Emergency Department Environmental Contamination With Methicillin-Resistant *Staphylococcus aureus* After Care of Colonized Patients

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Study objective: Methicillin-resistant *Staphylococcus aureus* (MRSA) transmission dynamics in the emergency department (ED) are not well defined; environmental surfaces may serve as reservoirs for transmission. This study investigates the effect of patients with a history of MRSA colonization or infection on subsequent MRSA contamination of the ED environment.

Methods: Adult ED patients with evidence of an MRSA-positive surveillance result or clinical microbiologic culture in the year preceding their current ED visit were enrolled. Cultures from 5 anatomic sites were obtained to detect active MRSA colonization. After patients' discharge and before environmental disinfection, up to 16 prespecified surfaces in their ED rooms were cultured. Strain typing was performed by repetitive-sequence polymerase chain reaction on all recovered MRSA isolates to determine concordance with the corresponding patient strain.

Results: Of 42 patients enrolled, 25 (60%) remained colonized with MRSA. Nineteen of the 25 ED rooms (76%) occupied by MRSA-colonized patients contained greater than or equal to 1 MRSA-contaminated environmental surface on patient discharge. Surfaces were more likely to be contaminated when rooms were occupied by patients colonized with MRSA at 1 body site (odds ratio 11.7; 95% confidence interval 1.5 to 91.5) and greater than or equal to 2 body sites (odds ratio 16.3; 95% confidence interval 3.1 to 86.8) compared with noncolonized patients. In 16 of the 19 ED rooms (84%) where MRSA was recovered, all environmental strains were concordant with the corresponding patient strain.

Conclusion: Contamination of the ED environment with MRSA from actively colonized patients is common. Improved environmental surface disinfection may help reduce transmission of MRSA to ED health care professionals and patients during emergency care. [Ann Emerg Med. 2019;74:50-55.]

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INTRODUCTION

Background

Emergency departments (EDs) provide a range of health care services and account for more than half of US hospital admissions. High patient volume, close patient proximity, rapid turnover, and competing patient care demands present unique challenges to both infection prevention and environmental disinfection in EDs. Contamination of the health care environment with multidrug-resistant organisms from colonized or infected patients creates opportunities for transmission to health care professionals and other patients.[1] Up to 13.5% of patients seeking ED care are colonized with methicillin-resistant *Staphylococcus aureus* (MRSA), often at body sites other than the nares.[2,3] Existing literature provides evidence that colonized patients shed bacteria and contaminate environmental surfaces during hospital admissions.[4-6] In contrast, MRSA transmission dynamics in the ED environment, and on a strain-specific level, are less defined. This study sought to characterize MRSA transmission from patients with a history of colonization or infection to ED environmental surfaces by using molecular strain typing.[7] Additionally, we aimed to compare the prevalence of postencounter ED environmental surface contamination between patients with and without ongoing MRSA colonization, and determine whether an increased number of MRSA-colonized body sites is associated with greater likelihood of environmental contamination during emergency care.

Editor's Capsule Summary

What is already known on this topic

Health care professionals and patients can acquire resistant bacteria from contact with the hospital environment.

What question this study addressed

This study sought to determine the extent to which patients with a history of methicillin-resistant *Staphylococcus aureus* (MRSA) colonization or infection in the preceding year contaminated environmental surfaces during an emergency department (ED) encounter.

What this study adds to our knowledge

Of 42 patients enrolled, 25 (60%) remained colonized. The rate of surface contamination with MRSA was highly associated with the patient's MRSA colonization status (76% versus 18%), as well as the number of colonized patient body sites.

How this is relevant to clinical practice

Patients with a recent history of MRSA colonization or infection pose a high risk of contaminating ED environmental surfaces, underscoring the importance of appropriate environmental disinfection.

MATERIALS AND METHODS

This pilot study was conducted from June to October 2016 at Barnes-Jewish Hospital, an academic teaching hospital in St. Louis, MO, with a 70-bed ED that receives greater than or equal to 90,000 patient visits annually. Approval for this study was provided by the Washington University School of Medicine Human Research Protection Office. A convenience sample of ED patients aged 18 years or older with an MRSA-positive surveillance result (eg, nasal colonization detected during a previous hospitalization) or clinical microbiologic culture in the year preceding their ED visit were approached for participation by trained ED study coordinators. After informed consent, cultures were obtained from the anterior nares, oropharynx, hands, axillae, and inguinal folds of each patient to assess for MRSA colonization. After patient discharge and before environmental disinfection, up to 16 prespecified surfaces in their treatment rooms were cultured. Surfaces were categorized a priori by the research team as "patient related" (most likely touched by patients), "health care related" (most likely touched by health care professionals), and "environment related" (not specific to medical care and located along the periphery of the room) (Table).

