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Hand and Nasal Carriage of Discordant *Staphylococcus aureus* Isolates among Urban Jail Detainees

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In 928 Dallas County Jail detainees, nasal carriage of *Staphylococcus aureus* was found in 32.8% (26.5% methicillin-susceptible *Staphylococcus aureus* [MSSA] and 6.3% methicillin-resistant *S. aureus* [MRSA]), and hand carriage was found in 24.9% (20.7% MSSA and 4.1% MRSA). Among MRSA nasal carriers, 41% had hand MRSA carriage; 29% with hand MRSA carriage had no nasal *S. aureus* carriage. The prevalence of carriage was not associated with duration of the jail stay up to 180 days.

Community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA) infections are among the predominant causes of skin and soft tissue infections (SSTIs) in North America (1), including in detainees in prisons (2–7) and jails (4, 8–14). Asymptomatic nasal MRSA carriage, a risk factor for clinical infection (15), occurs in 2.7% to 15.8% of U.S. detainees (5, 16–18), but the nares may not be the primary anatomic site of carriage of CA-MRSA strains (19, 20). In the health care setting, MRSA is transmitted from patient to patient via the hands of health care workers (21, 22), but it is not known if hand carriage plays a similar role in the community. We set out to determine the concordance of *S. aureus* strain types carried on the hands and in the nares of individual detainees.

In January 2009, in one unit of the Dallas County Jail, we selected 68 detention divisions, known as tanks, for inclusion in a randomized controlled trial aimed at preventing MRSA transmission. There is little interaction among the detainees housed in separate tanks.

All detainees in the study tanks were offered enrollment into the study. Each enrolled subject underwent a culture of the nares with a sterile swab (Copan Diagnostics, Inc., Murrieta, CA), premoistened in sterile saline, and a hand culture by the hand imprint method (23). On the day of collection, nasal culture specimens underwent enrichment culture at a commercial laboratory. A single *S. aureus* isolate from each positive culture was stored.

At the University of Chicago Medical Center (UCMC), all MRSA isolates from all the study tanks ($n = 68$) and all MSSA isolates from a sample of the study tanks ($n = 26$), chosen randomly after stratification by detainee gender and tank capacity, were assigned genotypes using a combination of staphylococcal cassette chromosome *mec* element (SCC*mec*) type (24, 25) (for MRSA), multilocus sequence type (MLST) (26), and the presence or absence of the Panton-Valentine leukocidin (PVL) genes (27).

For demographic statistical analyses, MRSA and methicillin-susceptible *Staphylococcus aureus* (MSSA) were categorized by the results of automated susceptibility testing (Vitek 2; bioMérieux, Inc., Durham, NC). Analyses were performed with Stata 11 (Stata Corp, College Station, TX); a P value of <0.05 was considered significant.

This study was approved by the institutional review boards of the University of Texas-Southwestern Medical Center and the UCMC and by the Office of Health Research Protections of the U.S. Department of Health and Human Services.

TABLE 1 Characteristics of the study population

Characteristic	Data for: All detainees, 2008	Study sample detainees	*P* value
Total no.	99,453	928	
Gender (no. [%])			
Male	77,686 (78.1)	693 (74.7)	0.01
Female	21,767 (21.8)	235 (25.3)	
Race (no. [%])			
Asian/Pacific Islander	504 (0.51)	3 (0.3)	0.7
Native American	50 (0.05)	0 (0)	
Black	49,261 (49.5)	469 (50.5)	
White	48,485 (48.8)	442 (47.6)	
Unknown	1,153 (1.2)	14 (1.5)	
Age (mean [±SD]) (yr)			
Both genders	33.53 (11.11)	33.54 (10.17)	0.3
Males	33.54 (11.33)	32.82 (10.15)	0.5
Females	33.48 (10.25)	35.67 (9.93)	0.0004

Of the 1,566 detainees who were offered enrollment, 928 (59.1%) underwent hand and nasal cultures. In each tank, 2 to 27 detainees were enrolled, with a range of 13% to 91% (mean, 55%) enrollment per tank. Compared with all 2008 detainees, females were overrepresented among the enrolled subjects (Table 1). Table 2 shows the results of these cultures. Hand MRSA carriage was

