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Multidrug-resistant Organisms in Hospitals: What Is on Patient Hands and in Their Rooms?

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Background. The impact of healthcare personnel hand contamination in multidrug-resistant organism (MDRO) transmission is important and well studied; however, the role of patient hand contamination needs to be characterized further.

Methods. Patients from 2 hospitals in southeast Michigan were recruited within 24 hours of arrival to their room and followed prospectively using microbial surveillance of nares, dominant hand, and 6 high-touch environmental surfaces. Sampling was performed on admission, days 3 and 7, and weekly until discharge. Paired samples of methicillin-resistant *Staphylococcus aureus* (MRSA) isolated from the patients' hand and room surfaces were evaluated for relatedness using pulsed-field gel electrophoresis and staphylococcal cassette chromosome *mec*, and Panton-Valentine leukocidin typing.

Results. A total of 399 patients (mean age, 60.8 years; 49% male) were enrolled and followed for 710 visits. Fourteen percent (n = 56/399) of patients were colonized with an MDRO at baseline; 10% (40/399) had an MDRO on their hands. Twenty-nine percent of rooms harbored an MDRO. Six percent (14/225 patients with at least 2 visits) newly acquired an MDRO on their hands during their stay. New MDRO acquisition in patients occurred at a rate of 24.6/1000 patient-days, and in rooms at a rate of 58.6/1000 patient-days. Typing demonstrated a high correlation between MRSA on patient hands and room surfaces.

Conclusions. Our data suggest that patient hand contamination with MDROs is common and correlates with contamination on high-touch room surfaces. Patient hand hygiene protocols should be considered to reduce transmission of pathogens and healthcare-associated infections.

Keywords. acute care hospitals; multidrug-resistant organisms; colonization; contamination; new acquisition.

Healthcare-associated infections are common, costly, and potentially lethal [1]. Appropriate hand hygiene for healthcare personnel (HCP) is widely recognized as an important approach for preventing infections in hospitalized patients [2, 3]. However, the importance of patient hand hygiene has been recognized only recently [4–7]. Early evidence suggests that this is a missed opportunity for infection reduction and prevention [7]. For example, in a US study of 100 hospitalized patients, 39% of patients' hands were contaminated with pathogens at ≥48 hours after admission [6]. Another recent study from post–acute care facilities reported that 1 in 4 recently hospitalized patients had at least 1 multidrug-resistant organism (MDRO) on their hands, suggesting that patient hand contamination with MDROs is common [7].

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High-touch surfaces in patient rooms, such as bed controls, call buttons, and bedside tray tables, represent a critically important MDRO reservoir [8, 9]. MDROs, including vancomycin-resistant enterococci (VRE), methicillin-resistant *Staphylococcus aureus* (MRSA), and resistant gram-negative bacilli (RGNB), are frequently shed by patients and staff, whereupon they contaminate surfaces for days, increasing the risk of acquisition by other patients, visitors, and hospital staff that come in contact with these surfaces [9–13].

Compared to other anatomic sites, patients' hands are likely to come in contact with high-touch surfaces, HCP, visitors, and other patients, increasing the risk of pathogen transmission. Therefore, we sought to characterize MDRO contamination on patients' hands and the high-touch surfaces in their rooms in hospital settings. The main objectives were to determine (1) the prevalence of MDROs on patients' hands and in their rooms within the first 24 hours of room arrival; (2) the rate of new acquisition of MDROs on patients' hands and on the high-touch surfaces in their rooms; and (3) the similarity between patients' hand contamination and high-touch room surface contamination. This information is necessary for the development,

evaluation, and implementation of effective patient hand hygiene programs in hospitals.

METHODS

Study Population and Design

This study, conducted between February and July 2017, was an observational, prospective cohort study targeting newly admitted hospitalized patients (within 24 hours of arrival to their room). General medicine patients at 2 hospitals in southeast Michigan were enrolled and followed prospectively to evaluate baseline colonization, high-touch surface contamination, and new acquisition of MDROs. The study was approved by the institutional review boards at both institutions. Informed consent to collect surveillance samples and patient-specific data were obtained from each patient or their durable power of attorney.

