CONCISE COMMUNICATION

Predicting High Prevalence of Community Methicillin-Resistant *Staphylococcus aureus* Strains in Nursing Homes

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We assessed characteristics associated with community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA) carriage among residents of 22 nursing homes. Of MRSA-positive swabs, 25% (208/824) were positive for CA-MRSA. Median facility CA-MRSA percentage was 22% (range, 0%–44%). In multivariate models, carriage was associated with age less than 65 years (odds ratio, 1.2; $P < .001$) and Hispanic ethnicity (odds ratio, 1.2; $P = .006$). Interventions are needed to target CA-MRSA.

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Community-associated strains of methicillin-resistant *Staphylococcus aureus* (CA-MRSA) have widely penetrated hospitals[1-3] and are a growing cause of invasive disease, including bloodstream infections, necrotizing fasciitis, and pnemonia.[4,5] The ability of USA300 in particular to cause severe disease may result from more frequent carriage of known MRSA toxins, such as Panton-Valentine leukocidin as well as the novel α toxin.[6,7]

The prevalence of CA-MRSA in nursing homes has not been well characterized compared with that in hospitals. Since most nursing home residents are admitted directly from hospitals, importation of CA-MRSA may be high. Furthermore, nursing home residents have many risk factors for MRSA, including diabetes, long-term use of indwelling devices, and inability to perform activities of daily living.[8] CA-MRSA penetration into nursing homes may require additional infection control measures, particularly if CA-MRSA proves to be more transmissible in this setting. Identifying facilities with a high CA-MRSA burden may allow targeted interventions. In this study, we measured the prevalence of CA-MRSA among nursing homes in a large California county and identified resident and facility characteristics associated with CA-MRSA carriage.

METHODS

Screening nursing home residents for MRSA. We assessed the frequency of CA-MRSA carriage among residents in a convenience sample of 22 of the 72 nursing homes in Orange County, California, during the period October 2008–May 2011. Participating nursing homes were less likely to belong to multistate corporations. We obtained bilateral nares swabs from 100 residents at a single visit (MRSA point prevalence) and from up to 100 residents upon admission (MRSA admission prevalence). For smaller nursing homes, multiple visits were required to obtain point prevalence swabs; visits were separated by at least twice the median length of stay at that nursing home. Samples were processed within 12 hours of collection. We previously collected the following variables for each individual swabbed: how long the resident had resided at the facility (nursing home day of swab collection), whether there was a known history of MRSA infection or colonization (from chart review), and whether the resident shared a room. The Institutional Review Board of the University of California Regents approved this study.

Identification of CA-MRSA by molecular typing. All strains were shipped to Imperial College London in the United Kingdom for staphylococcal protein A (*spa*) typing and stored at −80°C. Cells were harvested on blood agar plates (Oxoid) and incubated at 37°C overnight. DNA was extracted using Qiagen's DNeasy Blood and Tissue kit. DNA samples were eluted in 200 μL of elution buffer (10 mM Tris-Cl, 0.5 mM ethylenediaminetetraacetic acid; pH 9.0) and stored at −20°C. Following sequencing of the *spa* region, *spa* types were determined using Ridom StaphType, version 2.1. All strains belonging to *spa* type t008 (analogous to pulsed-field gel electrophoresis type USA300) were considered to be CA-MRSA. Multilocus sequencing typing (MLST) was also performed on a subset of the isolates (192/824) to confirm MRSA strain types.

Nursing home variables. Nursing home characteristics were obtained from resident admission assessments in the minimum data set (MDS) for the most recent year available, 2009 (http://www.resdac.org/MDS/data_available.asp). MDS is collected by nursing homes and transmitted to the Center for Medicare and Medicaid Services. It is a resident-level data set that assesses physical, psychological, and psychosocial functioning for all residents of Medicare-licensed nursing homes in the United States. Facility average resource utilization group (RUG) scores for 2007, the most recent year available, were obtained from LTCFocus.org, a website created by the Brown University Center for Gerontology and Healthcare Research and supported by the National Institute on Aging (http://www.ltcfocus.org). RUG scores reflect the average resident's level of care based on comorbidities and ability to function independently. Nursing home cost variables

