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Methicillin-resistant *Staphylococcus aureus* Colonization in the Long-term Care Setting: Characteristics of Nasal Carriage and Transmission

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ABSTRACT

Methicillin-resistant *Staphylococcus aureus* Colonization in the Long-term Care Setting: Characteristics of Nasal Carriage and Transmission
By Nimalie D. Stone, M.D.

Methicillin-resistant *Staphylococcus aureus* (MRSA) is highly prevalent in long-term care facilities (LTCFs) but its transmission dynamics are not well defined in this setting. Over a 6-month period we classified MRSA nasal carriage into 3 groups: *persistent* (all cultures positive), *intermittent* (at least one, but not all cultures positive), and *non-carrier* (no cultures positive). We plated each nasal swab on MRSA selective media for culture and graded growth on a semi-quantitative scale from 0 (no growth) to 6 (heavy growth).We calculated a growth score for each subject by averaging the growth from all cultures obtained to estimate burden of carriage. We defined *MRSA acquisition* as an initial negative culture followed by >1 positive culture with no subsequent negative cultures. We collected epidemiologic data for risk factor analysis and typed MRSA isolates by pulsed-field gel electrophoresis (PFGE). Among 412 residents at 3 LTCFs, MRSA prevalence was 59% with distributions of carriage similar at all three facilities: 20% persistent, 39% intermittent, 41% non-carriers. Multivariate analysis showed MRSA carriage was associated with prior history of MRSA culture (OR 3.5, $p<0.0001$), device use (OR 1.8, $p=0.03$), and receipt of systemic antibiotics (OR 1.7, $p=0.04$). The mean growth score of MRSA differed significantly between the persistent and intermittent positive carriers (3.4 vs. 1.2, $p<0.0001$). Of 254 residents with an initial negative swab, 25 (10%) acquired MRSA over the 6 months; rates were similar at all three LTCFs. Multivariate analysis demonstrated receipt of systemic antibiotics during the study was the only significant risk factor for MRSA acquisition (OR 7.8, $p=0.002$). MRSA strains from acquisitions were related to those from a roommate by PFGE in 9/25 (36%) cases; 6 of these 9 roommates had persistent carriage. MRSA colonization prevalence was high across three separate VA LTCFs. MRSA acquisition was strongly associated with antibiotic exposure in the LTCF. Roommate sources were often *persistent* carriers but transmission from roommates accounted for less than half of all MRSA acquisitions.

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INTRODUCTION

Infections and colonization with antibiotic resistant bacteria among residents of long-term care facilities (LTCFs) is an ongoing problem (1-3). Methicillin-resistant *Staphylococcus aureus* (MRSA) is an antibiotic resistant organism with the potential to be transmitted within healthcare facilities and establish colonization and/or infection in susceptible hosts. Studies in acute care populations have shown that eradication of MRSA colonization can decrease subsequent risk for infections following surgical procedures and in intensive care units (ICU) (4,5). Generalizing research findings from the acute care environment, guidelines published by the Society of Healthcare Epidemiologists of America (SHEA) recommend active surveillance, and cohorting of MRSA carriers in LTCFs to reduce transmission of MRSA within these facilities (6). However, aggressive institution of these measures may not be appropriate for elderly, frail LTCF residents and may result in negative consequences (e.g., social isolation, depression). Consequently, a better understanding of the epidemiology of MRSA colonization and transmission is needed in the long-term care setting.

This study examined the epidemiology of MRSA carriage among three geographically distinct LTCFs over a 6-month time period to identify patterns of MRSA transmission and explore risk factors associated with MRSA acquisition.

BACKGROUND

Longitudinal studies examining *Staphylococcus aureus* nasal carriage has distinguished at least three patterns: persistent carriage, intermittent carriage and non-carriage (7). Notably, persistent carriers have higher bacterial loads than intermittent carriers and a higher risk of developing invasive infection (7, 8). Methicillin-resistant *Staphylococcus aureus* (MRSA) has carriage patterns similar to those of *S. aureus* (9, 10); however, unlike *S. aureus* colonization which tends to be more prevalent in infants and children, MRSA colonization has been associated with age >60 years old (7, 11).

