Title

Environmental Cleaning Intervention and Risk of Acquiring Multidrug-Resistant Organisms From Prior Room Occupants

Journal

JAMA Internal Medicine, 171(6)

ISSN

2168-6106

Authors

Datta, Rupak

Platt, Richard

Yokoe, Deborah S

et al.

Publication Date

2011-03-28

DOI

10.1001/archinternmed.2011.64

Environmental Cleaning Intervention and Risk of Acquiring Multidrug-Resistant Organisms From Prior Room Occupants

Rupak Datta, MPH; Richard Platt, MD, MS; Deborah S. Yokoe, MD, MPH; Susan S. Huang, MD, MPH

Background: Admission to intensive care unit rooms previously occupied by carriers of methicillin-resistant *Staphylococcus aureus* (MRSA) or vancomycin-resistant enteroccoci (VRE) had been found to confer a 40% increased risk of acquisition, presumably through environmental contamination. Subsequently, a cleaning intervention was shown to reduce MRSA and VRE room contamination. We now evaluate the effect of this intervention on the risk of acquiring MRSA and VRE from prior room occupants.

Methods: We conducted a retrospective cohort study of patients admitted to 10 intensive care units at a 750-bed academic medical center during the enhanced cleaning intervention (from September 1, 2006, through April 30, 2008; n=9449) vs baseline (from September 1, 2003, through April 30, 2005; n=8203) periods. The intervention consisted of targeted feedback using a black-light marker, cleaning cloths saturated with disinfectant via bucket immersion, and increased education regarding the importance of repeated bucket immersion during cleaning. Intensive care units included medical, cardiac, burn/trauma, general surgery, cardiac surgery, thoracic surgery, and neurosurgery units. We calculated the number of room stays involving the potential for MRSA and VRE acquisition and then assessed the frequency at which eligible patients were exposed to rooms in which the prior occupants had MRSA-positive or VRE-positive status.

Results: Acquisition of MRSA and VRE was lowered from 3.0% to 1.5% for MRSA and from 3.0% to 2.2% for VRE ($P<.001$ for both). Patients in rooms previously occupied by MRSA carriers had an increased risk of acquisition during the baseline (3.9% vs 2.9%, $P=.03$) but not the intervention (1.5% vs 1.5%, $P=.79$) period. In contrast, patients in rooms previously occupied by VRE carriers had an increased risk of acquisition during the baseline (4.5% vs 2.8%, $P=.001$) and intervention (3.5% vs 2.0%, $P<.001$) periods.

Conclusions: Enhanced intensive care unit cleaning using the intervention methods may reduce MRSA and VRE transmission. It may also eliminate the risk of MRSA acquisition due to an MRSA-positive prior room occupant.

Arch Intern Med. 2011;171(6):491-494

Author Affiliations: Division of Infectious Diseases and Health Policy Research Institute, University of California Irvine School of Medicine, Irvine (Mr Datta and Dr Huang); Channing Laboratory, Brigham and Women's Hospital and Harvard Medical School, Boston, Massachusetts (Drs Platt, Yokoe, and Huang).

ENVIRONMENTAL CONTAMINATION with multidrug-resistant organisms may facilitate the spread of health care–associated infections. This is particularly important in intensive care units (ICUs), in which patients are at high risk of infection due to comorbidities, wounds, and the use of medical devices. Prior research[1] has shown that admission to an ICU room previously occupied by a patient harboring methicillin-resistant *Staphylococcus aureus* (MRSA) or vancomycin-resistant enterococci (VRE) was associated with a 40% increased risk of acquisition. In response to this finding, an intervention involving feedback regarding the adequacy of cleaning, repeated immersion of cleaning cloths into buckets filled with disinfectant, and an educational campaign was instituted and found to reduce MRSA and VRE room contamination.[2] We now assess the effect of this cleaning intervention on the risk of acquiring MRSA and VRE from prior room occupants.