TABLE 1. Characteristics of 22 Orange County Nursing Homes, 2009

Nursing home characteristic	Median (range)
No. of beds	99 (24–255)
No. of annual admissions	345 (31–1,894)
Length of stay, days	71 (26–369)
CA-MRSA isolates, %	22 (0–44)
Demographics, % of all facility residents	
Under 65 years old	10 (0–64)
Male sex	39 (21–67)
Nonwhite race	14 (1–88)
Hispanic ethnicity	10 (1–38)
Less than high school education	20 (0–64)
Medicare insurance	18 (1–41)
Comorbidities, % of all facility residents	
Diabetes	29 (17–59)
Congestive heart failure	20 (2–29)
Dementia	29 (13–75)
Chronic obstructive pulmonary disease	16 (2–26)
Renal failure	8 (0–28)
Cancer	9 (0–31)
Skin lesions	8 (3–10)
Fecal incontinence	45 (5–91)
Poor locomotion	66 (31–89)
Functional status, average score among all facility residents	
RUG score[a]	0.92 (0.81–1.43)
ADL score[b]	20 (11–27)

[a] Facility average resource utilization group (RUG) score reflects a resident's required level of care. RUG scores are calculated with reference to 1, where a RUG score higher than 1 indicates a higher required level of care.

[b] Facility activities of daily living (ADL) score indicates a resident's ability to perform activities of daily living, where 0 indicates complete independence and 28 indicates complete dependence on caregivers.

were obtained from the California Office of Statewide Health Planning and Development (http://www.oshpd.ca.gov) and included skilled nursing costs, total healthcare costs, and costs related to housekeeping, laundry, building maintenance, and dining (termed "hotel-type costs").

Analysis. Across all nursing homes, we calculated the percentage of CA-MRSA among all MRSA isolates and among isolates obtained at point prevalence versus admission prevalence screenings. We calculated the percentage of CA-MRSA for each facility.

We tested variables associated with individual carriage of USA300. Nursing home characteristics were assigned to all isolates from that facility. Variables with a P value less than .1 from bivariate tests were entered into a multivariate individual-level generalized estimating equation model and were retained at $\alpha = .05$. Variables included facility median length of stay, average RUG score, annual costs per bed (for hotel-type, skilled nursing, and total healthcare activities), swab type (admission vs point prevalence), and percentage of facility residents with the following characteristics: less than 65 years of age, less than a high school education, Hispanic ethnicity, diabetes, congestive heart failure, dementia (including Alzheimer's disease), chronic obstructive pulmonary disease, renal failure, cancer, fecal incontinence, and poor locomotion. All variables were continuous except for facility RUG score, which was dichotomized around the median value. Odds ratios (ORs) for all continuous variables were expressed per 10% increase except hotel-type costs, which were expressed per thousand dollars.

RESULTS

We collected 3,433 swabs (1,549 admission and 1,884 point prevalence) from 22 nursing homes. Of all swabs, 24% (824/3,433) were MRSA positive: 17% at admission (266/1,549) and 30% at point prevalence screening (558/1,884). Of MRSA isolates, 25% (208/824) were identified as t008 by *spa* typing and considered to be CA-MRSA. We tested 16% of t008 isolates (33/208) by MLST and confirmed that all were CC8. Across all nursing homes, 22% (60/266) of MRSA isolates obtained at admission were CA-MRSA, and 26% (148/558) of MRSA isolates obtained at point prevalence screening were CA-MRSA. The facility median percentage of CA-MRSA was 22% (range, 0%–44%). Facility characteristics are listed in Table 1.

In bivariate testing (Table 2), CA-MRSA carriage was associated ($P < .1$) with the facility's percentage of residents with the following characteristics: age under 65 years, Hispanic ethnicity, cancer, skin lesions, fecal incontinence, and poor locomotion skills. CA-MRSA carriage was not associated with high facility RUG score, hotel-type costs, admission swab type, or the percentage of residents with diabetes, congestive heart failure, dementia, chronic obstructive pulmonary disease, renal failure, or less than a high school education.

In multivariate models, CA-MRSA carriage was associated with facilities with a higher percentage of Hispanic residents (OR, 1.2 [or 20% increased odds per 10% Hispanic residents]; $P = .006$) and facilities with a higher percentage of residents under age 65 years (OR, 1.2 [or 20% increased odds per 10% residents under 65 years of age]; $P < .001$), controlling for whether the swab was obtained at admission (versus point prevalence screening). The percentage of residents under age 65 years was highly correlated with the percentage of residents with cancer; only 1 of these variables was able to exist in the model.