Long-term care facilities (LTCF) serve as an important reservoir for MRSA strains (2). Colonization rates in residents of LTCFs vary widely, ranging from 8-53% for nasal colonization and from 30-82% for wound colonization (12). Although the risk of development of invasive infections among MRSA colonized patients in the acute care setting has been well-demonstrated (13), there is debate about the impact of MRSA colonization in the long-term care setting. Muder et al. followed 197 patients from a Veterans Administration (VA) LTCF who had surveillance cultures of the anterior nares to determine *S. aureus* carrier status. Over a 36 month period, 25% of MRSA colonization individuals developed a staphylococcal infection compared to 4.5% of non-carriers (relative risk 3.8). (14) In contrast, Bradley et al. demonstrated only 6% of MRSA carriers developing infection versus 1% of non-carriers in a 12 month study within a different VA LTCF (9). The difference in outcomes between the two studies was attributed to the fact that the study by Muder included patients from an intermediate care unit who had a higher level of medical complexity, device utilization and nursing needs than the population in Bradley's cohort.

In the past few years, there has been an increase in the proportion of LTCF residents who are receiving post-acute care following hospitalization. Post-acute care includes skilled nursing care, rehabilitation, and wound care. Residents requiring post-acute care have more invasive devices and interventions, such as hemodialysis, and increased antibiotic exposure than other LTCF residents. This increased acuity places them at higher risk for both MRSA colonization and

infection (15, 16). Previous studies assessing MRSA colonization and subsequent risk of infection have been done in the long-term care setting without reference to whether the resident was receiving short term post acute care or was a long stay resident.

Acquisition of MRSA colonization is assumed to be an intermediate step toward development of invasive infections. The risk of progression from colonization to infection has been demonstrated in a variety of patient populations (13). Therefore, many control efforts have focused on reducing transmission of MRSA from known carriers to non-carriers by active surveillance and cohorting of carriers away from non-carriers (6, 17). With high prevalence of MRSA carriage in the long-term care setting, there is concern about the transmission of this organism in these facilities. However, there have been limited studies addressing the risk of MRSA transmission/acquisition in LTCFs. A better understanding of the impact of MRSA colonization and acquisition is needed in the long-term care setting. This study examined the epidemiology of MRSA colonization and acquisition among a cohort of residents in three VA LTCFs over a 6-month time period.

METHODS

This study was designed to test two specific hypotheses: **null hypothesis #1)** the frequency of nasal colonization with MRSA in the LTCF residents exposed to antibiotics or medical devices, hospitalized or with a pressure wound is statistically equal to the frequency of nasal colonization of those without those risk factors after controlling for appropriate confounding variables; **null hypothesis #2)** MRSA acquisition in the LTC setting occurs randomly.

This multi-centered prospective cohort study followed residents for a 6-month period. The three participating facilities were members of the VA Southeast Network and were located in Atlanta, GA, Augusta, GA, and Tuscaloosa, AL. All three facilities care for a mixture of patients some requiring chronic nursing home care and others receiving post-acute rehabilitation with skilled nursing needs. The Atlanta VA LTCF was a 100-bed nursing home care unit which was physically connected to an acute care medical center. The Augusta VA LTCF was a free standing 132-bed restorative nursing home which was 3 miles away from an acute care medical center. The Tuscaloosa VA LTCF was the largest facility in the study with 178 nursing home beds. This facility did not have an affiliated VA acute care medical center close by so most residents would move to a community medical center for acute care needs. Enrollment dates were staggered at each site so the total data collection period was from October 2006 until August 2007. All residents of the LTCFs were eligible for inclusion in the study except for respite care residents whose shortened length of stay (<2 weeks) was not sufficient to determine carrier status. A minimum of three nares cultures was required for defining MRSA carrier status and being included in the risk factor analyses.

