Legend: MRSA (MIC≥4µg/mL); VRE (MIC≥16µg/mL); K-ESBL (MIC≥16µg/mL); QREC (MIC>1µg/mL)

Figure 1: Distribution of Unique Patient Isolates Among Antimicrobial Resistant Organisms Reported by Infection Control Professionals from Participating Hospitals

Table 2. A Comparison of Resistance Rates across Hospital Characteristics (N=448)

Hospital Characteristics	**Antimicrobial Resistance Rates**			
	MRSA	**VRE**	**K-ESBL**	**QREC**
Profit-status				
Yes	29%	9%	11%	8%
No	37%	11%	6%	7%
Location				
Urban	**39%**	**13%**	7%	**8%**
Rural	**27%**	**5%**	4%	**4%**
Teaching hospital				
Yes	**42%**	**15%**	**9%**	8%
No	**32%**	**8%**	**5%**	6%
Hospital type				
VA	**45%**	12%	7%	**10%**
Non-VA	**33%**	11%	6%	**6%**
Bed size				
< 100 beds	**22%**	**6%**	**5%**	6%
100 – 199 beds	**33%**	**6%**	**6%**	6%
> 199 beds	**40%**	**13%**	**7%**	8%
Geographic region				
New England/Mid-Atlantic	34%	14%	11%	8%
East-North-Central/West-North-Central	35%	11%	4%	6%
South Atlantic/South Central	39%	9%	6%	6%
Mountain/Pacific	32%	12%	7%	9%

Figures in bold denotes statistically significant difference between strata; p< 0.05
Note: For bed size, resistance rates were compared across strata using the Jonckheere-Terpstra test. Resistance rates were compared across profit status, location, teaching status, hospital type, and geographic region using the Cochran-Mantel-Haenszel mean score statistic.

Table 3 presents organizational structure, processes, and resources, differentiated by AMR rates. Overall, organizational characteristics appeared to have the greatest impact on MRSA rates, particularly those within the process domain. Lower MRSA rates were significantly associated with factors relating to the appropriate use of antimicrobials in the structural, organizational, and resource domains. Specifically, providing feedback on the impact of antibiotic resistance, administrators actively supporting infection control activities, and the organizational processes established to ensure appropriate antibiotic prophylaxis, therapy, and response to antibiotic resistance strains were associated with lower MRSA rates. In contrast, standardized practices (e.g., using forms and formularies) were not associated with lower MRSA rates. QREC rates were significantly associated with the implementation of measures to improve hand hygiene compliance. Significantly lower K-ESBL rates were observed when nurse managers reinforced infection control policies to a great extent. However, organizations with greater standardized practices such as the use of antimicrobial order form and formularies reported higher K-ESBL and QREC rates and those that distributed guidelines to providers for treating infectious diseases reported higher MRSA, K-ESBL, and QREC rates. Guideline implementation on antimicrobial use and feedback on hand hygiene compliance made no difference in AMR rates.

Instituting processes for infection control was largely associated with lower MRSA and VRE rates. Hospitals that to a great extent ensured appropriate use of preoperative antimicrobial prophylaxis, employed best practices in empiric antimicrobial therapy, promptly reported changes in antimicrobial resistance, and accordingly changed therapy reported lower MRSA rates than those that did not. Hospitals that assessed hand hygiene compliance reported lower VRE rates. Resource adequacy was also associated with infection control. Lower MRSA rates were associated with greater extent of resource provision in preventing AMR and the availability of computer-assisted decision support system. However, levels of informational resources and decision automation made no difference.

DISCUSSION

Overall, lower AMR rates were reported when hospitals had a more mechanistic structure, implemented processes, and dedicated resources to infection control. The extent to which hospitals instituted formalized policies and protocols, demonstrated leadership/centralization of decision-making, implemented processes, and allocated resources corresponded to lower AMR rates. It is noteworthy that specific infection control practices were not consistently effective across all organisms. For example, reported hand hygiene practices were not associated with lower MRSA rates, but they were associated with lower QREC rates. Having nurse managers reinforce infection control policies was associated with increased K-ESBL rates. These trends may be impacted by factors that have yet to be fully researched and explicated, such as how environmental factors like room cleaning processes or underlying prevalence of the organism in the community may affect hospital AMR rates. Characteristics of nurse managers or the way in which they enforce the policies may also affect AMR rates. On the other hand, these observations

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Table 3. A Comparison of Resistance Rates Across Organizational and Hospital Characteristics (N=448)