The inclusion criteria included any patient: (1) newly admitted to participating hospital units—that is, general medicine floors (within 24 hours of admission to their room); and (2) at least 18 years of age. Exclusion criteria included any patient (1) under observation status, generally after a procedure; (2) transferred from another hospital; (3) with cystic fibrosis (due to their high likelihood of MDRO colonization); (4) receiving end-of-life care; (5) non-English speaking; or (6) transferred from an intensive care unit. If an enrolled patient was moved to a new room on a nonparticipating floor, he or she was discharged from the study.

Data Collection

Chart reviews were conducted and data collection sheets completed by trained research staff at each study visit on admission, hospital days 3 and 7, and weekly thereafter. A visit was defined as a patient interaction where clinical data and cultures from the patient and the patient's room were collected. Baseline demographic data were obtained from the patient's admission documentation, including age, sex, height, weight, race, admitting location, history of MDROs, admission diagnosis, Charlson comorbidity score [14], and dependence in activities of daily living (ADL) score [15, 16]. In addition to medical records, patient history of MDRO presence was obtained from clinical laboratory results within the past 90 days. Clinical data collected at each visit included diagnostic testing results (urine, sputum, blood, and wound cultures obtained during hospitalization), presence of an infection, antibiotic use, device use, presence of an open wound(s), and use of isolation precautions. Clinical infection was defined as the presence of infection by physician documentation and receipt of oral or parenteral systemic antibiotics. At the time of study discharge, we documented the discharge disposition as (1) discharged home; (2) discharged to skilled nursing facility; (3) discharged to another unit; (4) discharged at the patient's or family's request; or (5) other disposition, including hospice care or leaving the hospital against medical advice. Both hospitals have comprehensive infection prevention programs (Supplementary Materials).

Microbiologic Methods

Trained research staff swabbed the palm, fingers, and around nails of the dominant hand of enrolled patients, as well as the interior of the nares of both nostrils [7]. Samples were also collected from 6 high-touch surfaces in the patients' rooms: (1) bed control/bed rail; (2) call button/television remote; (3) bedside tray table top; (4) phone; (5) toilet seat; and (6) bathroom door knob. If roommates were enrolled and cultured on the same day (n = 10 visits), the toilet seat and bathroom door knob samples were collected once. Hospital A personnel also obtained perianal cultures from a subset of patients to correlate MDRO colonization with clinical cultures. Microbiological samples were collected at study enrollment (within 24 hours of the patient's arrival to their room), day 3, day 7, and weekly until hospital discharge, at which time a discharge set of cultures was obtained when possible. Premoistened Culturette swabs (Remel, Lenexa, Kansas) were used to obtain the high-touch room surface samples, applying the swab to a 5- × 20-cm area of each site. All samples were tested using standard microbiological methods by the research team. Enrolled patients were not cohorted based on study findings.

Additionally, we were interested in uncovering whether MRSA strains on patient hands were related to those found in the patient's room at the same visit. Thus, we performed molecular typing on patient hand and room surface MRSA isolates from both hospitals using pulsed-field gel electrophoresis (PFGE) and polymerase chain reaction (PCR)–based typing (for additional details, see Supplementary Materials) [17–20].

Statistical Analyses

The main outcomes of interest were baseline prevalence and incidence rates of acquisition of MDROs on patients' hands and on high-touch room surfaces. To assess MDRO presence on patient recruitment, data from all patients were used (n = 399; Supplementary Materials) [21, 22]. To estimate the incidence of MDRO acquisition during hospitalization, the analysis was limited to patients with at least 2 study visits (n = 225). To define new acquisition (per 1000 patient-days), we excluded patients colonized at baseline enrollment with that organism. For example, to define new MRSA acquisition, we excluded patients who were colonized with MRSA at enrollment. To define rates of new MDRO acquisition, we excluded patients colonized at enrollment with all 3 MDROs. At each patient or room surface site, we counted at-risk days from the baseline visit to the first visit in which we found a resistant pathogen or until the discharge visit. Data were analyzed using SAS version 9.4 (SAS Institute, Cary, North Carolina) and Stata version 13.0 (StataCorp, College Station, Texas) software.