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TABLE 2 Subjects with positive culture results in the nares, on the hands, or both

Culture site	Culture results (no. [%])			
	MRSA	MSSA	Any *S. aureus*	Negative
Nares	58 (6.3)	246 (26.5)	304 (32.8)	628 (67.4)
Hands	41 (4.1)	190 (20.7)	231 (24.9)	702 (75.2)
Any or both sites	75 (8.1)	318 (34.3)	383 (41.3)	545 (58.7)

nearly as prevalent as nasal MRSA carriage. Among subjects with nasal MRSA carriage, 41% had hand MRSA carriage, and 29% of those with hand MRSA carriage lacked nasal *S. aureus* carriage (Fig. 1).

In tanks chosen for MSSA genotyping, 160 MSSA isolates were collected. Five isolates were not received by the UCMC, and 3 isolates that were susceptible to oxacillin carried *mecA*; for genotyping analyses, these 3 isolates were considered to be MRSA. Among the 99 MRSA isolates collected, 4 were not received by the UCMC, and 3 were resistant to oxacillin but did not carry *mecA*; for genotyping analyses, these 3 isolates were considered to be MSSA. In all, 155 MSSA and 95 MRSA isolates were analyzed.

Among the MSSA isolates, 5/155 (3%) were PVL positive, compared with 75/95 (79%) of the MRSA isolates ($P < 0.001$). Among the MRSA isolates, 77% (73/95) were sequence type 8 (ST8), SCC*mec* type IV bearing, and PVL positive, which are characteristics that almost always identify USA300 MRSA in pulsed-field gel electrophoresis (28) (Table 3).

Twenty-five subjects (21% of the MSSA carriers) had genotypic concordance of MSSA strain pairs from hand and nasal cultures, while 21 (28% of the MRSA carriers at any site) had concordant MRSA strain types. Detainees with an ST8, SCC*mec* type IV-positive, and PVL-positive nasal MRSA isolate (characteristics commonly associated with USA300 MRSA) were more likely to have a concordant hand isolate (19/39 [49%]) than were detainees with a nasal MSSA isolate (25/78 [32%]) ($P = 0.0001$).

Among 17 subjects who had genotypic discordance of isolates from the hand and nares, 10 (59%) carried on the hand a strain type isolated from another detainee in the same tank. Thus, hand carriage may result from person-to-person transmission in the jail, although such transmission appeared to be uncommon in our cohort.

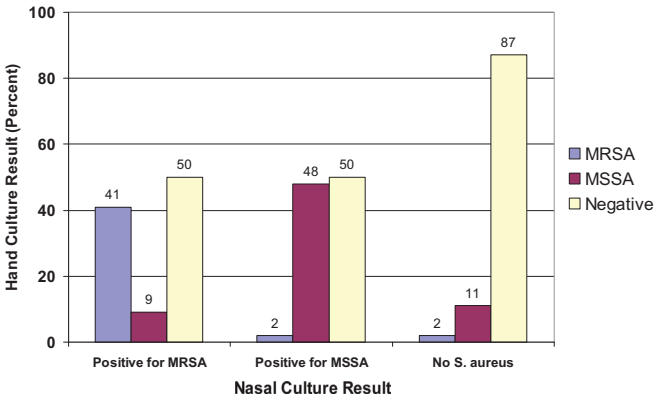

FIG 1 Results of nasal cultures stratified by hand culture results. For example, among subjects with nasal MRSA carriage, 41% had hand MRSA carriage and 9% had hand MSSA carriage. Note that some subjects had MRSA isolated from their hands in the absence of MRSA isolation from the nares. Others had MSSA isolated from their hands in the absence of MSSA isolation from the nares.