Eligible residents had their MRSA carrier status defined by sequential nares swab cultures, 3 weekly followed by 5 monthly. Each swab culture was plated to MRSA selective media and bacterial growth at 24 hours was graded by a semi-quantitative scale from 0 (no growth) to 6 (heavy growth). A growth score was calculated for each participant by averaging the

growth from all cultures obtained to estimate burden of nasal carriage. A representative colony from each positive MRSA nares culture underwent molecular strain characterization by pulsed-field gel electrophoresis (PFGE). Digital images of all PFGE gels were analyzed using Gelcompar II (Applied Maths). Percent similarities were identified on a dendrogram based on Dice coefficients. These stain types were compared to a digital database of known USA standard MRSA pulse-field patterns (*courtesy of Linda McDougal, Centers for Disease Control and Prevention, Atlanta, Georgia)* for classification within a USA group based on a similarity coefficient of $\geq$80% (18).

There were two primary outcome variables. **MRSA nasal carriage** was classified into 3 groups: *persistent* (all cultures positive), *intermittent* (at least one, but not all cultures positive), and *non-carrier* (no cultures positive). **MRSA acquisition** was defined as an initial negative culture followed by >1 positive culture with no subsequent negative cultures.

Predictor variables were collected for both MRSA carriage and MRSA acquisition risk factor analysis. These variables included: demographics (age, gender), prior medical conditions calculated into a *Charlson comorbidity index* (19) on a scale from 0-37 (higher score= increasing comorbidity), standardized quarterly evaluations of functional status extracted to calculate an activities of daily living index, *ADL index*, on a scale from 4-18 (higher score= increasing dependence), previous MRSA identified in surveillance/clinical cultures, antibiotic exposure in the 3 months prior to study entry and during the study, hospitalizations in the prior year and during the study, presence of a pressure wound during the study, and presence of any medical device during the study including urinary catheters, intravenous devices, and percutaneous gastrostomy tubes.

The first analysis compared risk factors between MRSA carriers to non-carriers. A secondary analysis between persistent MRSA carriers versus intermittent MRSA carriers was also performed with incorporation of growth score into the analysis. The second analysis compared risk factors between those with MRSA acquisition to non-carriers. Molecular strain analysis was

evaluated separately to explore the role of roommate transmission among those who acquired MRSA during the study. For each analysis, univariate analyses were conducted using the chi-square test for categorical variables and the Mann-Whitney test or Kruskal-Wallis test for continuous variables. Those variables significant at $p<0.05$ on univariate analyses were entered into the multivariable models along with other clinically meaningful variables to identify significant associations for each outcome. Several models were examined including a full model with all variables and a final model reduced to variables found significant by univariate examination. Goodness of Fit (GOF) statistics were calculated. All statistical analyses were carried out using SAS version 9.1 (Cary, NC)

RESULTS

There were 445 residents enrolled in the study among the three VA LTCFs: 107 from Atlanta (ATL), 139 from Augusta (AUG) and 199 from Tuscaloosa (TUSC). Overall, 329 residents were present in the facilities from the start of the study (inception cohort) while 116 (26%) were new admissions over the study period. All three study facilities had a similar proportion of new admissions (range 23%-29%) during the study period. The mean age of residents was 72.3 (range 23-101) and 98% of the study population was male which is consistent with the current demographics of the VA long-term care population. The comorbidity and functionality indices of the population were similar across the three study sites but the time spend in the facility prior to the study inception was shorter for residents in ATL compared to the other sites (Table 1).

The prevalence of MRSA carriage over the entire study period was 58% and there was no statistically significant difference in the prevalence of carriage among the three facilities ($p=0.64$, Chi-square for trend). Based on first culture obtained at study entry, MRSA prevalence was higher among the inception cohort compared to the new admission cohort (44% vs. 22%, $p<0.0001$). There was not a significant difference in the MRSA carrier prevalence between residents being admitted to the LTCF from home compared to those coming from other healthcare facilities (25% vs. 22%, $p=0.76$). The distribution of MRSA carriage was similar at all three facilities ($p=0.16$, Chi-square for trend), with 20% persistent carriers, 39% intermittent and 41% non-carriers among the 412 residents who had three or more cultures obtained so that status could be characterized. Thirty-three (7%) residents had fewer than 3 cultures and therefore could not have carrier status defined (Table 2). Among the non-carriers, only 24% were found to carry methicillin-susceptible *S. aureus*, while 76% did not carry any strain of *S. aureus* at all.