RESULTS

Baseline Characteristics

A total of 399 of 524 (76%) eligible patients were enrolled and followed for 710 visits (flowchart, Supplementary Figure 1). The baseline demographics of the patients are shown in Table 1. The mean age was 60.8 years (standard deviation, 16.8 years). Forty-nine percent were male; 64.4% identified as white and 25.3% identified as African American. A majority (80.5%) of patients had at least 1 comorbidity at baseline and 25% were dependent in at least 1 ADL. Baseline characteristics among patients dependent in at least 1 ADL vs patients completely independent are shown in Supplementary Table 1. There were no deaths among our subjects during the study period.

Patient and Room Surface Contamination With MDRO at Enrollment

Fourteen percent (56/399) of patients were colonized with an MDRO at baseline. Ten percent (40/399) had an MDRO on their hands, 7.5% (30/399) in their nares, and 3.5% (14/399) on both. Among those colonized with an MDRO, 57% (32/56) harbored MRSA, 36% (20/56) RGNB, and 14% (8/56) VRE. Perianal cultures were obtained from 41 patients at hospital A at the time of study enrollment; 7% (n = 3) of patients cultured at the perianal area were positive for VRE and 7% (n = 3) were positive for RGNB. Of the 56 patients colonized with an MDRO at enrollment, 11 (20%) had a history of MDRO colonization or infection (5 of whom were colonized with the same MDRO he or she had a reported history of—ie, 4 with MRSA, 1 with RGNB).

Twenty-nine percent (n = 115) of the sampled surfaces of patient rooms were contaminated with an MDRO at baseline (Figure 1). Fifteen percent of these surfaces were contaminated with RGNB, 8.5% with MRSA, and 8% with VRE. Hospitals A and B varied with regard to the types of MDROs identified. The most prevalent MDROs at hospital A were VRE (11%, n = 22), followed by MRSA (8%) and RGNB (1.5%); the most prevalent MDROs at hospital B were RGNB (29%, n = 57), followed by MRSA (9%) and VRE (5%). See Supplementary Table 2 for the most common RGNBs found on enrolled patients and room surfaces.

Hand Carriage of MDROs at Enrollment and During Follow-up

At baseline, 10% of patients' dominant hands were contaminated with an MDRO; 5% with MRSA, 3.5% with RGNB, and 2% with VRE. Of the 5% (n = 20 patients) with MRSA contamination on the hand, 10 (50%) were concurrently colonized at the nares. MRSA contamination at baseline remained persistent in 6 (30%) patients and transient in 14 (70%) patients. An additional 6.2% (n = 14) of 225 patients with a follow-up visit acquired a new MDRO on their hands (Figure 1). Of interest, we observed a stepwise increase in MDRO contamination in patients and room surfaces as the number of hours in the room prior to enrollment and baseline sampling increased (Figure 2).

We were particularly interested in correlation between clinical infection and colonization with an MDRO on patients' anatomic sites, in particular their dominant hands. Six study patients had an MRSA-positive clinical culture (3 wounds, 1 blood, 1 urine, and 1 sputum) during the study. Of these, MRSA was detected either from the patient's sample or the room sample 100% of the time (4/6 patient dominant hands, 2/6 patient nares, 1/6 patient hand and nares, 4/6 patient room). No VRE was detected in clinical cultures. Of the 84 total perianal cultures collected from 42 patients at hospital A, no colonization results correlated with clinical culture results.

To estimate the patient acquisition rates of a new MDRO, the analysis included 225 patients with >1 study visit (148 at hospital A, 77 at hospital B) (536 total sampling visits). At hospital A, 10.1% (n = 15/148) of patients acquired an MDRO during follow-up, for a rate of 29.0/1000 patient-days (Table 2). At hospital B, 7.8% (n = 6/77) of patients acquired an MDRO during follow-up, for a rate of 17.8/1000 patient-days. The median time to new colonization with MRSA, VRE, or RGNB was 11, 7, and 3 days, respectively (Supplementary Figure 2).

