Infection Control & Hospital Epidemiology (2021), **42**, 353–355
doi:10.1017/ice.2020.429

Concise Communication

MRSA prevalence and hospital-level antibiotic use: A retrospective study across 122 acute-care hospitals

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Abstract

We evaluated the relationship between local MRSA prevalence rates and antibiotic use across 122 VHA hospitals in 2016. Higher hospital-level MRSA prevalence was associated with significantly higher rates of antibiotic use, even after adjusting for case mix and stewardship strategies. Benchmarking anti-MRSA antibiotic use may need to adjust for MRSA prevalence.

(Received 18 June 2020; accepted 8 August 2020; electronically published 17 September 2020)

Antibiotic stewardship programs (ASPs) monitor antibiotic use and strive to improve antibiotic prescribing. The standard metric for ASPs is antibiotic days of therapy (DOT) per 1,000 days present.[1] Although this metric is easy to measure and responsive to stewardship interventions, it may also be influenced by external effects. For example, the prevalence of antibiotic-resistant bacteria, such as methicillin-resistant *Staphylococcus aureus* (MRSA), varies across geographic regions and could contribute to interhospital variation in antibiotic use.

Since 2007, the Veterans' Health Administration (VHA) has required that all patients admitted to the hospital undergo nasal swabbing to detect colonization with MRSA.[2] When aggregated to the hospital level, the results of these MRSA nasal swabs provide estimates of MRSA colonization rates among the patient population served by each facility.

In this study, we evaluated whether local MRSA prevalence rates were associated with hospital-level antibiotic use across the VHA.

Methods

Ethics

The institutional review board of the University of Iowa and Iowa City Veterans' Health Care System approved this study. The waiver for informed consent was granted by the institutional review board for this retrospective cohort.

Retrospective cohort

The study's retrospective cohort included all patient admissions to an acute-care bed at a VHA hospital during 2016. National administrative data were collected from the VHA's Corporate Data Warehouse via the Veterans' Affairs Informatics and Computing Infrastructure (VINCI). These data pertained to patient demographics, antibiotic use, and comorbidities, as defined by *International Classification of Diseases, Ninth Revision* (ICD-9) and *Tenth Revision* (ICD-10) codes.

Inpatient antibiotic use was collected from the bar-coding medication administration system based on the National Healthcare Safety Network (NHSN) Antimicrobial Use and Resistance Module.[3] Anti-MRSA antibiotics were identical to the NHSN list of antibiotic agents predominantly used for resistant gram-positive infections: ceftaroline, dalbavancin, daptomycin, linezolid, oritavancin, quinupristin/dalfopristin, tedizolid, telavancin, and intravenous vancomycin. For each patient admission, antibiotic use and time at risk for antibiotic exposure were summarized as days of therapy (DOT) and days present, respectively.[3]

At the hospital level, MRSA colonization and/or infection (hereafter "MRSA prevalence") was determined by calculating the proportion of admissions with a positive MRSA nasal swab upon admission and/or a MRSA-positive clinical culture obtained ≤1 day before or ≤2 days after admission.

Data from a mandatory nationwide survey (administered December 30, 2015, to January 15, 2016) were used to identify hospitals' self-reported ASP processes. We assumed survey responses reflected processes active during 2016.

Statistical analysis

The analysis data set included patient- and hospital-level characteristics that were aggregated to a monthly hospital level for 2016. The Spearman correlation coefficient was used to measure the correlation of hospital-level MRSA prevalence and aggregated unadjusted antibiotic use (total and anti-MRSA antibiotics). Negative binomial regression models were used to determine the association between a hospital's MRSA prevalence and its antibiotic use after accounting for intrahospital clustering, patient case mix, month, and use of hospital-based stewardship strategies. Days present represented

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Cite this article: Livorsi DJ, *et al.* (2021). MRSA prevalence and hospital-level antibiotic use: A retrospective study across 122 acute-care hospitals. *Infection Control & Hospital Epidemiology*, 42: 353–355, https://doi.org/10.1017/ice.2020.429

Table 1. Characteristics of 122 VHA Acute-Care Hospitals

Characteristic	Summary (N = 122 Hospitals)
Admissions per year, median no. (IQR)	4,376 (1,816–6,457)
Hospital locale, no. (%)	
Urban	109 (89.3)
Rural	13 (10.7)
Intensive care unit, no. (%)	108 (88.5)
Microbiology laboratory on-site, no. (%)	115 (94.3)
MRSA prevalence, median % (IQR)	8.0 (6.7–9.7)
Stewardship strategy for anti-MRSA agent, no. (%)	
Vancomycin strategy	
Restriction	11 (9.0)
Prospective audit-and-feedback	23 (18.9)
None	88 (72.1)
Ceftaroline strategy	109 (89.3)
Daptomycin strategy	111 (91.0)
Linezolid (intravenous) strategy	115 (94.3)
Linezolid (oral) strategy	118 (96.7)

Note. IQR interquartile range; MRSA methicillin-resistant *Staphylococcus aureus*.

the exposure time for risk of antibiotic use and were included in the models as an offset variable. Hospital-level MRSA prevalence was included as a continuous variable in regression models. The fixed coefficient of hospital-level MRSA prevalence was exponentiated and reported as incident rate ratios (IRRs) with 95% confidence intervals (CIs) such that an IRR of 1 indicates no association, whereas IRR > 1 or IRR < 1 indicates that a 1% change in the MRSA prevalence was associated with an increase or decrease in antibiotic use, respectively. All data analyses were conducted using SAS Enterprise Guide version 9.4 software (SAS Institute, Cary, NC).