The analysis to identify risk factors predictive of MRSA carriage included the 412 residents, 242 MRSA carriers (persistent or intermittent) and 170 non-carriers, who had at least 3 or more cultures of nasal swabs available to define MRSA carrier status. Univariate analysis of

risk factors predictive of MRSA carriage demonstrated significant associations for prior antibiotic exposure in the 3 months before study entry (p=0.0003), prior hospitalization in the 12 months prior to study entry (p=0.04), prior isolation of MRSA in surveillance/clinical culture prior to study entry (p<0.0001), presence of a pressure wound (p=0.0005), presence of a device during the study (p<0.0001), receipt of systemic antibiotics during the study (p<0.0001), and ADL index (p=0.006) with MRSA carriage during the study (Table 3). The final multivariable model was reduced from all risk factors studied in univariate analysis (Table 4A) to include only the significant risk factors as well as a variable for each site given the possibility that there were facility-level risk factors which could not be controlled for by our model. The strongest predictor of MRSA carriage during the study was prior isolation of MRSA in surveillance/clinical culture prior to study entry (RR 3.5, p<0.0001) although presence of a device and receipt of systemic antibiotics during the study were also significant risk factors (Table 4B).

In an analysis looking for risk factors which might differentiate persistent carriage (n=83) from intermittent carriage (n=159), only prior isolation of MRSA in surveillance/clinical culture prior to study entry (57% vs. 33%, p=0.0005) was statistically different between the two groups. However, mean growth score from swabs obtained over the study period was significantly lower in the intermittent carriage cohort compared to the persistent cohort across all three facilities (1.2 vs. 3.4, p<0.0001, t-test) (Table 5). This difference in growth score remained statistically meaningful even when taking the average from only the positive swabs obtained from the intermittent cohort compared to the persistent carriers (2.4 vs. 3.8, p<0.0001, t-test).

Among the 412 residents included in the initial analysis, 245 (62%) had their first nares swab culture negative for MRSA. Of those, 25 (10%) fit the pattern for MRSA acquisition over the study period. The distribution of MRSA acquisition was similar among the three facilities: 6/64 (9%) in ATL, 9/79 (11%) in AUG, and 10/101 (10%) in TUSC. The incidence density of acquisition was approximately 1 acquisition/ 1,000 facility days. Mean time to acquisition was 49 days (range 7-147), but the mean time to acquisition among just the 6 residents who were new

admissions to the facilities was 25 days. The mean time the non-carriers were followed during the study was 140 days.

Analysis for risk factors associated with MRSA acquisition during the study compared the 25 residents who acquired MRSA carriage to the 170 non-carriers. Univariate analysis identified several exposures which were difference between the two groups including prior antibiotic exposure in the 3 months before study entry ($p<0.0001$), presence of a device during the study ($p=0.04$), presence of an intravenous line (peripheral or central) during the study ($p<0.0001$), receipt of systemic antibiotics during the study ($p<0.0001$), and higher Charlson comorbidity index ($p=0.03$), (Table 6). The multivariable model revealed that only receipt of systemic antibiotics during the study remained a significant predictor of MRSA acquisition after controlling for presence of an intravenous line during the study, Charlson comorbidity index and transfer to a hospital during the study (Table 7). Further evaluation into antibiotic exposure during the study revealed that those who acquired MRSA had a longer duration of antibiotic exposure (22 days vs. 8 days for non-carriers, $p<0.0001$, t-test), and fluoroquinolone antibiotics were used with greater frequency in this group relative to the total population (68% in the acquisition group vs. 27% of the total population).

Among the 25 residents who acquired MRSA, 12 either had no primary roommate or a roommate who was a non-carrier, making it likely that the source of acquisition was someone or something other than the roommate. Of the 13 whose roommates were MRSA carriers, 9 had a strain that by analysis of PFGE typing could have been related to their roommate's strain; 5 of these were highly related (Figure 1). Among these 9 individuals who may have acquired MRSA from their roommate, 6 (67%) of them had roommates who were persistent carriers. Also, 5/9 (56%) who may have acquired MRSA from a roommate were new admissions to the facility.