DISCUSSION

There is growing evidence that nursing homes have high CA-MRSA prevalence and contribute to regional spread among healthcare facilities.[9,10] In our study of more than 20 nursing homes, we found that CA-MRSA was present in all but 2. CA-MRSA prevalence also varied greatly, reaching nearly half of MRSA carriers in 1 facility. As in hospitals, CA-MRSA may

TABLE 2. Bivariate Analysis of Factors Associated with Carriage of Community Methicillin-Resistant *Staphylococcus aureus* (MRSA) Strains

Variable	OR[a]	*P*
Nursing home characteristic		
Median length of stay	1.0	.4
Hotel-type costs per bed (in $1,000s)	1.0	.7
Skilled nursing costs per bed (in $1,000s)	0.9	.7
Total healthcare costs per bed (in $1,000s)	1.0	.9
Demographics, % of all facility residents		
Age under 65 years	1.3	<.001
Hispanic ethnicity	1.4	<.001
Less than high school education	1.2	.1
Comorbidities, % of all facility residents		
Diabetes	1.2	.2
Congestive heart failure	0.9	.8
Dementia	0.8	.1
Chronic obstructive pulmonary disease	1.1	.8
Renal failure	0.9	.7
Cancer	0.4	.002
Skin lesions	0.9	.05
Fecal incontinence	1.2	.06
Poor locomotion	0.7	.001
Functional status, average score among all facility residents		
High facility RUG score	1.2	.60
Isolate characteristic		
MRSA isolate obtained at admission	0.8	.19

[a] Odds ratios (ORs) for all variables are expressed per 10% increase except facility resource utilization group (RUG) score (which was dichotomized around the median value) and cost variables (which are expressed per thousand dollars).

already be endemic in some nursing homes. High burden of CA-MRSA (versus healthcare-associated MRSA) may necessitate additional interventions, such as enhanced environmental cleaning or skin decolonization.

Our regional study found that variation in CA-MRSA prevalence was associated with several facility-level characteristics, suggesting that targeting high-risk nursing homes may be beneficial to reduce prevalence. CA-MRSA carriage was associated with facilities with more residents under age 65 years. In the community, USA300 frequently infects children and younger adults, particularly in high-contact settings, such as child care centers, sports activities, and the military. In turn, younger nursing home residents may be more mobile and better able to interact with others, increasing the risk of MRSA acquisition. In our model, the percentage of residents under age 65 years was interchangeable with the percentage of residents with cancer; facilities with more residents with cancer had lower CA-MRSA prevalence. This finding may reflect patient transfer patterns among hospitals, as patients with cancer are often referred to tertiary care centers, where CA-MRSA prevalence is generally low. Nursing homes that receive patients from these tertiary care hospitals may thus have more patients with cancer and lower CA-MRSA prevalence.

CA-MRSA carriage was also associated with facilities with more Hispanic residents. This finding did not appear to reflect resident socioeconomic status or low-resource nursing homes, as we did not find associations between CA-MRSA carriage and residents' level of education or facility spending on healthcare or hotel-type costs. CA-MRSA carriage is also common among other nonwhite groups, perhaps reflecting cultural or genetic differences in the likelihood of CA-MRSA carriage or the higher incidence of certain risk factors for carriage (such as diabetes) among nonwhite groups. Finally, our model controlled for whether the swab was obtained at admission or during point prevalence screening. CA-MRSA was not significantly more common at admission, suggesting that CA-MRSA prevalence in nursing homes may not be driven simply by influx from hospitals and the community and that transmission between residents may occur.

This study has several limitations, including its sample size of only 22 nursing homes. Yet ours is one of the largest studies, to our knowledge, of MRSA within nursing homes in a single region. We collected only nasal swabs, and CA-MRSA is often present exclusively extranasally. Still, nasal swabbing is known to capture the majority of MRSA carriers, as was found in a recent nursing home study of nasal versus extranasal carriage.[10] In addition, since our admission and point prevalence assessments were not performed serially in the same nursing home residents, we are unable to be certain of the fraction of imported versus transmitted MRSA. Finally, our data collection did not allow us to control for several important comorbidities and devices that might impact CA-MRSA carriage. However, despite a lack of individual-level variables, our facility-level assessment is relevant for identifying nursing homes that may have high CA-MRSA prevalence and benefit from infection control interventions, such as enhanced environmental cleaning or decolonization.

In this regional study, we found that CA-MRSA prevalence was highly variable, with nearly half of residents in one facility identified as CA-MRSA carriers. CA-MRSA carriage was associated with facility-level characteristics, such as a high prevalence of residents under 65 years old or of Hispanic ethnicity. Further research is needed to determine whether reducing CA-MRSA prevalence requires interventions different from those used for healthcare-associated MRSA.

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