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Emergency department environmental contamination with methicillin-resistant *Staphylococcus aureus* following care of colonized patients

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Abstract

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 investigated the impact 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 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 patient discharge and prior to environmental disinfection, up to 16 pre-specified surfaces in their ED rooms were cultured. Strain typing was performed by repetitive-sequence PCR 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 (76%) ED rooms occupied by MRSA-colonized patients contained 1 MRSA-contaminated environmental surface upon discharge. Surfaces were more likely to be contaminated when rooms were occupied by patients colonized with MRSA at 1 body site (odds ratio [OR], 11.7; 95% CI, 1.5–91.5) and 2 body sites (OR, 16.3; 95% CI, 3.1–86.8) compared to non-colonized patients. In 16 of the 19 (84%) ED rooms where MRSA was recovered, all environmental strains were concordant with the corresponding patient strain.

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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 healthcare professionals and patients during emergency care.

Keywords

emergency department; methicillin-resistant *Staphylococcus aureus*; environmental contamination

Background

Emergency departments (EDs) provide a range of healthcare services and account for over half of U.S. 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 healthcare environment with multidrug-resistant organisms (MDROs) from colonized or infected patients creates opportunities for transmission to healthcare professionals (HCP) 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 prior history of colonization or infection to ED environmental surfaces using molecular strain typing.[7] Additionally, we aimed to compare the prevalence of post-encounter 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.

Methods

This pilot study was conducted from June–October 2016 at Barnes-Jewish Hospital, an academic teaching hospital in St. Louis, Missouri, with a 70-bed ED that receives 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 18 years of age with an MRSA-positive surveillance (e.g., nasal colonization detected during prior hospitalization) or clinical microbiological culture in the year preceding their ED visit were approached for participation by trained ED study coordinators. Upon 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 prior to environmental disinfection, up to 16 pre-specified surfaces in their treatment rooms were cultured. Surfaces were categorized *a priori* by the research team as “patient-related” (most likely touched by patients), “healthcare-related” (most likely touched by HCPs), and “environment-related” (not specific to medical care and located along the periphery of the room) (Table 1).

Cultures were obtained via pre-moistened ESwab (ThermoFisher Scientific, Waltham, MA) to detect MRSA colonization. Swab transport media was inoculated into tryptic soy broth with 6.5% sodium chloride (BBL, Becton Dickinson [BD], Franklin Lakes, NJ) and incubated overnight at 35°C. Broth was then aliquoted to trypticase soy agar with 5% sheep blood (BBL, BD) and incubated overnight. Samples yielding *S. aureus* (determined by colony morphology, latex agglutination assay, catalase production, and Gram 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 PCR (repPCR) 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 prior to surface sampling and since last MRSA culture. All tests of significance were two-tailed. Data were analyzed using SPSS v24 for Windows (IBM SPSS; Chicago, IL).

Results

Of 72 patients approached to participate in the study upon ED presentation, 42 with either prior MRSA colonization (N=9) or prior MRSA infection (N=33) were enrolled. Participants were 60% African-American (40% Caucasian) and 50% female; the mean age was 45 years (range, 22–82). The median time since last positive MRSA culture was 53 days (range, 31–220).

Of 42 patients, 25 (60%) were MRSA-colonized at 1 body site (median, 2 sites; range, 1–5); 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, 189–318).

Overall, 1 environmental surface was MRSA-contaminated in 22 (52%) rooms. The stretcher rail (20%), pillow/bedsheet (17%), and computer mouse (12%) were the most commonly MRSA-contaminated surfaces. MRSA was recovered from 1 patient-related surface(s) in 14 (33%), healthcare-related surface(s) in 11 (26%), and environment-related surface(s) in 7 (17%) ED rooms.

MRSA was more likely to be recovered from ED environmental surfaces in rooms occupied by MRSA-colonized patients compared to non-colonized patients (Table 1), particularly from patient-related and environment-related surfaces. Among the 25 ED rooms occupied by MRSA-colonized patients, upon discharge, 19 (76%) contained at least one surface contaminated with MRSA (median, 1 surface; range, 1–12) compared to 3 (18%) contaminated rooms of 17 non-colonized participants (each at 1 surface). The number of

MRSA-colonized body sites impacted the likelihood of MRSA recovery from ED environmental surfaces; compared to non-colonized patients, the odds ratio (OR) for surface contamination was 11.7 (95% CI, 1.5–91.5) among those colonized with MRSA at 1 body site and 16.3 (95% CI, 3.186.8) among those colonized at 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 1).