Organizational Characteristics	**Antimicrobial Resistance Rates**			
The extent to which the hospital…	**MRSA**	**VRE**	**K-ESBL**	**QREC**
Structure				
Formalized Protocols				
Implement guidelines for important types of antimicrobial use				
Not at all/very little	40%	14%	11%	5%
Some	37%	11%	7%	7%
Great/very great	35%	10%	6%	7%
Implement measures to improve compliance with hand hygiene				
Not at all/very little	42%	19%	19%	**12%**
Some	35%	12%	7%	**5%**
Great/very great	36%	10%	6%	**8%**
Provide feedback on the impact of antibiotic resistance				
Not at all/very little	**39%**	11%	7%	7%
Some	**37%**	9%	7%	7%
Great/very great	**29%**	12%	5%	7%
Provide feedback on compliance with hand hygiene guidelines				
Not at all/very little	36%	11%	5%	6%
Some	38%	12%	8%	7%
Great/very great	34%	10%	6%	8%
Standardized Practices				
Disseminate clinical practice guidelines/algorithms to providers for treatment of infectious diseases				
Not at all/very little	**32%**	8%	**4%**	**4%**
Some	**37%**	12%	**6%**	**7%**
Great/very great	**38%**	12%	**9%**	**8%**
Use antimicrobial order forms				
Not at all/very little	35%	10%	**6%**	6%
Some	41%	13%	**8%**	9%
Great/very great	37%	9%	**7%**	8%
Use a restrictive antimicrobial hospital formulary				
Not at all/very little	31%	8%	5%	**5%**
Some	41%	14%	6%	**6%**
Great/very great	36%	11%	8%	**8%**
Leadership Structure/Centralized Hierarchy				
Administrators participate in decision making regarding improving clinical services				
Not at all/very little	**41%**	7%	5%	4%
Some	**41%**	13%	6%	7%
Great/very great	**34%**	11%	7%	7%
Top-level administrators actively support infection control activities				
Not at all/very little	**41%**	12%	11%	8%
Some	**39%**	11%	6%	7%
Great/very great	**34%**	10%	7%	7%
Nurse Managers reinforce infection control policies				
Not at all/very little	40%	10%	**5%**	7%
Some	37%	12%	**8%**	7%
Great/very great	35%	10%	**6%**	7%
Organizational Processes for Infection Control				
Ensure appropriate use of preoperative antimicrobial prophylaxis				
Not at all/very little	**43%**	9%	13%	7%
Some	**38%**	12%	5%	6%
Great/very great	**34%**	10%	7%	7%
Ensure best practices in choice of empiric antimicrobial therapy				
Not at all/very little	**38%**	8%	6%	6%
Some	**39%**	12%	6%	7%
Great/very great	**33%**	10%	6%	7%
Promptly report significant changes in antimicrobial resistance				
Not at all/very little	**37%**	11%	5%	6%
Some	**41%**	11%	7%	7%
Great/very great	**32%**	11%	7%	7%
Rapidly change therapy after receiving reports of antimicrobial resistance				
Not at all/very little	**38%**	**10%**	11%	13%
Some	**42%**	**14%**	8%	6%
Great/very great	**34%**	**10%**	6%	7%
Assess hand hygiene compliance through observation				
Not at all/very little	37%	**15%**	8%	6%
Some	37%	**10%**	6%	7%
Great/very great	34%	**10%**	7%	7%
Resources				
Provide appropriate resources to prevent antimicrobial resistance				
Not at all/very little	**42%**	12%	8%	8%
Some	**36%**	10%	7%	7%
Great/very great	**34%**	10%	7%	7%
Informational				
Improves antimicrobial prescribing practices through educational means				
Not at all/very little	33%	11%	6%	6%
Some	39%	11%	8%	6%
Great/very great	34%	10%	5%	7%

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Communicate trends in antimicrobial usage to physicians				
Not at all/very little	36%	10%	5%	5%
Some	39%	12%	8%	8%
Great/very great	35%	10%	6%	7%
Information-technology				
Computer assisted decision support systems				
Not at all/very little	**39%**	11%	7%	6%
Some	**36%**	10%	7%	7%
Great/very great	**34%**	11%	5%	7%
Automation of decisions to reduce errors				
Not at all/very little	35%	11%	7%	5%
Some	35%	11%	6%	7%
Great/very great	37%	11%	7%	8%
Values in bold denote statistically significant differences between strata; p< 0.05.				

highlight the need for a comprehensive approach to infection control in order to effectively prevent infections from all resistant organisms rather than focusing on a single organism and assuming it is representative of all resistant organisms.

The lower rates observed with formalized practices, centralized hierarchy, and leadership support may be attributed to enhanced clarity of goals and expectations for infection control throughout the organization [23]. In particular, providing feedback on antibiotic resistance and implementing measures to improve hand hygiene compliance, as a part of the organization's formalized protocols, may have provided metrics that participants could use to modify their behavior and translate the feedback into action [6,24]. Centralization of administrative structure and leadership support may have reinforced the organizational emphasis on infection control [25,26]. On the other hand, standardized practices, such as using guidelines, antimicrobial order forms, and a restrictive antimicrobial hospital formulary, was associated with higher rates. This may be attributed to the fact that when standards dictate how providers should behave and practice, providers have less flexibility to problem-solve, which then stifles creativity, a sense of ownership by clinicians, and innovation.