Similarity Between Patient Hand Contamination and Room Surface Contamination

The room surfaces of patients were contaminated with MRSA, RGNB, and VRE at 9.2%, 13.2%, and 9.7% of visits, respectively. Patient hands were colonized with MRSA at 5% of the sampling study visits, RGNB at 3.0%, and VRE at 2.5% of visits. In 10% (73/710) of sampling visits, patients and their room surfaces were concurrently colonized with an MDRO (ie, patient and environment samples were positive for the same MDRO on the same sampling visit). Hand contamination with MRSA and VRE were each associated with contamination of the patient's high-touch room surfaces by the same organism (Table 3). For example, of 35 visits where patient hands were colonized with MRSA, 71.4% of patient rooms were also contaminated with MRSA (Table 3). MRSA was not detected in the patient's room in 94.1% of visits when MRSA was not found on hands ($P < .001$). To confirm this finding, we typed 118 MRSA isolates from all 25 visits where MRSA was recovered from *both* the patient's dominant hand and at least 1 room surface at the same visit. At hospital A, all 15 visits (n = 9 patients) showed matching MRSA strains (≥90% in 14 visits, 86% in 1 visit using Dice criteria for PFGE and PCR typing [19]) between the hand sample and at least 1 environmental site. At hospital B, 9 of the 10 visits (n = 7 patients) showed matching MRSA strains (100% similarity). One such case in which the same MRSA strain was on the patient and in the patient's room is shown in Supplementary Figure 3. The single visit that did not show 100% similarity between MRSA strains included a USA300 from both the patient hand and room surface at enrollment and a USA800 on the patient hand at a subsequent visit.

DISCUSSION

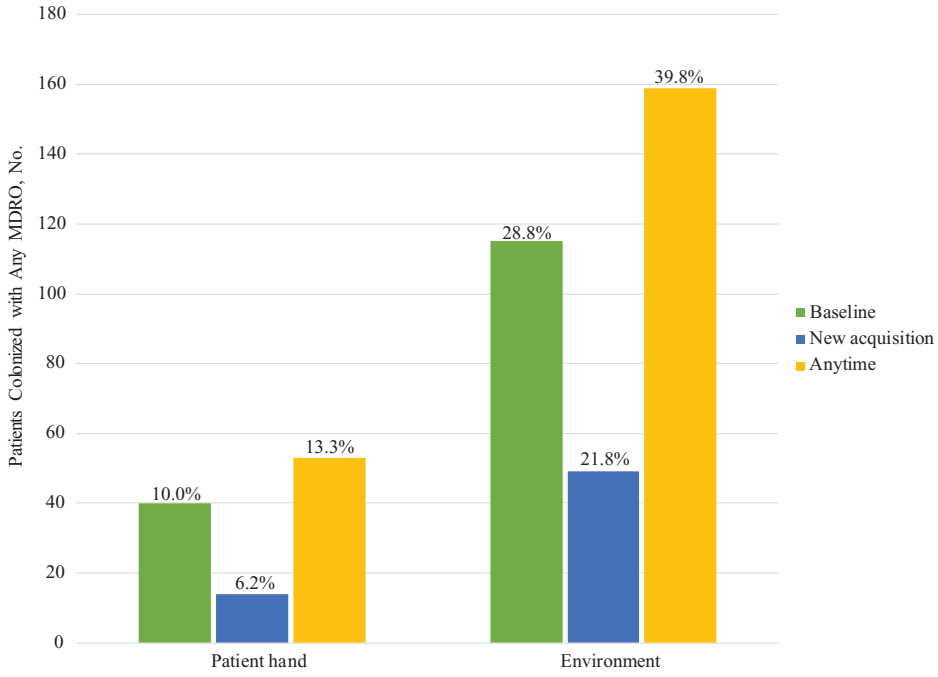
For more than a century, hand hygiene research, resources, and promotion have almost exclusively focused on improving HCP