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

Of 132 total MRSA isolates recovered, 10 unique strains were identified (by repPCR). In 18 of 19 (95%) rooms in which MRSA was recovered from the patient and environment, at least one environmental surface was contaminated with a patient-concordant strain; all environmental strains were concordant with a corresponding patient strain in 16 of 19 (84%) rooms. Overall, 51 of 61 (84%) MRSA-contaminated environmental surfaces 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 as not all patients with a history of colonization or infection with MRSA in the past year remained colonized at the time of their current 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 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 could 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 HCPs could have been at greater risk of contaminating the environment with MRSA. In addition, HCPs and patient visitors were not able to be sampled for MRSA colonization. It is possible that these unmeasured factors could have influenced the frequency with which MRSA environmental contamination was observed. Finally, while 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

Presently, MRSA was recovered from 60% of patients seeking ED care, up to a year after prior detection. A previous study reported 49% of patients remained MRSA-colonized in the

year following a positive culture.[9] We demonstrated that MRSA-colonized patients were more likely to contaminate their healthcare environments than those without MRSA colonization. Further, increasing 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-related surfaces and environment-related surfaces, but not healthcare-related surfaces (e.g., computer keyboard and mouse). In the latter case, it is possible that those surfaces rarely come in direct contact with patients during ED care.

Contamination of the healthcare environment with MRSA and other MDROs poses a transmission risk to HCPs and other patients. While transmission of healthcare-associated pathogens, including MRSA, most commonly occurs via HCP hands, contaminated hospital surfaces also play a significant role.[10] HCP MRSA hand contamination is equally likely following contact with colonized patients' skin and commonly touched environmental surfaces in patients' rooms.[4] Healthcare-related surfaces were contaminated with MRSA in two rooms occupied by non-MRSA-colonized patients. This finding highlights the need for HCP hand hygiene and healthcare equipment disinfection in all ED rooms, not just those with patients suspected or known to be colonized with an MDRO.

Risk of MDRO transmission is particularly high when compliance with infection prevention strategies is suboptimal. Up to 19% of routine intensive care unit (ICU) patient interactions result in HCP MRSA contamination.[5] Inadequate environmental disinfection further increases opportunities for HCP hand contamination. Positive environmental cultures have been associated with a four-fold elevated risk of MDRO contamination of HCP gloves and gowns.[6] Compounded by variable hand hygiene and glove use in EDs, this could lead to increased transmission of MDROs to other patients. While little is known about the efficacy of ED environmental disinfection, one study showed that fewer than half of all ICU surfaces are cleaned during terminal disinfection.[11] Moreover, admission to a room previously occupied by a patient with an MDRO is associated with an increased likelihood of MDRO acquisition (threefold 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 five body sites for colonization, and inclusion of molecular strain typing via 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. As contact isolation and hand hygiene compliance may vary in EDs, addressing MRSA contamination through improved environmental disinfection may help reduce transmission of MRSA to HCPs and patients alike. Likewise, chlorhexidine bathing and other MRSA decolonization strategies may have a role in reducing environmental contamination and healthcare-associated infections in the emergency care setting and are deserving of further investigation.

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Figure 1.

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.

Table 1.

Relationship between patient MRSA colonization and environmental surface MRSA contamination

Environmental surface	Environmental Surface Contamination				Odds ratio* (95% CI)
	All patients n=42 (%)	Patients colonized with MRSA n=25 (%)	Patient concordant MRSA n=25 (%)	Patients not colonized with MRSA n=17 (%)	
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 (0)	
Call light (n=40)	3 (8)	3 (13)	3 (13)	0 (0)	
Stretcher mattress (n=40)	3 (8)	3 (13)	3 (13)	0 (0)	
Stretcher rail (n=40)	8 (20)	8 (33)	7 (29)	0 (0)	
TV remote (n=31)	2 (7)	2 (12)	2 (12)	0 (0)	
Pillow/bedsheet (n=41)	7 (17)	6 (25)	6 (25)	1 (6)	
Healthcare-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 (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 (0)	
Blood tube drawer (n=42)	2 (5)	2 (8)	2 (8)	0 (0)	
Thermometer (n=41)	3 (7)	3 (13)	3 (13)	0 (0)	
Monitor (n=41)	3 (7)	3 (13)	2 (8)	0 (0)	
Environment-related	7 (17)	7 (28)	6 (24)	0 (0)	N/A [¶]
Sink handle (n=42)	4 (10)	4 (16)	3 (12)	0 (0)	
Light switch (n=42)	3 (7)	3 (12)	3 (12)	0 (0)	
Interior door handle (n=34)	3 (9)	3 (16)	2 (11)	0 (0)	

NOTE. MRSA, methicillin-resistant *Staphylococcus aureus*; %, column percentages; Odds ratios and confidence intervals (CI) were determined using Cochran-Mantel-Haenszel tests; Denominator of environmental surfaces varied due to 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-related, healthcare-related, or environment-related surfaces

[‡] Patient-related: surfaces in closest proximity to the patient and most likely to be touched by the patient during their ED visit

[§] Healthcare-related: surfaces that a healthcare 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 confidence interval could not be calculated for environment-related surfaces as some cells are 0; p=0.03 for this category by Fisher's exact test.