METHODS

A quaternary ammonium agent was used for baseline discharge cleaning. The cleaning intervention, as previously described,[2] included 3 additional procedures: (1) targeted feedback regarding the adequacy of cleaning using a novel, nontoxic tracking marker whose marks are visible only under UV light ("black-light"),[3] (2) changing the application of disinfectant from pouring from bottles onto cleaning cloths to bucket immersion of cleaning cloths, and (3)

Table 1. Description of ICU Room Occupants and Absolute Risk of MRSA and VRE Acquisition According to Study Period[a]

Occupant	Baseline	Intervention
MRSA		
Age, median (range), y	62 (15-103)	62 (15-100)
Length of stay, median (range), d		
Pre-ICU	6 (0-287)	6 (0-238)
ICU	3 (1-133)	3 (1-105)
Post-ICU	4 (0-287)	5 (0-239)
Male sex	4377 (57.4)	4899 (56.2)
Comorbidity		
Diabetes mellitus	1718 (22.5)	2545 (29.2)
End-stage renal disease	389 (5.0)	364 (4.2)
End-stage liver disease	142 (1.9)	218 (2.5)
Solid cancer	1935 (25.4)	2567 (29.5)
Hematologic malignant neoplasm	385 (5.1)	576 (6.6)
Immunocompromised, noncancer	401 (5.3)	401 (4.6)
ICU room stays		
Total eligible	10 151 (100)	11 849 (100)
Prior occupant MRSA-positive	1454 (14.3)	1443 (12.2)
Acquired MRSA during ICU stay	57 (3.9)	21 (1.5)
Prior occupant MRSA-negative	8697 (85.7)	10 406 (87.8)
Acquired MRSA during ICU stay	248 (2.9)	161 (1.5)
VRE		
Age, median (range), y	62 (15-103)	62 (15-100)
Length of stay, median (range), d		
Pre-ICU	0 (0-137)	0 (0-114)
ICU	3 (1-134)	3 (1-95)
Post-ICU	4 (0-287)	5 (0-239)
Male sex	4471 (57.3)	4959 (56.2)
Comorbidity		
Diabetes mellitus	1759 (22.5)	2599 (29.5)
End-stage renal disease	390 (5.0)	365 (4.1)
End-stage liver disease	138 (1.8)	217 (2.5)
Solid cancer	1940 (24.9)	2556 (29.0)
Hematologic malignant neoplasm	375 (4.8)	539 (6.1)
Immunocompromised, noncancer	365 (4.7)	373 (4.2)
ICU room stays		
Total eligible	10 349 (100)	11 871 (100)
Prior occupant VRE-positive	1291 (12.5)	1446 (12.2)
Acquired VRE during ICU stay	58 (4.5)	51 (3.5)
Prior occupant VRE-negative	9058 (87.5)	10 425 (87.8)
Acquired VRE during ICU stay	256 (2.8)	205 (2.0)

Abbreviations: ICU, intensive care unit; MRSA, methicillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant enterococci.

[a]Patients may be represented more than once because of multiple ICU admissions. Data are given as number (%) unless otherwise indicated.

education regarding the importance of repeated bucket immersion during cleaning.

Data collection and analyses were performed identically for MRSA and VRE. We obtained census information detailing ICU occupants and occupancy dates from September 1, 2006, through April 30, 2008, and from September 1, 2003, through April 30, 2005. Intensive care units included medical (n=2), cardiac, burn/trauma, general surgery, cardiac surgery (n=2), thoracic surgery, and neurosurgery (n=2) units. They routinely performed high-compliance admission and weekly MRSA and VRE screening, systematically distinguishing between imported and incident cases. For each occupant, we collected demographic and comorbidity data based on *International Classification of Diseases, Ninth Revision* codes within 1 year of ICU admission. We also collected each occupant's pre-ICU, ICU, and post-ICU length of stay; duration of room vacancy before ICU admission; and carrier status at ICU admission and discharge.

Carrier status was obtained from infection control and microbiology laboratory records. Patients were eligible for acquiring MRSA during an ICU stay if they had no history of MRSA before room admission and no MRSA-positive culture results within 2 days of ICU admission.[4] Identical criteria were used for VRE. Patients could contribute data from any number of room stays until MRSA or VRE acquisition occurred.

We calculated the number of room stays involving the potential for MRSA and VRE acquisition. We then assessed the frequency at which eligible patients were exposed to rooms in which the prior occupants had MRSA-positive or VRE-positive status. To evaluate the association between a prior occupant with MRSA-positive or VRE-positive status and MRSA or VRE acquisition by the next occupant, we used generalized linear mixed models in baseline, intervention, and combined models. Models controlled for the collected variables described herein and accounted for clustering by ward.

RESULTS

A total of 8203 and 9449 patients had 11 528 and 13 359 ICU stays during baseline and intervention periods, respectively. After excluding carriers on ICU admission, the number of patients eligible for MRSA or VRE acquisition was 7629 and 7806 at baseline and 8716 and 8824 during the intervention, respectively. Patient characteristics are summarized in **Table 1**.