TABLE 3 Genotypes of all MRSA isolates and of 155 MSSA isolates by strain type[a]

Genotype	Data (no. [%]) by culture site		
	Nares	Hand	Combined
MRSA (all study tanks)			
ST5/II/PVL$^-$	2 (4)	0 (0)	2 (2)
ST5/IV/PVL$^-$	4 (7)	2 (5)	6 (6)
ST8/IV/PVL$^+$	41 (72)	32 (92)	73 (77)
ST72/IV/PVL$^-$	2 (4)	1 (3)	3 (3)
ST840/IV/PVL$^-$	2 (4)	0 (0)	2 (2)
Unavailable	2 (4)	2 (5)	4 (4)
Other[b]	4 (7)	1 (3)	5 (5)
Total	57 (100)	38 (100)	95 (100)
MSSA (one-third of study tanks)			
ST1/PVL$^-$	1 (1)	1 (1)	2 (1)
ST5/PVL$^-$	6 (8)	6 (8)	12 (7)
ST6/PVL$^-$	5 (6)	7 (9)	12 (7)
ST7/PVL$^-$	0 (0)	2 (3)	2 (1)
ST8/PVL$^-$	5 (6)	3 (4)	8 (5)
ST8/PVL$^+$	2 (3)	0 (0)	2 (1)
ST12/PVL$^-$	1 (1)	2 (3)	3 (2)
ST15/PVL$^-$	5 (6)	3 (4)	8 (5)
ST20/PVL$^-$	3 (4)	7 (9)	10 (6)
ST30/PVL$^-$	0 (0)	2 (3)	2 (1)
ST45/PVL$^-$	4 (5)	3 (4)	7 (4)
ST45slv/PVL$^-$	3 (4)	0 (0)	3 (2)
ST72/PVL$^-$	7 (9)	4 (5)	11 (7)
ST109/PVL$^-$	1 (1)	5 (7)	6 (4)
ST188/PVL$^-$	8 (10)	7 (9)	15 (9)
ST398/PVL$^-$	11 (14)	10 (13)	21 (13)
ST508/PVL$^-$	2 (3)	1 (1)	3 (2)
ST535/PVL$^-$	2 (3)	2 (3)	4 (2)
ST1776/PVL$^-$	1 (1)	1 (1)	2 (1)
ST1776/PVL$^+$	0 (0)	2 (3)	2 (1)
ST1860/PVL$^-$	0 (0)	4 (5)	4 (2)
Other[c]	11 (14)	5 (7)	16 (10)
Total	78 (100)	77 (100)	155 (100)

[a] The format used for strain type data is as follows: MLST/SCC*mec* type (for MRSA)/presence (PVL$^+$) or absence (PVL$^-$) of the PVL genes.
[b] Other genotypes of MRSA include those with only a single isolate obtained at baseline from the nares cultures, ST5/IV/PVL$^+$, ST8/IV/PVL$^-$, ST72/IV/PVL$^+$, and ST188/IV/PVL$^-$, or from the hand cultures, ST59/IV/PVL$^-$. Also, one isolate not included here from the baseline nares assessment was determined to be a coagulase-negative *Staphylococcus* species.
[c] Other genotypes of MSSA include those with only one isolate obtained from the baseline nares cultures, ST8slv/PVL$^+$, ST30slv/PVL$^-$, ST45dlv/PVL$^-$, ST97/PVL$^-$, ST278/PVL$^-$, ST348/PVL$^-$, ST432/PVL$^-$, ST537/PVL$^-$, ST582/PVL$^-$, ST683/PVL$^-$, and ST959/PVL$^-$, or from the hand cultures, ST15slv/PVL$^-$, ST34/PVL$^-$, ST87/PVL$^-$, ST434/PVL$^-$, and ST630/PVL$^-$.

MRSA was isolated from detainees in 42/68 tanks (62%), where the prevalence of MRSA colonization ranged from 6.4% (1/18) to 50% (4/8). Power was limited to assess the clustering of strain types by tank, but in 31/42 tanks (74%), no 2 detainees carried a genetically concordant MRSA strain. In the other 11/42 tanks, either 2 or 3 of the tested detainees carried concordant MRSA isolates (range, 8% [2/24] to 37% [3/8]). Thus, we did not find evidence of frequent spread of MRSA among detainees.