Cultures were obtained by premoistened ESwab (ThermoFisher Scientific, Waltham, MA) to detect MRSA colonization. Swab transport medium was inoculated into tryptic soy broth with 6.5% sodium chloride (BBL; Becton Dickinson, Franklin Lakes, NJ) and incubated overnight at 35°C (95°C). Broth was then aliquoted to trypticase soy agar with 5% sheep blood (BBL; Becton Dickinson) and incubated overnight. Samples yielding *S aureus* (determined by colony morphology, latex agglutination assay, catalase production, and Gram's stain) were tested for antibiotic susceptibility by Kirby-Bauer disk diffusion according to Clinical and Laboratory Standards Institute guidelines. All recovered MRSA isolates were analyzed for strain typing by repetitive-sequence polymerase chain reaction to determine concordance between recovered isolates as previously described.[7,8]

Fisher's exact and Cochran-Mantel-Haenszel tests examined the relationship between patient MRSA colonization and environmental MRSA contamination by surface type. Logistic regression analysis evaluated the association between the number of MRSA-colonized body sites and environmental contamination. Kruskal-Wallis tests examined the relationship between the number of MRSA-colonized body sites and the median number of MRSA-contaminated environmental surfaces, and between environmental contamination and median time spent in the ED room before surface sampling and since last MRSA culture. All tests of significance were 2 tailed. Data were analyzed with SPSS (version 24; IBM SPSS, Chicago, IL).

RESULTS

Of 72 patients approached to participate in the study on ED presentation, 42 with either previous MRSA colonization (N=9) or previous MRSA infection (N=33) were enrolled. Participants were 60% black (40% white) and 50% women; the mean age was 45 years (range 22 to 82 years). The median time since last positive MRSA culture result was 53 days (range 31 to 220 days).

Of 42 patients, 25 (60%) were MRSA colonized at greater than or equal to 1 body site (median 2 sites; range 1 to 5 sites), most often in the nares (48%), followed by the inguinal folds (37%), oropharynx (32%), hands (24%), and axillae (24%). The median time patients spent in their room before environmental sampling was 244 minutes (range 189 to 318 minutes).

Overall, greater than or equal to 1 environmental surface was MRSA contaminated in 22 rooms (52%). The stretcher rail (20%), pillow or bedsheet (17%), and

Table. Relationship between patient MRSA colonization and environmental surface MRSA contamination.

	Environmental Surface Contamination				
Environmental Surface	**All Patients, n=42 (%)**	**Patients Colonized With MRSA, n=25 (%)**	**Patient-Concordant MRSA, n=25 (%)**	**Patients Not Colonized With MRSA, n=17 (%)**	**Odds Ratio* (95% CI)**
Any environmental surface†	22 (52)	19 (76)	18 (72)	3 (18)	14.8 (3.1–69.5)
Patient related‡	14 (33)	13 (52)	13 (52)	1 (6)	17.3 (2.0–151.4)
Telephone (n=36)	4 (11)	4 (19)	4 (19)	0	
Call light (n=40)	3 (8)	3 (13)	3 (13)	0	
Stretcher mattress (n=40)	3 (8)	3 (13)	3 (13)	0	
Stretcher rail (n=40)	8 (20)	8 (33)	7 (29)	0	
TV remote (n=31)	2 (7)	2 (12)	2 (12)	0	
Pillow/bedsheet (n=41)	7 (17)	6 (25)	6 (25)	1 (6)	
Health care related§	11 (26)	9 (36)	7 (28)	2 (12)	4.2 (0.8–22.8)
Procedure light handle (n=39)	4 (10)	4 (16)	3 (12)	0	
Mouse (n=42)	5 (12)	4 (16)	3 (12)	1 (6)	
Keyboard (n=41)	3 (7)	2 (8)	2 (8)	1 (6)	
Scanner (n=42)	4 (10)	4 (16)	3 (12)	0	
Blood tube drawer (n=42)	2 (5)	2 (8)	2 (8)	0	
Thermometer (n=41)	3 (7)	3 (13)	3 (13)	0	
Monitor (n=41)	3 (7)	3 (13)	2 (8)	0	
Environment related‖	7 (17)	7 (28)	6 (24)	0	NA¶
Sink handle (n=42)	4 (10)	4 (16)	3 (12)	0	
Light switch (n=42)	3 (7)	3 (12)	3 (12)	0	
Interior door handle (n=34)	3 (9)	3 (16)	2 (11)	0	