Overall, MRSA and VRE acquisition decreased when comparing intervention to baseline periods (Table 1). Acquisition fell from 3.0% (305 of 10 151) to 1.5% (182 of 11 849) for MRSA and from 3.0% (314 of 10 349) to 2.2% (256 of 11 871) for VRE ($P < .001$ for both). When evaluating acquisition by prior occupant status, patients in rooms previously occupied by MRSA carriers had an increased risk of acquisition during the baseline (3.9% vs 2.9%, $P = .03$) but not the intervention (1.5% vs 1.5%, $P = .79$) period. In contrast, patients in rooms previously occupied by VRE carriers had an increased risk of acquisition during the baseline (4.5% vs 2.8%, $P = .001$) and intervention (3.5% vs 2.0%, $P < .001$) periods.

In multivariate models evaluating predictors of acquisition, the presence of an MRSA-positive prior occupant predicted MRSA acquisition in baseline (odds ratio [OR], 1.4; $P = .04$) but not intervention (OR, 1.1; $P = .66$) models. In contrast, VRE acquisition remained associated with VRE-positive prior occupants in baseline (OR, 1.4; $P = .02$) and intervention (OR, 1.4; $P = .04$) models. **Table 2** lists other variables associ-

Table 2. Predictors of MRSA and VRE Acquisition

Model[a]	Odds Ratio (95% Confidence Interval)	*P* Value
MRSA		
Pre-ICU length of stay	1.2 (1.1-1.3)	<.001
Duration of room vacancy between occupants	0.9 (0.8-1.0)	.03
Age per decade increase	1.1 (1.0-1.2)	<.001
End-stage liver disease	1.8 (1.2-2.9)	.008
Prior occupant status and intervention interaction		
Baseline		
MRSA-negative	1 [Reference]	
MRSA-positive	1.3 (1.0-1.8)	.04
Intervention		
MRSA-negative	0.6 (0.5-0.7)	<.001
MRSA-positive	0.5 (0.3-0.8)	.006
VRE		
Pre-ICU length of stay	1.4 (1.3-1.6)	<.001
Age, in decades	1.1 (1.1-1.2)	<.001
Male sex	0.8 (0.7-1.0)	.05
Surgical ICU (vs medical)	0.5 (0.3-0.7)	<.001
Diabetes mellitus	1.3 (1.1-1.6)	.004
End-stage renal disease	1.5 (1.1-2.0)	.008
Hematologic malignant neoplasm	1.4 (1.0-1.8)	.04
Prior occupant status and intervention interaction		
Baseline		
VRE-negative	1 [Reference]	
VRE-positive	1.4 (1.0-1.8)	.04
Intervention		
VRE-negative	0.6 (0.5-0.8)	<.001
VRE-positive	0.9 (0.6-1.2)	.35

Abbreviations: See Table 1.

[a] Adjusted for age, sex, comorbidities, pre-ICU length of stay, prior occupant length of stay, duration of room vacancy before occupancy, and clustering by ICU ward. Measured comorbidities included diabetes mellitus, end-stage renal disease, end-stage liver disease, solid cancer, immunocompromised noncancer, and hematologic malignant neoplasm.

ated with MRSA and VRE acquisition.

COMMENT

The increased risk of MRSA and VRE acquisition attributable to the carrier status of prior room occupants, as previously observed by some of us,[1] led to an intervention that improved ICU cleaning and reduced MRSA and VRE room contamination.[2] The cleaning intervention significantly reduced overall MRSA acquisition by 49% and VRE acquisition by 29%. However, the cleaning intervention had differential effects on the risk of acquisition due to the positive carrier status of prior room occupants. It eliminated the increased acquisition risk from MRSA-positive prior occupants but did not erase the increased acquisition risk associated with VRE-positive prior occupants.

Whereas enhanced ICU cleaning appears to be effective in decreasing MRSA and VRE transmission, it may be more effective in reducing transmission of MRSA compared with VRE. Reasons for this difference may include the generally higher burden of VRE contamination and evidence that room contamination may be a major factor in VRE transmission.[5] Other authors[2,6] have found that 12% to 14% of rooms previously occupied by VRE carriers had residual contamination even after environmental cleaning. In addition, VRE contamination has been shown to persist through 3 standard room cleanings, even with bucket-based cloth-immersion cleaning.[7]

Study limitations include the lack of data regarding antibiotic use. Antibiotic exposure is associated with increased VRE shedding among carriers and increased VRE acquisition among patients exposed to carriers.[8,9] Nevertheless, these and other unmeasured factors are unlikely to be differentially distributed by prior occupant status. Bed and nursing assignments are made independent of prior occupant carrier status.