Table 1. Baseline Characteristics of Patients

Characteristic	All Patients (N = 399)	Hospital A (n = 200)	Hospital B (n = 199)
Age, mean, y (SD)	60.8 (16.8)	58.7 (16.2)	63.0 (17.2)
Sex, male	195 (48.9)	98 (49.0)	97 (48.7)
Race			
White	257 (64.4)	173 (86.5)	84 (42.2)
African American	101 (25.3)	15 (7.5)	86 (43.2)
Admitted from			
Home	385 (96.5)	188 (94.0)	190 (95.5)
Urgent care/clinic	49 (12.3)	42 (21.0)	7 (3.5)
ED transfer	16 (4.0)	15 (7.5)	1 (0.5)
Outpatient	3 (0.8)	3 (1.5)	0 (0)
Home healthcare service	1 (0.3)	0 (0)	1 (0.5)
Nursing home/assisted living	13 (3.3)	11 (5.5)	9 (4.5)
Homeless shelter	1 (0.3)	1 (0.5)	0 (0)
Days of study follow-up, mean (SD)	2.3 (3.0)	3.5 (3.8)	1.0 (0.1)
No. of study visits, mean (SD)	1.8 (0.9)	2.1 (0.9)	1.5 (0.7)
Reason for study discharge			
Discharged home	322 (80.7)	152 (76.0)	170 (85.4)
Discharged to subacute rehab/SNF	34 (8.5)	25 (12.5)	9 (4.5)
Discharged to another unit	31 (7.8)	15 (7.5)	16 (8.0)
At patient or family request	5 (1.3)	3 (1.5)	2 (1.0)
Other (hospice or left AMA)	7 (1.8)	5 (2.5)	2 (1.0)
Shared room	229 (57.4)	137 (68.5)	92 (46.2)
History of MDRO (in past 90 d)	28 (7.0)	25 (12.5)	3 (1.5)
MRSA	9 (2.3)	8 (4.0)	1 (0.5)
RGNB	18 (4.5)	17 (8.5)	1 (0.5)
VRE	4 (1.0)	3 (1.5)	1 (0.5)
Any comorbidity	321 (80.5)	167 (83.5)	154 (77.4)
ADL, No. (%) dependent			
Bathing	76 (19.0)	55 (27.5)	21 (10.6)
Dressing	70 (17.5)	50 (25.0)	20 (10.1)
Toileting	61 (15.3)	43 (21.5)	18 (9.0)
Transferring	89 (22.3)	66 (33.0)	23 (11.6)
Continence	41 (10.3)	31 (15.5)	10 (5.0)
Feeding	18 (4.5)	8 (4.0)	10 (5.0)
≥1 ADLs dependent	101 (25.3)	73 (36.5)	28 (14.1)
Present at enrollment:			
Any infection	117 (29.3)	82 (41.0)	35 (17.6)
SSTI	38 (9.5)	27 (13.5)	11 (5.5)
UTI	26 (6.5)	20 (10.0)	6 (3.0)
Pneumonia	26 (6.5)	20 (10.0)	6 (3.0)
Antibiotic use	170 (42.6)	107 (53.5)	63 (31.7)
Device use	68 (17.0)	46 (23.0)	22 (11.1)
Urinary catheter	13 (3.3)	8 (4.0)	5 (2.5)
Nephrostomy tube	2 (0.5)	1 (0.5)	1 (0.5)
Feeding tube	12 (3.0)	9 (4.5)	3 (1.5)
Central venous catheter	34 (8.5)	23 (11.5)	11 (5.5)
Dialysis catheter	16 (4.0)	13 (6.5)	3 (1.5)
Open wound(s)	51 (12.8)	37 (18.5)	14 (7.0)
Contact precautions	36 (9.0)	32 (16.0)	4 (2.0)

Data are presented as no. (%) unless otherwise specified.