DISCUSSION

We found MRSA carriage to be highly prevalent (58%) over this 6-month study with similar rates of carriage demonstrated among three geographically distinct VA LTCFs. The primary risk factors for being an MRSA carrier based on multivariable analysis were prior isolation of MRSA in surveillance/clinical culture prior to study entry, presence of a device, and receipt of systemic antibiotics during the study. Similar risk factors for MRSA carriage have previously been described in the literature (9, 20-23) in the LTC setting. The patterns of MRSA carrier status, (persistent, intermittent and non-carrier), previously described in the literature (7, 9, 10), were confirmed in this larger cohort with similar distributions at all three LTCFs. There were more intermittent carriers in this 6 month study compared to an 8-week longitudinal pilot done previously at the ATL LTCF (36% vs. 23%) (10); this may be a result of the longer duration of surveillance. Burden of bacterial carriage, reflected in the mean growth score, was the only distinguishing characteristic between the persistent and intermittently positive carriers. We demonstrated the importance of bacterial burden in a pilot study (10) but the present study represented three distinct sites and a larger cohort.

The acquisition rate of MRSA in the LTCFs was 0.42% per week. The rate of acquisition was similar across all three LTCFs despite the fact that each facility was regionally distinct and had different geographical relationships to acute care medical centers. ATL LTCF was physically connected to the acute care hospital, while AUG and TUSC were separate, free-standing facilities. Also, of note, there was an active surveillance and cohorting strategy to prevent MRSA transmission being done at TUSC but the rate of acquisition was no different there compared to ATL and AUG, in which no MRSA surveillance strategies were implemented.

The major risk factor for acquisition of MRSA was systemic antibiotic exposure during the study. Although prior antibiotic exposure is a well described risk factor for MRSA carriage and infection, (24-26) our study showed antibiotic use as a risk for MRSA acquisition following a prior documented negative culture. During a hospital outbreak of MRSA, a case-control study

demonstrated that fluoroquinolones exposure was independently associated with hospital-acquired MRSA even when controlling for other risk factors in a multivariable model (27). In a recent study looking at risk of nosocomial acquisition of MRSA among patients with exposure to MRSA colonized roommates, acquisition was independently associated with exposure to levofloxacin (28). Several studies, including those cited above, have suggested a relationship between fluoroquinolone exposure and MRSA colonization or infection. A quasi-experimental study by Madaras-Kelly et al. showed by segmented regression analysis a significant reduction in nosocomial MRSA rates following the implementation of a computerized order entry tool to reduce fluoroquinolone use (29). Active surveillance cultures tend to be the primary focus of many recent MRSA prevention strategies though antibiotic stewardship is also mentioned in recommendations for addressing MRSA transmission in the healthcare setting.

Despite the emphasis in guidelines on preventing MRSA transmission among roommates, most of the acquisition events seen in this study could not be linked back to a roommate. Among the 254 residents initially at risk, only 9 (3.5%) were likely from our data to have acquired MRSA from their roommate. This finding was comparable to the study by Bradley et al. in 1991 which concluded that 3% of transmission events were due to roommates, even though the MRSA prevalence in Bradley's cohort was significantly lower than what was seen in the current study (9). Unique in this study was the finding that if roommates were the likely source of transmission, the majority of them were persistent carriers. The relationship between high bacterial burden of nasal carriage with persistent MRSA carriage raised the possibility that persistent carriers may confer a greater potential to serve as a source of transmission to non-carriers.

There were a few limitations to this study. Since the majority of residents (74%) enrolled were present in the long-term care facilities for an average of 2 years prior to the start of the study, the study only captured a small portion of total time at risk for this cohort. This could have led to misclassification bias in the assignment of MRSA carrier cohorts. This would be particularly relevant to the small cohort of 25 new acquisitions; of these, only 6 residents were new to the

facilities during the study. Censored swab results due to resident's leaving the facility may have also resulted in misclassification. Although this bias could influence risk factor analysis, it should favor the null hypothesis. Misclassifications should occur with similar frequency into every cohort resulting in a balanced distribution of risk factors among the groups. Therefore, any statistically significant findings would be more likely to reflect true risk factors for predicting either MRSA carriage or risk of acquisition. There was potential for loss of sensitivity in detecting MRSA nasal carriage using the culture technique, compared to PCR-based systems, however, the repeated cultures that were part of this protocol should have increased the likelihood of identifying MRSA carriers. Although we were able to identify risk factors at the time of MRSA surveillance swabbing, we did not capture the total length of time a risk factor was present. Therefore, we were not able to incorporate the duration of risk factor exposure into the analysis.