CI, Confidence interval; *NA*, not applicable.
Odds ratios and CIs were determined with Cochran-Mantel-Haenszel tests. The denominator of the environmental surfaces varied because of differing surface availability in each room.
*Comparison made between patients colonized with MRSA and patients not colonized with MRSA.
†Any environmental surface: contamination at any of the patient-, health care–, or environment-related surfaces.
‡Patient related: surfaces in closest proximity to the patient and most likely to be touched by him or her during the ED visit.
§Health care related: surfaces that a health care provider would most likely touch in the course of providing patient care.
‖Environment related: surfaces not specific to medical care and located along the periphery of the ED treatment room.
¶Odds ratio and CI could not be calculated for environment-related surfaces because some cells were 0; $P=.03$ for this category by Fisher's exact test.

computer mouse (12%) were the most commonly MRSA-contaminated surfaces. MRSA was recovered from greater than or equal to 1 patient-related surface in 14 ED rooms (33%), greater than or equal to 1 health care-related surface in 11 ED rooms (26%), and greater than or equal to 1 environment-related surface in 7 ED rooms (17%).

MRSA was more likely to be recovered from ED environmental surfaces in rooms occupied by MRSA-colonized patients compared with noncolonized patients (Table), particularly from patient- and environment-related surfaces. Among the 25 ED rooms occupied by MRSA-colonized patients, on discharge, 19 (76%) contained at least 1 surface contaminated with MRSA (median 1 surface; range 1 to 12 surfaces) compared with 3 contaminated rooms (18%) of 17 noncolonized participants (each at 1 surface). The number of MRSA-colonized body sites affected the likelihood of MRSA recovery from ED environmental surfaces; compared with that for noncolonized patients, the odds ratio for surface contamination was 11.7 (95% confidence interval 1.5 to 91.5) among those colonized with MRSA at 1 body site and 16.3 (95% confidence interval 3.1 to 86.8) among those colonized at greater than or equal to 2 body sites. Furthermore, increasing number of MRSA-colonized body sites appeared to be associated with an increase in the median number of MRSA-contaminated environmental surfaces (Figure).

Neither time since last MRSA-positive culture result nor time spent in the ED room was significantly associated with environmental contamination. Neither current colonization nor environmental contamination was influenced by whether the patient was previously colonized versus infected.

Of 132 total MRSA isolates recovered, 10 unique strains were identified (by repetitive-sequence polymerase chain

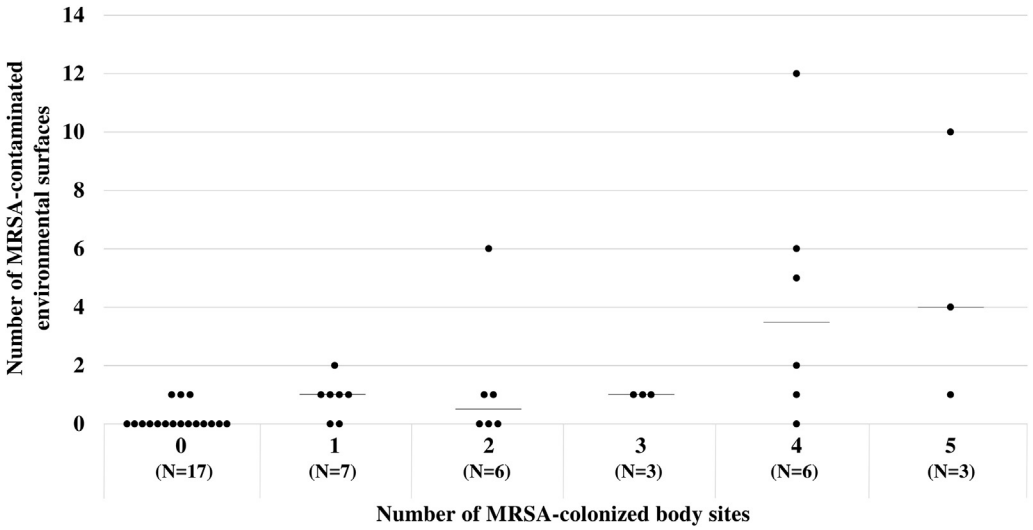

Figure. Association between increasing number of MRSA-colonized body sites and number of MRSA-contaminated environmental surfaces. Black lines represent median number of MRSA-contaminated environmental surfaces. Overlapping points are jittered along the x axis, with each point representing one study participant.

reaction). In 18 of 19 rooms (95%) in which MRSA was recovered from the patient and environment, at least 1 environmental surface was contaminated with a patient-concordant strain; all environmental strains were concordant with a corresponding patient strain in 16 of 19 rooms (84%). Overall, 51 of 61 MRSA-contaminated environmental surfaces (84%) were contaminated with patient-concordant strains; concordance was highest (93%) from environmental surfaces classified as patient related.