Abbreviations: ADL, activities of daily living; AMA, against medical advice; ED, emergency department; MDRO, multidrug-resistant organism; MRSA, methicillin-resistant *Staphylococcus aureus*; RGNB, resistant gram-negative bacteria; SD, standard deviation; SNF, skilled nursing facility; SSTI, skin and soft tissue infection; UTI, urinary tract infection; VRE, vancomycin-resistant enterococci.



Baseline (n = 399)	40/399 (10.0%)	115/399 (28.8%)
New acquisition* (n = 225 with at least one follow-up visit)	14/225 (6.2%)	49/225 (21.8%)
Anytime during hospital stay (n = 399)	53/399 (13.3%)	159/399 (39.8%)

Figure 1. Percentage of patient hand contamination and room surface contamination with multidrug-resistant organisms (MDROs). Patient hand contamination (left 3 columns) and patient room contamination (right 3 columns) were calculated at baseline, follow-up visits, and any time during follow-up. The table underneath indicates the raw numbers represented in the figure. *A patient can be colonized with 1 MDRO at baseline and be at risk to acquire another MDRO.

hand hygiene [23, 24]. These efforts have included efficient, safer, and more effective cleansing products, innovative educational delivery models, materials, and training, as well as auditing strategies. With contemporary patients allotting substantial time toward interactions and procedures inside and outside their rooms, pathogen transfer between the environment and patient hands is likely and yet understudied. In this prospective cohort study, conducted in 2 different hospitals with diverse patient populations, we show that 10% of patient hands were colonized with an MDRO at enrollment, 29% of rooms were contaminated within 24 hours of admission, and patient hand contamination was associated with patient room contamination with the same MDRO. Furthermore, 6.2% of patient hands and 21.8% of rooms newly acquired an MDRO during the hospital stay.

Numerous studies show that on average, about 5% of HCP hands are contaminated with an MDRO [25–27], the most common being MRSA, VRE, and RGNB, such as *Acinetobacter* species and *Pseudomonas aeruginosa* [27]. Research on patient hand contamination by pathogens is now emerging [6, 7, 21, 28–31]. Hedin and colleagues, using a fingerprinting method, showed that *Escherichia coli*, *Klebsiella* species, enterococci, and *S. aureus* were commonly found on patient hands in a Swedish hospital during an outbreak with enteric pathogens [31]. Cao et al swabbed the dominant hands of 357 post–acute care patients newly admitted to nursing facilities and showed that 24% of this high-risk group had an MDRO on admission and an additional 10% acquired a new MDRO during their stay [7]. Cross-transmission with the environment was evident in a follow-up study showing that when post–acute care patients' hands are culture-positive for an MDRO, their environment is often contaminated with the same MDRO [21, 28].

Our study advances this literature now in hospitals [32] by showing that the rates of patient hand contamination with an MDRO on admission to a hospital are high and new acquisition is frequent, perhaps surpassing that of HCP [25, 26]. In emerging healthcare systems where there is emphasis for early mobility, financial penalties for adverse events related to immobility and falls, and frequent treatment or procedures out of the room, patient hand contamination can have significant implications on MDRO transmission with both near and far environmental surfaces.

Furthermore, we show that one-third of the patient rooms were contaminated with an MDRO on the day of admission, with contamination evident in patients recruited within the first 8 hours of room occupancy, suggesting that patients were often admitted with an MDRO and that there was a rapid change in