Results

Table 1 shows characteristics of the 122 hospitals. There were 548,476 patient admissions across these sites. The median age was 68 years (interquartile range [IQR], 61–74) and 88.4% were men. Additional patient-admission characteristics are shown in Supplementary Table 1 (online).

At the hospital level, the median rate of MRSA prevalence upon admission was 8.0% (IQR, 6.7%–9.7%; total range, 3.8%–13.3%). Across all hospitals, the median use of anti-MRSA and total antibiotics was 96.5 (IQR, 81.1–116.9) and 562.1 (IQR, 505.9–631.6) DOT per 1,000 days present, respectively. Intravenous vancomycin accounted for most anti-MRSA antibiotic use (median, 88.7 DOT per 1,000 days present) followed by daptomycin (3.1 DOT per 1,000 days present) and linezolid (2.6 DOT per 1,000 days present).

A hospital's MRSA prevalence was weakly and positively correlated to its anti-MRSA antibiotic use (r = 0.48; $P < .0001$) and its total antibiotic use (r = 0.38; $P < .0001$). In a hospital-level risk adjusted analysis, a hospital's MRSA prevalence was significantly associated with its monthly use of both anti-MRSA and total antibiotics (IRR, 1.05; 95% CI, 1.02–1.07; IRR, 1.02; 95% CI, 1.01–1.03) (Table 2). A 5% increase in the hospital's MRSA prevalence was associated with an increase in the monthly use of anti-MRSA antibiotics and total antibiotics by 23.6 and 8.3 DOT per 1,000 days present, respectively.

Table 2. Association of a Hospital's MRSA Prevalence to Its Use of Anti-MRSA and Total Antibiotics (n = 122 Hospitals)

Variable	Spearman's Rank-Order Correlation, Rho (*P* Value)	Adjusted Comparison, IRR (95% CI)[a]
Anti-MRSA antibiotic use, DOT per 1,000 days present	47.5% (<.0001)	1.05 (1.02–1.07)
Total antibiotic, DOT per 1,000 days present	38.3% (<.0001)	1.02 (1.01–1.03)

Note. DOT, days of therapy; IRR, incident rate ratio; MRSA, methicillin-resistant *Staphylococcus aureus*.
[a]Adjusted for aggregated patient variables (ie, mean age, percent male, percent white, percent obese, mean APACHE, percent medical specialty, percent ICU observations, percent with immunosuppression, percent comorbidities: alcohol abuse, congestive heart failure, chronic obstructive pulmonary disease, dementia, diabetes, drug abuse, severe liver disease, neurological deficit, paralysis, peripheral vascular disease, renal failure) and hospital variables (ie, stewardship strategy for vancomycin, daptomycin, ceftaroline, linezolid), and month of admission.

Discussion

Meaningful benchmarking of antibiotic use across facilities will likely require some degree of risk adjustment, which could include both patient level and hospital level factors.[4] In this study, we found an association between MRSA prevalence at admission among a hospitalized population and that hospital's use of anti-MRSA antibiotics. Although this association was statistically significant, it was relatively small in magnitude. Nevertheless, these findings suggest that a hospital's endemic rate of antibiotic resistance may influence antibiotic prescribing and, in turn, may be a necessary factor to adjust for when making interfacility antibiotic use comparisons.

We suspect that hospitals with a higher MRSA prevalence prescribed more anti-MRSA antibiotics for several reasons. First, a vast body of literature indicates nasal colonization with MRSA can inform clinical suspicion for MRSA as a pathogen at certain body sites.[5,6] Since all patients admitted to VHA hospitals are screened for MRSA with a nasal swab, we suspect that the results of this test likely informed clinicians' empiric antibiotic choice. Second, in hospitals with a higher prevalence of MRSA, clinicians may be more inclined to start empiric anti-MRSA antibiotics. However, a VHA study of pneumonia found that local MRSA prevalence was not associated with treatment decisions.[7] Finally, a higher rate of MRSA colonization at a hospital would lead to a higher rate of MRSA infections;[8] this, in turn, would result in a higher volume of anti-MRSA antibiotic use.

We acknowledge the possibility that higher antibiotic use drove higher MRSA prevalence rates. Prior literature shows that receipt of systemic antibiotics is a risk factor for MRSA acquisition.[9,10] But because we defined MRSA prevalence at the time of hospital admission, we regard this as an unlikely explanation of our findings.

Our study has several strengths. For one, we were able to describe the relationship between antibiotic use and local MRSA prevalence rates across a geographically diverse healthcare system. In addition, we used survey data to adjust for a hospital's reported stewardship strategies and administrative data to adjust for differences in patient mix.

Our study also has a few limitations. First, this was a cross-sectional study, and we were unable to demonstrate causality. Second, we were only able to asses antibiotic use by volume, not antibiotic

https://doi.org/10.1017/ice.2020.429 Published online by Cambridge University Press

appropriateness. Third, all stewardship strategies were self-reported and were not validated. Finally, our study was limited to the VHA and may not be generalizable to other populations.

In conclusion, we found that higher hospital-level MRSA prevalence was associated with significantly higher rates of antibiotic use, even after adjusting for case mix and reported antibiotic stewardship strategies. Future benchmarking of anti-MRSA antibiotic use across hospitals may need to be risk adjusted using baseline rates of MRSA prevalence.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/ice.2020.429

Acknowledgments. 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 or the United States Government.

Financial support. This work was supported in part by a Career Development Award (to D.J.L.) from the VA Health Services Research and Development Service (grant no. CDA 16-204).

Conflict of interest. The authors report no conflicts of interest related to this.

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