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Prevalence of and Factors Associated With Multidrug Resistant Organism (MDRO) Colonization in 3 Nursing Homes

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Nursing home residents are at risk for acquiring and transmitting MDROs. A serial point-prevalence study of 605 residents in 3 facilities using random sampling found MDRO colonization in 45% of residents: methicillin-resistant *Staphylococcus aureus* (MRSA, 26%); extended-spectrum β-lactamase–producing *Enterobacteriaceae* (ESBL, 17%); vancomycin-resistant *Enterococcus* spp. (VRE, 16%); carbapenem-resistant *Enterobacteriaceae* (CRE, 1%). MDRO coloni- zation was associated with history of MDRO, care needs, incon- tinence, and catheters.

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Healthcare-associated infections (HAIs) due to multidrug- resistant organisms (MDRO) are a threat to the US healthcare system.[1] The 1.4 million persons residing in nursing homes in the United States are an important consideration when evaluating HAIs and MDRO epidemiology.[2,3] Nursing home residents are increasingly recognized as potential vectors of MDRO transmission.[4] In addition, carbapenem-resistant *Enterobacteriaceae* (CRE) are a particular threat to the US healthcare system,[1] and there is increasing evidence that long-term care is associated with CRE colonization.[3] Nursing home residents may be MDRO colonized;[5] however, prior investigations have predominantly focused on MRSA and on specific populations, such as those with dementia, and were conducted prior to emergence of CRE.[6,7] An assessment of MDRO colonization, including multiple MDROs and risk-factor assessment is important to understanding the scope of MDRO colonization. The main purposes of this investiga- tion were (1) to evaluate the colonization prevalence of common and emerging MDROs, including methicillin- resistant *Staphylococcus aureus* (MRSA), vancomycin- resistant *Enterococcus* spp. (VRE), extended-spectrum β-lactamase–producing *Enterobacteriaceae* (ESBL), and CRE, and (2) to define resident characteristics associated with colonization.

METHODS

We conducted a serial point-prevalence study of MDRO colonization at 3 nursing homes in southern California. We conducted 6 point-prevalence samplings of 50 residents each at least 2 weeks apart at each facility from June through August 2015. Residents were selected by randomly sampling occupied beds at each facility. Residents under hospice care were excluded. If patients refused swabbing, we continued to randomly select participants until 50 residents had been swabbed. Residents could be sampled more than once if they remained in the facility over multiple surveillance periods. Combined

axilla/groin swabs were assessed for MRSA, VRE, ESBL, and CRE, and bilateral nares swabs were assessed for MRSA. All swabs (BD BBL CultureSwab, Becton Dickinson, San Jose, CA) were processed within 6 hours of sampling. To screen for MDROs, we utilized Spectra MRSA chromogenic agar (Thermo Scientific, Waltham, MA) for MRSA, *Campylobacter* agar (BD BBL, Becton Dickson, Sparks, Maryland) with 10% sheep blood with vancomycin 10 μg, cephalothin 15 μg, trimethoprim 5 μg, polymyxin-B 2.5 units, amphotercin-B 2 μg for VRE, MacConkey agar (BD BBL, Becton Dickson, Sparks, Maryland) with a 2 μg cefpodoxime disk (BD BBL, Becton Dickson, Sparks, Maryland) for ESBL organisms, and MacConkey agar with a 2 μg meropenem disk (BD BBL, Becton Dickson, Sparks, Maryland) for CRE. Isolates on Spectra chromatic agar that were the typical denim blue color were not further confirmed. The identification of Enterococci isolated on *Campylobacter* agar was verified by matrix-assisted laser desorption ionization time-of-flight mass spectroscopy (MALDI- TOF-MS) using VITEK MS from BioMerieux (Durham, North Carolina). Vancomycin resistance was not confirmed because we have previously demonstrated the ability of this agar to detect VRE.[8] MRSA isolates identified by the initial ESBL screen were further confirmed using MALDI-TOF-MS and the presence of an ESBL was confirmed by phenotypic testing using cefotaxime and ceftazidime with and without clavulanic acid. Isolates identified as a CRE in the initial screening were further identified by MALDI-TOF-MS and disk diffusion using meropenem. If needed due to a questionable result, the disk diffusion was repeated using meropenem, ertapenem, imipenem, and/or doripenem.