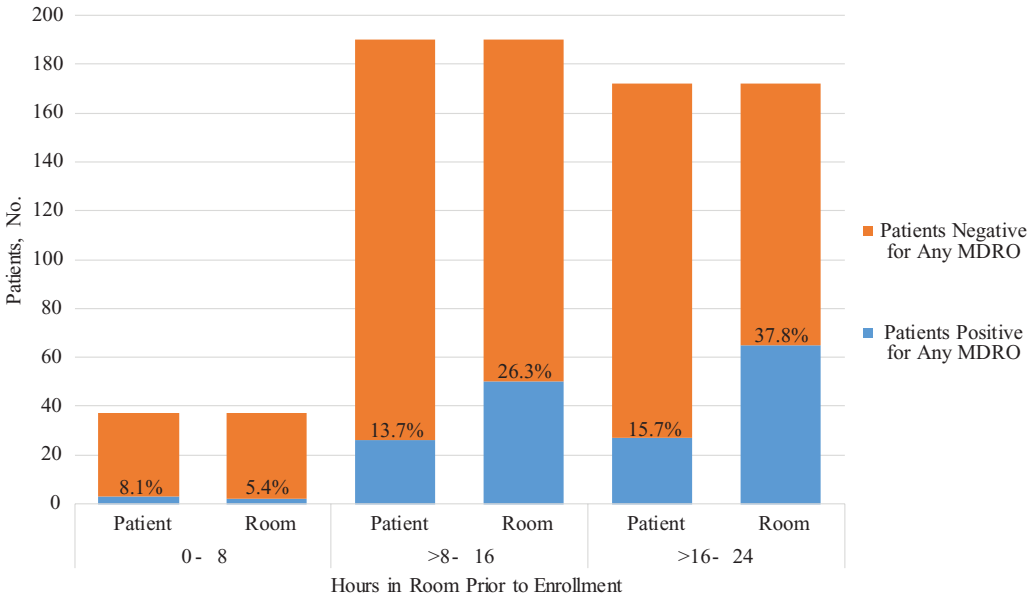


Figure 2. Multidrug-resistant organisms (MDROs) on patients and room surfaces by time in room prior to enrollment. Number of patients enrolled and cultured within 0–8 hours in the room, >8 to 16 hours in the room, and >16 to 24 hours in the room and proportion of patient and rooms colonized with MDROs.

microbial milieu in patients' rooms after admission. This was most pronounced in patients with a clinical culture that was positive for MRSA, where a majority of MRSA-infected patients also harbored MRSA on their hands. Future projects should explore how often patients come to the emergency room from the community with an MDRO, or any potential new MDRO acquisition by patients when being evaluated within our emergency rooms or when receiving their diagnostic workup from the emergency room. We show that hand contamination with MRSA, VRE, and RGNB is associated with high-touch room surface contamination with the same organism, suggesting active transmission with strain match approaching 100% between MRSA on patient hands and their room surfaces. Whether patient hand hygiene interventions and enhanced patient engagement can reduce environmental contamination, MDRO transmission, and nosocomial infections merits further evaluation [33–36]. Our observations suggest that at the minimum, patient hand hygiene programs should be targeted to MRSA-infected patients as an additional infection prevention strategy.

We note a few limitations. First, although we recruited nearly 400 patients and conducted >700 visits, our sample is a fraction of all patients admitted to a hospital. Second, we obtained perianal cultures from a subset of patients to see if they predict clinical infection better than hand contamination. Future studies could obtain multianatomic site samples to further explore this question. Third, we did not perform high-touch surface cultures prior to room occupancy as recruitment occurred once patients were admitted to their rooms. Fourth, we cannot ascertain whether a patient contaminated the high-touch room surfaces or whether pathogens were introduced by HCPs. Finally, our study does not address patient-to-patient transmission of pathogens, which remains a critical gap in MDRO transmission literature [37] and will be explored in subsequent projects. Although MRSA strains were deemed similar using both PFGE and PCR criteria, future studies should define the degree of similarity and timing of divergence using advanced genomic methods.

Limitations notwithstanding, our study also has strengths. First, this prospective cohort study was conducted in 2 different hospitals, serving very different and diverse populations. Second, we repeated the sampling over multiple follow-up visits from the same patients, allowing us to characterize new acquisition rates at the patient level. Finally, we are the first to correlate patient hand contamination with high-touch room surface contamination in hospital settings using both traditional microbiologic and advanced molecular methods. This research is important to demonstrate similarity between patient hand and environmental contamination to then design future patient hand hygiene interventions that would reduce both.

While the burden of preventing infections has largely been borne by HCP, our study shows that patient hands are an important reservoir and play a crucial role in the transmission of pathogens in acute care hospitals. Thus, patient hand hygiene protocols should be implemented and tested for their ability to reduce environmental contamination, pathogen transmission, and healthcare-associated infections as well as to increase meaningful patient engagement in infection prevention.