LIMITATIONS

This pilot study has several limitations. First, our sample size was limited because not all patients with a history of colonization or infection with MRSA in the past year remained colonized at their ED visit. The small number of MRSA-positive patients studied may limit the generalizability of our findings. Second, this was a single-center study performed in an academic urban ED that may not be representative of all EDs, particularly in terms of patient population served, patient volume, and community prevalence of MRSA. Third, environmental cultures were uniformly obtained at the end of the ED visit (without sampling of the room before admission), irrespective of patient time spent in the room, patient acuity, or nature of medical care received. It is plausible that longer ED visits would have allowed more opportunities for colonized patients to interact with and contaminate environmental surfaces, although in our analysis, length of time in the room was not associated with the likelihood of MRSA environmental contamination. Likewise, higher-acuity patients requiring invasive procedures, wound care, or more frequent interactions with health care professionals could have been at greater risk of contaminating the environment with MRSA. In addition, health care professionals and patient visitors were not able to be sampled for MRSA colonization. It is possible that these unmeasured factors influenced the frequency with which MRSA environmental contamination was observed. Fourth, although we sampled 5 body sites and 16 environmental surfaces for MRSA colonization, our culture methods were not quantitative, so the burden of MRSA at body sites and environmental surfaces was not determined.

DISCUSSION

MRSA was recovered from 60% of patients seeking ED care up to a year after previous detection. A previous study reported that 49% of patients remained MRSA colonized in the year after a positive culture result.[9] We demonstrated that MRSA-colonized patients were more likely to contaminate their health care environments than those without MRSA colonization. Furthermore, an increase in the number of MRSA-colonized body sites appeared to be associated with an increase in the number of MRSA-contaminated environmental surfaces. This effect was significant for patient- and environment-related surfaces, but not health care–related ones (eg, computer keyboard, computer mouse). In the latter case, it is possible that those surfaces rarely come in direct contact with patients during ED care.

Contamination of the health care environment with MRSA and other multidrug-resistant organisms poses a transmission risk to health care professionals and other

patients. Although transmission of health care–associated pathogens, including MRSA, most commonly occurs through health care professionals' hands, contaminated hospital surfaces also play a significant role.[10] MRSA contamination by health care professionals' hands is equally likely after contact with colonized patients' skin and commonly touched environmental surfaces in patients' rooms.[4] Health care–related surfaces were contaminated with MRSA in 2 rooms occupied by patients not colonized with MRSA. This finding highlights the need for health care professional hand hygiene and health care equipment disinfection in all ED rooms, not just those occupied by patients with suspected or known colonization with a multidrug-resistant organism.

Risk of multidrug-resistant organism transmission is particularly high when compliance with infection prevention strategies is suboptimal. Up to 19% of routine ICU patient interactions result in health care professional MRSA contamination.[5] Inadequate environmental disinfection further increases opportunities for health care professional hand contamination. Environmental surfaces with growth of multidrug-resistant organisms on culture have been associated with a 4-fold elevated risk of multidrug-resistant organism contamination of health care professional gloves and gowns.[6] Compounded by variable hand hygiene and glove use in EDs, this could lead to increased transmission of multidrug-resistant organisms to other patients. Although little is known about the efficacy of ED environmental disinfection, one study showed that less than half of all ICU surfaces are cleaned during terminal disinfection.[11] Moreover, admission to a room previously occupied by a patient with a multidrug-resistant organism is associated with an increased likelihood of multidrug-resistant organism acquisition (3-fold for MRSA) by the secondary patient, likely facilitated by environmental contamination.[12]

The present study addresses an important gap in current research concerning environmental transmission dynamics of MRSA in EDs. Exploration of these dynamics is strengthened by sample collection before environmental disinfection, sampling of 5 body sites for colonization, and inclusion of molecular strain typing by a highly discriminatory methodology. The degree to which the ED environment contributes to MRSA transmission is influenced by the extent of surface contamination in rooms occupied by colonized patients. Identification of frequently contaminated surfaces can aid development of disinfection protocols tailored to EDs. Because contact isolation and hand hygiene compliance may vary in EDs, addressing MRSA contamination through improved environmental disinfection may help reduce transmission of MRSA to health care professionals and patients alike. Likewise, chlorhexidine bathing and other MRSA decolonization strategies may have a role in reducing environmental contamination and health care–associated infections in the emergency care setting and are deserving of further investigation.

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Author contributions: SYL, PGH, SLH, and SAF conceived and designed the study. SYL and SAF obtained research funding. SYL, SLH, and SAF supervised the conduct of the study, data collection, and patient recruitment. TWR, MLS, and CEM performed microbiologic culture, antibiotic susceptibility, strain typing, and managed the data, including quality control. DRJ, PGH, and SM provided statistical advice on study design and analyzed the data. SYL and DRJ drafted the manuscript, and all authors contributed substantially to its revision. SYL takes responsibility for the paper as a whole.

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