Resident characteristics were collected from the medical record using a standardized form. Medical devices (eg, central lines, urinary catheters, and other devices) were recorded by direct observation of the resident during surveillance. Additional variables included gender, MDRO history, total care requirement (bed bound), non-lucidity, incontinence, and presence of selected comorbidities (eg, diabetes, hemodialysis). We conducted bivariate analyses using χ^2 tests to evaluate theassociation of each characteristic with each MDRO outcome (MRSA, VRE, ESBL, CRE, and any MDRO). Variables were entered into multivariate logistic regression models using a criterion for entry of 0.1 and retained at $\alpha < 0.05$ based upon clinical relevance of the variables. Adjustments were made for repeated measures by generalized linear mixed models for analysis of resident characteristics. Statistical analyses were conducted using SAS version 9.3 (SAS Institute, Cary, NC). This study was approved by the University of California–Irvine and Providence Little Company of Mary Medical Center institutional review boards.

RESULTS

A total of 1,800 swabs were obtained from 605 residents: 82 patients were swabbed twice, 37 patients were swabbed 3 times, and 40 patients were

swabbed ≥ 4 times. Resident characteristics are presented in Table 1. Overall, 45% (n = 272) of residents were found to harbor ≥1 MDRO. MRSA was noted in 26% of residents (n = 160): 20% of residents (n = 121) in the nares, and 18% of residents (n = 108) on the skin. Skin-only MRSA colonization was detected in 39 patients. ESBL colonization was found in 17% of residents (n = 100); VRE was detected in 16% of residents (n = 99); and CRE was detected in 1% of residents (n = 5). Multiple MDRO colonization was detected: 12% of residents had 2 MDROs (n = 70), and 2% of residents harbored 3 MDROs (n = 11).

MDRO colonization differed by facility. MDRO colonization prevalence rates at Facility 1 were assessed as follows: any MDRO, 46% (n = 138; range, 34%–60% during the 6 week surveillance period); MRSA, 38% (n = 113; range, 28%–40%);
VRE, 7% (n = 22; range, 0%–16%); ESBL, 11% (n = 33; range, 6%–18%); and CRE, not detected. MDRO colonization pre- valence rates at Facility 2 were assessed as follows : any MDRO, 34% (n = 102; range, 28%–48%); MRSA, 15% (n = 45; range,
6%–22%); VRE, 19% (n = 56; range, 10%–36%); ESBL, 8% (n = 25; range, 6%–22%); and CRE, not detected. MDRO colonization prevalence rates at Facility 3 were assessed as follows : any MDRO, 57% (n = 171; range, 48%–68%); MRSA, 34% (n = 101; range, 30%–38%); VRE, 11% (n = 33; range, 8%–16%); ESBL, 28% (n = 83; range, 18%–36%); and CRE 2% (n = 6; range, 0–4%).

Patient characteristics are presented overall and stratified by any MDRO colonization (Table 1). Multivariate results are summarized in Table 2. Factors associated with CRE were not assessed due to low prevalence. Factors associated with any MDRO colonization included MDRO history, bed-bound status, incontinence, and urinary catheter. Similar factors were associated with MRSA and ESBL, although VRE colonization was associated with urinary catheters, central venous catheters, and wounds (Table 2).

DISCUSSION

The burden and predictors of MDRO colonization in nursing homes remains poorly understood despite several studies suggesting that nursing home residents are at high risk for colonization[5,6] and MDRO acquisition.[3–5,7] Evidence on MDRO prevalence and factors associated with MDRO colonization may help fuel much-needed strategies for infection prevention in nursing homes.[9]

In a systematic assessment of 4 key MDROs in nursing home residents, colonization was common and exceeded colonization prevalence seen in acute-care hospitals, including intensive care units (ICUs).[5,10,11] Not surprisingly, the burden of MRSA colonization was consistently high among all 3 facilities. Nares remained the dominant reservoir, raising important questions for nasal decolonization. Nares surveil- lance alone would have missed 24% of MRSA carriers (n = 39) who were colonized only

on the skin. The importance of non- nares testing for MRSA colonization has been previously noted[11] and may be relevant for surveillance and infection control programs. VRE and ESBL colonization were prevalent in all 3 facilities, reinforcing the notion that nursing home patients are important MDRO reservoirs.[3–5] CRE was seen in

TABLE 1. Patient Factors Associated with Any MDRO Colonization, Bivariate Analysis