In summary, we show that enhanced ICU cleaning involving targeted feedback using a black-light marker, disinfectant-saturated cleaning cloths, and increased education regarding best-practice cleaning methods may reduce MRSA and VRE transmission and eliminate the risk of MRSA acquisition due to an MRSA-positive prior room occupant. Recent studies have particularly highlighted the black-light marker component of this campaign for its superior role in providing feedback compared with routine visual inspection.[3,10] However, additional studies are needed to evaluate the differential effect of enhanced cleaning on MRSA vs VRE. This may be particularly relevant for hospitals with high VRE prevalence where the burden of VRE con-

tamination may demand more rigorous cleaning methods.

Accepted for Publication: September 28, 2010.

Correspondence: Rupak Datta, MPH, Division of Infectious Diseases and Health Policy Research Institute, University of California Irvine School of Medicine, 100 Theory, Ste 110, Irvine, CA 92697 (rdatta@uci.edu).

Author Contributions: Mr Datta and Drs Yokoe and Huang had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Datta, Platt, and Huang. *Acquisition of data:* Datta, Yokoe, and Huang. *Analysis and interpretation of data:* Datta and Huang. *Drafting of the manuscript:* Datta. *Critical revision of the manuscript for important intellectual content:* Datta, Platt, Yokoe, and Huang. *Obtained funding:* Huang. *Administrative, technical, and material support:* Datta. *Study supervision:* Platt and Huang.

Financial Disclosure: None reported.

Funding/Support: This study was supported by grant K23AI64161 from the National Institutes of Health.

Role of the Sponsors: The funding agency had no role in the design or conduct of the study, the analysis of the data, or the preparation of the manuscript.

Previous Presentation: This study was presented at the 19th Annual Meeting of the Society for Healthcare Epidemiology of America; March 20, 2009; San Diego, California.

REFERENCES

1. Huang SS, Datta R, Platt R. Risk of acquiring antibiotic-resistant bacteria from prior room occupants. *Arch Intern Med*. 2006;166(18):1945-1951.
2. Goodman ER, Platt R, Bass R, Onderdonk AB, Yokoe DS, Huang SS. Impact of an environmental cleaning intervention on the presence of methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococci on surfaces in intensive care unit rooms. *Infect Control Hosp Epidemiol*. 2008;29(7):593-599.
3. Carling PC, Briggs JL, Perkins J, Highlander D. Improved cleaning of patient rooms using a new targeting method. *Clin Infect Dis*. 2006;42(3):385-388.
4. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections, 1988. *Am J Infect Control*. 1988;16(3):128-140.
5. Martínez JA, Ruthazer R, Hansjosten K, Barefoot L, Snydman DR. Role of environmental contamination as a risk factor for acquisition of vancomycin-resistant enterococci in patients treated in a medical intensive care unit. *Arch Intern Med*. 2003;163(16):1905-1912.
6. Hayden MK, Bonten MJ, Blom DW, Lyle EA, van de Vijver DAMC, Weinstein RA. Reduction in acquisition of vancomycin-resistant enterococcus after enforcement of routine environmental cleaning measures. *Clin Infect Dis*. 2006;42(11):1552-1560.
7. Byers KE, Durbin LJ, Simonton BM, Anglim AM, Adal KA, Farr BM. Disinfection of hospital rooms contaminated with vancomycin-resistant *Enterococcus faecium*. *Infect Control Hosp Epidemiol*. 1998;19(4):261-264.
8. Paterson DL, Muto CA, Ndirangu M, et al. Acquisition of rectal colonization by vancomycin-resistant *Enterococcus* among intensive care unit patients treated with piperacillin-tazobactam versus those receiving cefepime-containing antibiotic regimens. *Antimicrob Agents Chemother*. 2008;52(2):465-469.
9. D'Agata EMCD, Gautam S, Green WK, Tang Y-W. High rate of false-negative results of the rectal swab culture method in detection of gastrointestinal colonization with vancomycin-resistant enterococci. *Clin Infect Dis*. 2002;34(2):167-172.
10. Carling PC, Parry MF, Bruno-Murtha LA, Dick B. Improving environmental hygiene in 27 intensive care units to decrease multidrug-resistant bacterial transmission. *Crit Care Med*. 2010;38(4):1054-1059.