Despite these limitations, this study provided some important information about the risk factors for MRSA carriage and acquisition in the long-term care setting. Prevalence of MRSA was high but documented transmission was less than one episode per week. Of those residents who acquired MRSA, most of them likely acquired the organism from someone other than their roommate. Our study suggested that the risk of MRSA transmission is not the same for all carriers – persistent carriers may be involved in more transmission. Finally, these data emphasize that infection control should be coupled with efforts to optimize antibiotic utilization. Antibiotic exposure increases the risk of MRSA acquisition and the current strategies focused on cohorting MRSA carriers away from non-carriers may not be adequate in preventing acquisition for many of those at risk due to the communal living conditions of the residents. A multi-faceted strategy of antibiotic stewardship, targeted surveillance and selected resident cohorting might be the best way to limit transmission and acquisition of MRSA in this vulnerable population.

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Table 1. Characteristics of residents within each of the three VA long-term care facilities enrolled in the study

Variable	Atlanta n=107	Augusta n=139	Tuscaloosa n=199	Total n=445	p-value*
Mean age (Range 23-101 yrs)	71	72.8	72.5	72.3	0.63
Male gender (%)	95%	98%	99%	98%	0.12
Mean length of stay in facility prior to study entry (Range 1-7977 days)	472	781	824	726	**0.02**
Mean Charlson index (Range 0-11)	3.27	3.39	2.99	3.18	0.29
Mean activities of daily living index (Range 4-18)	9.3	10.9	10.2	10.3	**0.04**
Mean facility days per resident during study period (Range 1-365)	244.6	286.3	248.3	259.2	**0.06**
Number of deaths during 1 year study	31 (29%)	35 (25%)	73 (37%)	139 (31%)	0.07

* Kruskal-Wallis for continuous variables; Chi-sq for trend for dichotomous variables

Table 2. Distribution of MRSA carrier cohorts by long-term care facility

Carrier cohort	Atlanta n=107	Augusta n=139	Tuscaloosa n=199	Total* n=445
Persistent	21 (20%)	28 (20%)	34 (17%)	83 (19%)
Intermittent	29 (27%)	46 (33%)	84 (42%)	159 (36%)
Non-carrier	48 (45%)	57 (41%)	65 (33%)	170 (38%)
Less than 3 swabs obtained	9 (8%)	8 (6%)	16 (8%)	33 (7%)

* p=0.16, Chi-sq for trend

Table 3. Univariate analysis of risk factors for MRSA carriage during the study

Variable	MRSA carriers during study (n=242)	Non-carriers (n=170)	p-value
Antibiotic use in prior 3 months	122 (50%)	55 (32%)	**0.0003**
Hospitalization in prior 12 months	129 (53%)	73(43%)	**0.04**
Previous MRSA in culture	100 (41%)	26 (15%)	**<0.0001**
Presence of a wound	90 (37%)	36 (21%)	**0.0005**
Presence of any device during the study	154 (64%)	65 (38%)	**<0.0001**
Antibiotic use during the study	153 (63%)	72 (42%)	**<0.0001**
Hospitalization during the study	40 (17%)	18 (11%)	0.09
Mean age*	72.5	71.8	0.48
Mean length of stay in facility prior to study*	830	690	0.13
Mean Charlson index *	3.12	3.05	0.51
Mean activities of daily living index*	10.7	9.4	**0.006**

Chi-square for dichotomous variables; *Mann-Whitney for continuous variables

Table 4A. Multivariable analysis of risk factors predictive of MRSA carriage among long-term care facility residents (n=412): All predictors from univariate analysis in model

