

## CONCISE COMMUNICATION

## Patient Hand Colonization With MDROs Is Associated with Environmental Contamination in Post-Acute Care

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We assessed multidrug-resistant organism (MDRO) patient hand colonization in relation to the environment in post-acute care to determine risk factors for MDRO hand colonization. Patient hand colonization was significantly associated with environmental contamination. Risk factors for hand colonization included disability, urinary catheter, recent antibiotic use, and prolonged hospital stay.

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Evidence that healthcare personnel serve as vectors for multidrug-resistant organism (MDRO) transmission is extensive.<sup>1</sup> Patients in modern healthcare systems are especially mobile, are encouraged to be independent, and frequently visit common areas. We performed this study to further understand the role of patient hand colonization in transmission and spread of MDROs within post-acute care (PAC) facilities.

### METHODS

As described in previous work,<sup>2</sup> a prospective microbial surveillance study was conducted at 6 PAC facilities in Southeast Michigan. Facilities were for-profit and ranged in size from 74 to 143 beds. Between 41% and 51% of eligible patients were enrolled in this study at each facility (Supplemental Table 1). On each visit, swabs were collected from patient hands, from other anatomic sites, and from high-touch surfaces in the environment.<sup>2</sup> Methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant Enterococcus (VRE), and resistant gram-negative bacteria (RGNB) were identified using standard microbiological methods. Study personnel also collected information on patient characteristics and medical history.<sup>3</sup>

We used multinomial logistic regression to compare the relative risk of MDRO hand colonization, as well as colonization at any site (other than hands), versus no colonization at any body site, clustering by facility. First, we conducted univariate analyses. We conducted a multivariate analysis including factors found to be significant at  $P \leq .05$  in the univariate analyses.

To evaluate whether hand colonization with MDROs was associated with environmental contamination with the same MDRO, we evaluated all visit samples and used Pearson's

$\chi^2$  test to assess the independence of patient hand and room colonization for each MDRO.

### RESULTS

Bacterial swabs were obtained from 650 patients and rooms over 1,607 study visits (18,689 patient days), including 14,869 environmental samples. Most patients (94.9%) were admitted to a PAC following an acute-care hospital stay. The average time to enrollment was 5.6 days. Mean age was 74.7 years (standard deviation [SD], 12.2). The average Physical Self-Maintenance Scale (PSMS)<sup>4</sup> score at baseline was 14.5 (SD, 4.6), and the average Charlson comorbidity score<sup>5</sup> was 2.6 (SD, 2.1). The mean study follow-up time was 29 days (SD, 44.1 days), and 2.5 visits (SD, 1.7) per patient. At enrollment, 54 (8.4%) patients had an indwelling urinary catheter, 17 (2.6%) had a feeding tube, and 80 (12.4%) had a peripherally inserted central catheter.

A total of 164 (25.4%) patients were colonized with an MDRO on their hands at baseline. To assess risk factors, we compared the relative risk of hand colonization with any MDRO as well as colonization of other body sites (but not hands) versus no colonization at baseline. Significant multivariate predictors of hand colonization included male sex (RR, 1.62; 95% CI, 1.30–2.01), PSMS score (RR, 1.10; 95% CI, 1.08–1.12), urinary catheter (RR, 1.79; 95% CI, 1.13–2.86), antibiotic use in prior 30 days (RR, 2.24; 95% CI, 1.78–2.80), and recent prolonged (>2 weeks) hospital stay (RR, 5.01; 95% CI, 2.71–9.27) (Table 1). Disabilities in bathing (RR, 2.22; 95% CI, 1.66–2.97), ambulation (RR, 2.66; 95% CI, 2.05–3.44), toileting (RR, 2.44; 95% CI, 2.09–2.85), dressing (RR, 2.19; 95% CI, 1.40–3.43), and grooming (RR, 1.79; 95% CI, 1.30–2.46) were independent predictors of MDRO hand colonization.

In a sensitivity analysis of 175 patients enrolled within 3 days of PAC admission, male sex, PSMS score, and antibiotic use in prior 30 days remained significant predictors (Supplemental Table 2). Very few patients in this subpopulation had urinary catheters or prolonged hospitalizations, limiting the strength of significance testing.