	Total, No. (%)	MDRO+ , No. (%)	MDRO , No. (%)	OR (95% CI)	*P* Value
No.	605	272 (45)	333 (55)		
MDRO history	76 (13)	**61 (22)**[a]	**15 (5)**	**4.0 (2.4–7.0)**	**<.0001**
Diabetes	201(33)	99 (36)	102 (31)	1.3 (0.9–1.8)	.1
Hemodialysis	35 (6)	16 (6)	19 (6)	1.0 (0.5–2.0)	.9
Bed bound	108 (18)	**73 (27)**	**35 (11)**	**2.4 (1.6–3.8)**	**.0001**
Not lucid	170 (28)	96 (35)	74 (22)	1.4 (1.0–2.0)	.07
Incontinent	293 (48)	**171 (63)**	**122 (37)**	**2.0 (1.4–2.6)**	**<.0001**
Urinary catheter	70 (12)	**51 (19)**	**19 (6)**	**2.9 (1.7–5.0)**	**.0002**
Central lines	56 (9)	34 (13)	22 (7)	1.5 (0.8–2.8)	.2
Peripheral i.v.	114 (19)	52 (19)	62 (19)	0.8 (0.5–1.3)	.3
Other devices[b]	51 (8)	34 (13)	17 (5)	1.7 (1.0–3.0)	.05
Wounds	170 (28)	88 (32)	82 (25)	1.2 (0.8–1.7)	.4

NOTE. MDRO, multidrug-resistant organism; i.v., intravenous administration device.
[a]Bold font indicates statistical significance.
[b]Such as nasogastric tube, G-tube, J-tube, or surgical drains.

Table 2. Multivariate Logistic Regression for Factors Associated with Any MDRO, MRSA, VRE, and ESBL Colonization

	Any MDRO		MRSA		VRE		ESBL	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
MDRO history[a]	**3.4 (2.0–5.9)**[b]	**<.001**	**3.6 (1.5–8.3)**	**.003**	0.5 (0.05–4.4)	.5	**4.1 (1.6–10.4)**	.003
Bed bound	**2.0 (1.2–3.1)**	**.006**	**1.7 (1.0–2.9)**	**.04**	1.4 (0.7–2.5)	.3	**2.6 (1.3–5.4)**	.008
Incontinent	**1.6 (1.2–2.3)**	**.006**	**1.6 (1.1–2.5)**	**.02**	1.2 (0.8–2.0)	.4	1.3 (0.7–2.3)	.4
Urinary catheter	**2.0 (1.1 3.6)**	**.02**	**2.0 (1.1–3.7)**	**.03**	**2.7 (1.5–5.1)**	**.002**	0.7 (0.3–1.8)	.5
Central line	1.4 (0.7–2.5)	.3	0.7 (0.3–1.4)	.3	**2.0 (1.0–4.2)**	**.05**	1.2 (0.4–3.2)	.8
Other devices[c]	1.2 (0.7–2.2)	.5	1.4 (0.7–2.6)	.3	**0.3 (0.1–0.9)**	**.03**	1.5 (0.6–3.6)	.4
Wounds	1.3 (0.9–1.9)	.3	1.0 (0.6–1.5)	.9	**2.1 (1.3–3.3)**	**.003**	1.3–(0.7–2.5)	.4
Not lucid	1.0 (0.7–1.5)	.9	0.9 (0.6–1.5)	.7	0.8 (0.5–1.4)	.4	1.6 (0.8–3.0)	.2
Diabetes	1.2 (0.9–1.8)	.2	1.4 (0.9–2.2)	.1	0.9 (0.6–1.5)	.7	0.9 (0.5–1.7)	.8
Hemodialysis	0.8 (0.4–1.6)	.5	0.9 (0.4–2.3)	.9	0.6 (0.2–1.9)	.4	1.8 (0.6–5.5)	.3

NOTE. MDRO, multidrug-resistant organism; MRSA, methicillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant *Enterococci*; ESBL, extended-spectrum β-lactamase–producing *Enterobacteriaceae*.
[a]Reflects history of the outcome MDRO.
[b]Bold font indicates statistical significance.
[c]Such as nasogastric tube, G-tube, J-tube, or surgical drains.

only 1 center, with only a 2% prevalence at that facility based on skin swabs

alone.