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Table 2. Incidence Rates (per 1000 Patient-Days) of New Multidrug-resistant Organism Acquisition

	New Acquisition Event/Patient-Days at Risk (Rate per 1000 Patient-Days)											
	MRSA			RGNB			VRE			Any MDRO		
Site	Hospital A	Hospital B	Total	Hospital A	Hospital B	Total	Hospital A	Hospital B	Total	Hospital A	Hospital B	Total
Patient's body site												
Hand	3/510 (5.9)	1/318 (3.1)	4/828 (4.8)	5/537 (9.3)	1/327 (3.1)	6/864 (6.9)	5/518 (9.7)	1/338 (3.0)	6/856 (7.0)	11/537 (20.5)	3/338 (8.9)	14/875 (16.0)
Nares	2/498 (4.0)	0/326 (0.0)	2/824 (2.4)	3/560 (5.4)	4/329 (12.2)	7/889 (7.9)	2/561 (3.6)	0/338 (0.0)	2/899 (2.2)	7/548 (12.8)	4/338 (11.8)	11/886 (12.4)
Hand or nares	2/477 (4.2)	0/315 (0.0)	2/792 (2.5)	8/529 (15.1)	5/320 (15.6)	13/849 (15.3)	6/511 (11.7)	1/338 (3.0)	7/849 (8.2)	15/517 (29.0)	6/338 (17.8)	21/855 (24.6)
Patient's room	11/467 (23.6)	1/307 (3.3)	12/774 (15.5)	8/525 (15.2)	13/244 (53.3)	21/769 (27.3)	21/456 (46.1)	2/331 (6.0)	23/787 (29.2)	35/502 (69.7)	14/334 (41.9)	49/836 (58.6)
Patient's body site or room	12/477 (25.2)	1/323 (3.1)	13/800 (16.3)	14/521 (26.9)	16/314 (51.0)	30/835 (35.9)	22/501 (43.9)	3/334 (9.0)	25/835 (29.9)	39/497 (78.5)	18/334 (53.9)	57/831 (68.6)

Data include 148 patients at hospital A and 77 patients at hospital B with at least 1 follow-up visit.

Abbreviations: MDRO, multidrug-resistant organism; MRSA, methicillin-resistant *Staphylococcus aureus*; RGNB, resistant gram-negative bacteria; VRE, vancomycin-resistant enterococci.

Table 3. Association Between Patient Hand Contamination and Room Surface Contamination With Multidrug-resistant Organisms

	Patient Hands, No. (Column %)											
	MRSA Contamination				RGNB Contamination				VRE Contamination			
Patient Room	Positive	Negative	Total	*P* Value	Positive	Negative	Total	*P* Value	Positive	Negative	Total	*P* Value
All visits (n = 710)												
Positive	25 (71.4)	40 (5.9)	65 (9.2)	< .001	11 (52.4)	83 (12.0)	94 (13.2)	.003	16 (88.9)	53 (7.7)	69 (9.7)	< .001
Negative	10 (28.6)	635 (94.1)	645 (90.8)	…	10 (47.6)	606 (88.0)	616 (86.8)	…	2 (11.1)	639 (92.3)	641 (90.3)	…
Total	35	675	710	…	21	689	710	…	18	692	710	…
Baseline visits (n = 399)												
Positive	12 (60.0)	22 (5.8)	34 (8.5)	.0006	9 (64.3)	51 (13.2)	60 (15.0)	.005	6 (75.0)	26 (6.6)	32 (8.0)	.01
Negative	8 (40.0)	357 (94.2)	365 (91.5)	…	5 (35.7)	334 (86.8)	339 (85.0)	…	2 (25.0)	365 (93.4)	367 (92.0)	…
Total	20	379	399	…	14	385	399	…	8	391	399	…

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; RGNB, resistant gram-negative bacteria; VRE, vancomycin-resistant enterococci.

Notes

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