### Association Between Patient Hand Colonization and Environmental Contamination

Patients' hands were colonized with MRSA at 174 visits (10.8% of 1,605 visits); VRE on 218 visits (13.6% of 1,607 visits); and RGNB on 91 visits (5.7% of 1,607 visits). Patient rooms were contaminated with MRSA on 429 visits (26.7% of 1,605 visits); VRE on 725 visits (45.1% of 1,607 visits); and RGNB on 502 visits (31.2% of 1,607 visits). Patient hands and patient environment were positive for the same organism in 21.9% of visits (352 of 1,607 visits). Hand colonization with MRSA, VRE, and RGNB were associated with analogous

TABLE 1. Predictors of Patient Hand Colonization With Multidrug-Resistant Organisms

Characteristic	Patient Colonization <sup>a</sup>				
	No Colonization ( <i>n</i> = 277), No. (%)	No Hand Colonization, Other Body Site(s) Colonized ( <i>n</i> = 204)		Hands Colonized ( <i>n</i> = 164)	
		No. (%)	Multivariate RR (95% CI)	No. (%)	Multivariate RR (95% CI)
Age, y, mean (SD)	74.6 (12.8)	74.6 (11.6)	1.00 (0.98–1.02)	74.8 (12.0)	1.01 (0.99–1.03)
Male	110 (39.7)	82 (40.2)	1.09 (0.83–1.43)	81 (49.4) <sup>b</sup>	1.62 (1.30–2.01) <sup>c</sup>
Charlson comorbidity score, mean(SD)	2.5 (2.1)	2.4 (2.0)	0.95 (0.86–1.05)	2.9 (2.0) <sup>b</sup>	1.01 (0.92–1.10)
Cognitive sum score, mean (SD) <sup>d,e</sup>	12.8 (3.5)	13.1 (3.2)	NA	12.7 (3.6)	NA
Physical self-maintenance score, mean (SD) <sup>f</sup>	13.6 (4.3)	14.4 (4.7)	1.05 (0.99–1.11)	15.8 (4.6) <sup>b</sup>	1.10 (1.08–1.12) <sup>c</sup>
Feeding disability	13 (4.7)	20 (9.8) <sup>b</sup>	2.18 (1.16–4.08) <sup>c</sup>	10 (6.1)	0.94 (0.47–1.87)
Bathing disability	126 (45.5)	106 (52.0)	1.30 (0.94–1.80)	108 (65.9) <sup>b</sup>	2.22 (1.66–2.97) <sup>c</sup>
Ambulation disability	161 (58.1)	121 (59.3)	1.08 (0.71–1.65)	126 (76.8) <sup>b</sup>	2.66 (2.05–3.44) <sup>c</sup>
Toileting disability	69 (24.9)	64 (31.4) <sup>b</sup>	1.37 (1.04–1.82) <sup>c</sup>	78 (47.6) <sup>b</sup>	2.44 (2.09–2.85) <sup>c</sup>
Dressing disability	151 (54.5)	119 (58.3)	1.19 (0.84–1.68)	118 (72.0) <sup>b</sup>	2.19 (1.40–3.43) <sup>c</sup>
Grooming disability	64 (23.1)	55 (27.0)	1.24 (0.78–1.97)	61 (37.2) <sup>b</sup>	1.79 (1.30–2.46) <sup>c</sup>
Urinary catheter	14 (5.1)	15 (7.4) <sup>b</sup>	1.14 (0.79–1.63)	25 (15.2) <sup>b</sup>	1.79 (1.13–2.86) <sup>c</sup>
Feeding tube	3 (1.1)	8 (3.9)	NA	6 (3.7)	NA
Peripherally inserted central venous catheter	26 (9.4)	24 (11.8)	1.13 (0.51–2.48)	30 (18.3) <sup>b</sup>	1.54 (0.85–2.79)
Antibiotic use in previous 30 d <sup>e</sup>	142 (53.0)	127 (63.5) <sup>b</sup>	1.50 (1.09–2.07) <sup>c</sup>	120 (74.5) <sup>b</sup>	2.24 (1.78–2.80) <sup>c</sup>
Diabetes	107 (38.6)	89 (43.6)	1.31 (0.89–1.92)	78 (47.6) <sup>b</sup>	1.34 (0.99–1.82)
Dementia <sup>e</sup>	46 (16.7)	34 (16.7)	NA	29 (17.7)	NA
Prolonged Hospital Stay (>2 wks)	11 (4.0)	16 (7.8) <sup>b</sup>	1.84 (1.07–3.16) <sup>c</sup>	33 (20.1) <sup>b</sup>	5.01 (2.71–9.27) <sup>c</sup>

NOTE. SD, standard deviation; NA, not available.

<sup>a</sup>*N* = 645; 5 patients were not cultured on hands at baseline.

<sup>b</sup>These variables were significant at *P* < .05 in clustered univariate analysis and included in the adjusted model. Disability variables are collinear; adjusted relative risk ratios (RRs) for these do not include other disability variables.