Resident variables independently associated with any MDRO colonization included history of MDRO, bedbound status, urinary or fecal incontinence, and presence of an indwelling urinary catheter. The association of MDRO colonization with MDRO history was not surprising.[5] Our finding that patients with diminished functional status are at higher risk for MDRO colonization may prove helpful for targeted infection control interventions. It is reassuring that residents able to independently conduct their activities of daily living may be least likely to harbor transmissible pathogens. Previous hospitalization in an acute-care hospital and previous antimicrobial therapy have been previously associated with MDRO carriage and infection, but these variables were not included in our investigation.[5] While our observations may help identify patients at higher risk for MDRO colonization, the overall burden of MDROs is sufficiently high that universal approaches may be required as part of prevention efforts.

Our study is limited in that we tracked colonization, not subsequent infections. Nevertheless, MDRO colonization is a known risk factor for infection.[5] Future studies may wish to examine relationships between colonization and clinical infections with MDROs, antibiotic utilization, and hospital readmissions. Another limitation is that we did not conduct concomitant rectal surveillance for enteric MDROs. Thus, our measured prevalence of VRE, ESBL, and CRE may be underestimates. We performed a 1-time rectal surveillance (n = 179) at 2 facilities and results did not differ markedly from our measured rates: MRSA, 17% rectal versus 28% multi-site swab; VRE, 9% rectal versus 12% multi-site swab; ESBL, 23% rectal versus 16% multi-site swab; and CRE, 2% rectal versus 1% multi-site swab. We do not know whether rectal surveillance identified the same or different carriers than our skin swabs due to de-identification of swabs at the time of collection. Future investigations may consider systematic rectal surveillance, if feasible.

In summary, MDRO colonization prevalence within nursing homes is very high, and these rates exceed published reports from other clinical care settings. Residents with total care needs and devices are at higher risk for MDRO colonization. The high burden of MDRO pathogens within the nursing home population strongly suggests that effective and practical infection prevention strategies are needed to protect the safety of this vulnerable population from MDRO acquisition and infection.

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REFERENCES

1. Antibiotic resistance threats in the United States, 2013. Centers for Disease Control and Prevention website. http://www.cdc.gov/ drugresistance/threat-report-2013/. Published 2013. Accessed August 24, 2016.
2. Overview of nursing facility capacity, financing, and ownership in the United States in 2013. Henry J. Kaiser Family Foundation website. http://kff.org/medicaid/report/nursing-facilities-staffing- residents-and-facility-deficiencies-2009-through-2014/. Published 2014. Accessed February 5, 2016.

3. Slayton RB, Toth D, Lee BY, et al. Vital signs: estimated effects of a coordinated approach for action to reduce antibiotic-resistant infections in health care facilities—United States. *Morb Mortal Wkly Rep* 2015;64:826–831.
4. Huang SS, Septimus E, Kleinman K, et al. Targeted versus universal decolonization to prevent ICU infection. *New Engl J Med* 2013;368:2255–2265.
5. Bonomo RA. Multiple antibiotic-resistant bacteria in long-term-care facilities: an emerging problem in the practice of infectious diseases. *Clin Infect Dis* 2000;31:1414–1422.
6. Murphy CR, Quan V, Kim D, et al. Nursing home characteristics associated with methicillin-resistant *Staphylococcus aureus* (MRSA) Burden and Transmission. *BMC Infect Dis* 2012;12:269.
7. Mitchell SL, Shaffer ML, Loeb MB, et al. Infection management and multidrug-resistant organisms in nursing home residents with advanced dementia. *JAMA Intern Med* 2014;174: 1660–1667.
8. Shigei J, Tan G, Shiao A, de la Maza LM, Peterson EM. Comparison of two commercially available selective media to screen for vancomycin-resistant enterococci. *Am J Clin Pathol* 2002;117: 152–155.
9. Smith PW, Bennett G, Bradley S, et al. SHEA/APIC Guideline: infection prevention and control in the long-term care facility. *Am J Infect Control* 2008;36:504–535.
10. Weintrob AC, Roediger MP, Barber M, et al. Natural history of colonization with Gram-negative multidrug-resistant organisms among hospitalized patients. *Infect Control Hosp Epidemiol* 2010;31:330–337.
11. McKinnell JA, Huang SS, Eells SJ, Cui E, Miller LG. Quantifying the impact of extranasal testing of body sites for methicillin- resistant *Staphylococcus aureus* colonization at the time of hospital or intensive care unit admission. *Infect Control Hosp Epidemiol* 2013;34:161–170.