Risk factor	Risk Ratio (95% Confidence Interval)	p-value
Resident in Augusta*	1.14 (0.61-2.11)	0.68
Resident in Tuscaloosa*	1.32 (0.71-2.45)	0.38
Antibiotic use in prior 3 months	1.26 (0.73-2.16)	0.41
Hospitalization in prior 12 months	1.05 (0.63-1.75)	0.84
Previous MRSA in culture	3.43 (1.99-5.91)	**<0.0001**
Presence of a wound	1.74 (1.04-2.92)	**0.04**
Presence of any device during the study	1.86 (1.06-3.27)	**0.03**
Antibiotic use during the study	1.62 (0.96-2.73)	0.07
Hospitalization during the study	1.22 (0.60-2.47)	0.59
Age	1.02 (0.99-1.04)	0.07
Length of stay in facility prior to study	1.00 (1.00-1.00)	0.36
Charlson index	1.01 (0.90-1.13)	0.85
Activities of daily living index	1.00 (0.95-1.06)	0.84

*Resident in Atlanta =reference group

Table 4B. Multivariable analysis of risk factors predictive of MRSA carriage among long-term care facility residents (n=412): Reduced model including only significant predictors from univariate analysis

Risk factor	Risk Ratio (95% Confidence Interval)	p-value
Resident in Augusta*	1.17 (0.64-2.17)	0.60
Resident in Tuscaloosa*	1.36 (0.74-2.50)	0.33
Antibiotic use in prior 3 months	1.20 (0.70-2.06)	0.50
Hospitalization in prior 12 months	0.95 (0.59-1.52)	0.82
Previous MRSA in culture	3.45 (2.03-5.94)	**<0.0001**
Presence of a wound	1.66 (0.99-2.76)	0.05
Presence of any device during the study	1.83 (1.05-3.17)	**0.03**
Antibiotic use during the study	1.72 (1.03-2.86)	**0.04**
Activities of daily living index	1.01 (0.96-1.06)	0.71

*Resident in Atlanta =reference group

Table 5. Comparison of mean growth scores between intermittent and persistent MRSA carrier cohorts among three long-term care facilities

MRSA carrier cohort	Atlanta	Augusta	Tuscaloosa	Total
Intermittent carriers (n)	1.23 (29)	1.33 (46)	1.08 (84)	1.18 (159)
Persistent carriers (n)	4.11 (21)	3.26 (28)	3.01 (34)	3.37 (83)
p-value*	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

*Mann-Whitney test

Table 6. Univariate analysis of risk factors for MRSA acquisition during the study

Variable	MRSA acquisition (n=25)	Non-carriers (n=170)	p-value
Antibiotic use in prior 3 months	19 (76%)	55 (32%)	**<0.001**
Previous MRSA in culture	6 (24%)	26 (15%)	0.27
Presence of a wound	8 (32%)	36 (21%)	0.23
Presence of any device during the study	15 (60%)	65 (38%)	**0.04**
Presence of an intravenous line during the study	5 (20%)	4 (2%)	**<0.0001**
Antibiotic use during the study	22 (88%)	72 (42%)	**<0.0001**
Hospitalization during the study	6 (24%)	18 (11%)	0.06
Mean age*	72.2	71.8	0.86
Mean length of stay in facility prior to study*	414	690	0.22
Mean Charlson index *	4.00	3.05	**0.03**
Mean activities of daily living index*	10.7	9.4	0.27

Chi-square for dichotomous variables; *Mann-Whitney for continuous variables

Table 7. Multivariable analysis of risk factors predictive of MRSA acquisition among long-term care facility residents (n=195)

Risk factor	Risk Ratio (95% Confidence Interval)	p-value
Antibiotic use during the study	7.76 (2.1-28.56)	**0.002**
Hospitalization during the study	1.51 (0.48-4.72)	0.48
Presence of an intravenous line during the study	4.37 (1.00-19.12)	0.05
Charlson index	1.20 (0.98-1.47)	0.08

Figure 1. Pulse-field gel electrophoresis (PFGE) image demonstrating relatedness of MRSA strains isolated from two roommates (ID 256 and ID 283). Also present on gel are PFGE standards for USA500 type-strain (USA500 and NRS500).