<sup>c</sup>These variables were significant at *P* < .05 in clustered multivariate analysis.

<sup>d</sup>Possible cognitive sum score range, 0–15; higher scores indicate higher cognitive function.

<sup>e</sup>Possible physical self-maintenance score range, 6–30; higher scores indicate more functional disability.

<sup>f</sup>These variables had missing data. The totals for each are cognitive sum score, *n* = 627; antibiotic use, *n* = 629; and dementia, *n* = 644. For multivariate analyses, missing values were assigned as zero, and a missing control was added.

environmental contamination (Table 2). Examining hand colonization among patients followed for at least 60 days (4 visits), we found MRSA and VRE hand colonization to be more persistent than RGNB (Supplemental Table 3).

## DISCUSSION

In our study, patient hand colonization with an MDRO was pervasive. Functional disability, indwelling medical devices, and recent antibiotic use were predictive of an MDRO on patient hands at baseline. When patient hands were found to be colonized with an MDRO, their environment was often contaminated with the same MDRO. Our findings suggest that environmental contamination is significantly associated with patient hand colonization.

Our results support other work showing that MDRO colonization in PAC is widespread and that patient disability increases the risk of acquiring an MDRO.<sup>3,6</sup> In acute care, contaminated environment has been shown to contribute

to MDRO transmission and interventions targeting improved environmental cleaning can decrease the risk of patients becoming infected.<sup>7</sup> We have extended this work by assessing the role patient hands may play in MDRO colonization and transmission. The connection between disability and risk of MDRO colonization is important; when patients are unable to independently move around or use the bathroom, they are less likely to have direct access to a sink or alcohol-based hand rub, increasing the risk of transmission. Some patients had hand colonization without environmental contamination, suggesting that they may have acquired the MDRO from another source (e.g., healthcare worker or a common area).

Evidence correlating environmental contamination to patient colonization with MDROs in the PAC setting is scarce; most studies are based in acute care.<sup>8</sup> Building on patient hand hygiene as a concept for infection control, future studies should focus on well-designed trials with patient hand-hygiene interventions, with measures of pathogen colonization and infection that evaluate the role patient hands may have in self-inoculation.

TABLE 2. Association Between Patient Hand Colonization and Environmental Contamination With MDROs (All Visits)<sup>a</sup>

Patient Hands	Patient Environment			P Value
	Positive, No. (%)	Negative, No. (%)	Total	
<b>MRSA Colonization</b>				
Positive	<b>145 (83.3)</b>	29 (16.7)	174	<.001
Negative	284 (19.9)	<b>1,147 (80.2)</b>	1431	
Total	429	1,176	1605 <sup>a</sup>	
<b>VRE Colonization</b>				
Positive	<b>202 (92.7)</b>	16 (7.3)	218	<.001
Negative	523 (37.7)	<b>866 (62.4)</b>	1389	
Total	725	882	1607	
<b>RGNB Colonization</b>				
Positive	<b>57 (62.6)</b>	34 (37.4)	91	.01
Negative	445 (29.4)	<b>1,071 (70.7)</b>	1516	
Total	502	1,105	1607	

NOTE. MRSA, methicillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant Enterococcus; RGNB, resistant gram-negative bacteria. Bold font indicates agreeing hand colonization and environmental contamination (ie, positive & positive, negative & negative).

<sup>a</sup>Results were inconclusive for MRSA colonization in 2 hand samples.

The strengths of this study are its prospective design, unique population, and ample environmental and anatomic site sampling. This study has several limitations. First, we focused on newly admitted PAC patients; a similar study should focus on institutionalized patients who are in long-term care. Second, conducting molecular typing is critical to understanding transmission dynamics and should be addressed in future studies; this aspect was beyond the scope of this study. Third, patient microbiological data previous to arrival and history of prior room occupants were not available. Fourth, swabs for environmental culture may not be the most sensitive method for detecting contamination and may underestimate our findings. Finally, we sampled for-profit PAC facilities in southeast Michigan; thus, results may not be generalizable nationwide. However, epidemiological investigations in nursing homes across the nation have also shown high prevalence and new acquisition of MDROs.<sup>9</sup>

Targeting patient hand hygiene in the PAC setting is practical, simple, and intuitive. The act of having patients wash their hands also incorporates emerging concepts of active patient engagement and shared responsibility in patient safety.<sup>10</sup>

Further investigation of patient hands as a target of enhanced infection prevention in those with known pathogen colonization may yield productive results. If hand colonization with pathogens can be decreased, there may be an associated decrease in environmental colonization and possibly infection.

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#### SUPPLEMENTARY MATERIAL

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