Organizations that indicated to a great extent the processes available to ensure appropriate use of antimicrobial prophylaxis, best practices in empiric antimicrobial therapy choice, reporting of significant AMR changes, rapid therapeutic change with AMR reporting, and hand hygiene compliance, reported lower AMR rates. These findings showed that the establishment and standardization of processes to prevent and control AMR may have further reduced possible ambiguity in practice and organizational goals related to infection control. Needless to say, resources are important for any organizational initiative to succeed and it was expected that organizations providing appropriate resources for AMR prevention would show lower AMR rates. IT capabilities are an integral part of today's health care environment and our findings showed that hospitals with computerized tools reported lower MRSA rates. This may be because IT, as a critical organizational resource, complements structural properties and facilitates organizational processes to implement best practices [27]. Although AMR rates showed a decreasing trend with greater informational resources, these differences were not significant. It is possible that information disseminated through educational means, which are often passive or unidirectional by nature, may not be sufficient by itself without additional mechanisms to induce behavioral change in providers. By the same logic, factors that approached infection control from a facility-wide perspective such as implementing AMR guidelines, general feedback on hand hygiene compliance, automation of clinical decisions, showed no difference in AMR rates. These strategies were not individually targeted or tailored and there would be no way of monitoring or tracking accountability, which would in turn have little or no effect on modifying provider behaviors.

This study represents one of the first opportunities to systematically examine organizational structure, processes, and resources and infection control outcomes. Organizational factors may help promote best practices and sustain practitioner behaviors surrounding compliance, which may lead to improvement in quality and outcomes [28,29]. In addition, our study investigated AMR in four major clinically and epidemiologically important types of pathogens [5,30]. Despite these strengths, a number of limitations should be discussed. First, the cross-sectional nature of the study design does not permit the identification of causal relationships between key structural and process measures and outcomes. Future research may focus on organizational factors and AMR outcomes in a longitudinal fashion. Second, given that hospitals that were larger, teaching, VA, and/or urban tended to have higher AMR rates than their respective counterparts, it should be noted that the generalizability of these findings may be impacted by the responding sample's being significantly larger, more likely to be a teaching or VA hospital, and less likely to be rural than the source population of all U.S. hospitals. Future studies may be designed with sampling strategies to better ensure appropriate proportions of different hospitals. Finally, reliance on self-reported AMR surveillance may present some limitations. Self-reported data unaccompanied by central reference laboratory testing of organisms did not allow independent confirmation of resistant phenotype. These data also generally included all organisms tested in a laboratory without differentiating hospital and community acquisition. Nevertheless, data from the Intensive Care AMR Epidemiology Program, sponsored by the Centers for Disease Control and Prevention (CDC), have shown that hospital antibiograms often closely approximated AMR rates among nosocomial pathogens [31].

Examining organizational characteristics in the context of AMR rates can provide insights into the challenging issue of preventing infections [27]. Our findings have managerial, organizational, and policy implications. From a managerial perspective, centralized decision-making and formalized protocols may reduce uncertainty in promoting infection control. Processes facilitating particular organizational practices (e.g., infection control) are often more responsive to managerial or practice interventions because they may be more mutable [5,6]. Managers and practitioners may align processes with organizational structure to achieve the goal of AMR reduction [27,32,33]. In addition, our findings identified organizational factors that enabled hospitals to leverage their structural conditions, processes, and resources to implement best practices. These organizational factors also help to build organizational capacity to support overall quality improvement efforts [14].

CONCLUSION

Notwithstanding greater attention and major efforts to decrease transmission, infection control remains a challenge to health care organizations. For example, the continued emergence of organisms such as carbapenemase-producing Enterobacteriaceae [2,34] and *Clostridium difficile* [2] illustrate the importance of further developing strategies to effectively combat antimicrobial-resistant organisms. There is a need to better understand organizational factors in facilitating the implementation of infection control in U.S. hospitals. Identifying organizational characteristics associated with lower AMR rates may offer some concrete strategies in which hospitals can evaluate their current capabilities to implement effective processes or practices to foster and sustain a culture of patient safety.

ACKNOWLEDGEMENT

We would like to acknowledge the participation of infection control professionals, faculty and staff. This research was supported by the Department of Veterans Affairs, a VA Medical Research Merit Epidemiology Grant, and partially supported by the Health Services Research and Development Center of Excellence (grant HFP 04-148). There are no conflicts of interest to disclose. The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs. We are also very grateful to three anonymous reviewers for their helpful comments and peer-review.

DISCLOSURE

The authors declare no conflicts of interest.

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Cite this article

Chou A, Wendelboe A, McCoy K, Willis D, Doebbeling B (2017) Organizational Characteristics of Infection Control Processes and Antimicrobial Resistance Rates in US Hospitals. J Prev Med Healthc 1(1): 1005