For MSSA, in 15/26 tanks (58%), no 2 detainees carried genetically concordant strains. In the other 11/26 tanks (42%), between

TABLE 4 Characteristics of MRSA carriers (nares and/or hands)

Characteristic	Data for: MRSA carriers	Non-MRSA carriers	*P* value
Gender (no. [%])			
Male	54/693 (7.8)	639/693 (92.2)	0.6[a]
Female	21/235 (8.9)	214/235 (91.1)	
Race (no. [%])			
White	25/442 (5.7)	417/442 (94.3)	0.008[a]
Black	49/469 (10.5)	420/469 (89.6)	
Age (yr)			
Mean (±SD)	33.3 (10.0)	33.6 (10.2)	0.8[b]
Median	32.1	31.9	
Range	18.3–55.9	18.5–72.1	
Length of stay in jail at time of culture (days)			
Mean (±SD)	98 (118)	109 (131)	0.3[c]
Median	57	69	
Range	1–677	1–1,410	

[a] Chi-square test.
[b] *t* test.
[c] Wilcoxon rank-sum test.

TABLE 5 Logistic regression model of variables associated with MRSA colonization

Risk factor	OR (95% CI)	*P* value
Age	1.0 (0.97–1.04)	0.8
Length of jail stay[a]	0.89 (0.74–1.1)	0.2
White male (reference)	1.0	NA[b]
Black male	2.7 (1.5–5.0)	0.002
White female	2.2 (0.95–5.1)	0.07
Black female	2.0 (0.87–4.4)	0.1

[a] Log-transformed variable.
[b] NA, not applicable.

2 and 4 tested detainees carried MSSA isolates that shared a concordant genotype (range, 12% [2/17] to 57% [4/7]); in 5 of the 11 tanks, only 2 detainees carried concordant MSSA, and in 4 of the tanks, ST398 MSSA/PVL-negative isolates were carried by >1 detainee, as described elsewhere (29). Thus, we did not find evidence of frequent transmission of MSSA among detainees, with the exception of ST398 (29).

Table 4 shows the bivariate association of demographic characteristics with MRSA carriage. Regression analysis demonstrated that among 910 white and black subjects, black males (odds ratio [OR], 2.7; 95% confidence interval [CI], 1.5 to 5.0; $P = 0.002$) were more likely than white males to carry MRSA (Table 5). In a separate regression model, carriage of an *S. aureus* isolate was not associated with age or length of jail stay, but black females (OR, 0.51; 95% CI, 0.33 to 0.79; $P = 0.003$) were about half as likely as white males to carry an *S. aureus* isolate.

Our findings cannot be used to determine the frequency of transmission of *S. aureus* in the jail. However, our data suggest that in-jail transmission of *S. aureus* is uncommon. First, only a minority of the tanks housed more than 2 detainees who carried genotypically concordant *S. aureus* strains. Second, among detainees with jail stays of <6 months, there was a trend toward a decreased likelihood of MRSA carriage with a longer stay ($P = 0.1$). Of the detainees in jail for 1 or 2 days, 17% (4/23) carried MRSA; of those who had arrived in the previous 1 to 7 days, 12% (8/68) carried MRSA. This decrease with longer stay is consistent with published data. In 2006 at the Baltimore County Jail, 15.8% of newly arriving detainees had nasal MRSA carriage (17). In the Los Angeles County Jail (LACJ), 9% of MRSA SSTIs in 2002 and 14% in 2003 were diagnosed <5 days after arrival (4), and a computer model suggested that the epidemic of CA-MRSA SSTIs in the LACJ was not fueled by transmission within the jail (30).

Our study has limitations. We did not assess how frequently MRSA is actually transmitted, carriage in the throat, perineum, or axilla, or the impact of hygienic behaviors, substance abuse, or past medical history on the likelihood of *S. aureus* carriage. Also, some tanks had a small percentage of enrolled detainees.

Hand colonization with MRSA has been considered by many to be a relatively unimportant, transient phenomenon. However, it may represent a means of person-to-person MRSA transmission that is amenable to intervention, particularly in the community in settings in which hand washing is not frequent.

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