Methicillin Resistant *Staphylococcus aureus:* Carriage Rates and Characterization of Students in a Texas University

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OBJECTIVE: To evaluate the carriage rates of *Staphylococcus aureus* and methicillin resistant *Staphylococcus aureus* (MRSA) in a university student population and describe risk factors associated with the carriage of each.

DESIGN: Cross-sectional study (N = 203). Institutional Review Board approval was obtained from Texas State University-San Marcos.

SETTING: Texas State University-San Marcos, San Marcos, TX.

PARTICIPANTS: Two-hundred and three university student samples were collected from December 2007 to July 2008.

INTERVENTIONS: None indicated.

MAIN OUTCOME MEASURES: The sample set was screened for *S. aureus* and MRSA identification by standard microbiological techniques and confirmed by use of a Vitek 2 per manufacturer recommendation. Antibiotic susceptibility testing was conducted on each MRSA isolate by Vitek 2. A questionnaire was conducted with each student to acquire demographic and risk factor information. Demographic data is shown by raw numbers, percentages, mean, and median where applicable. The compiled data was screened and analyzed by chi square (p values) and odds ratio (OR) with confidence interval (CI) to determine significance.

RESULTS: Of the 203 participants who were screened, 60 (29.6%) carried *S. aureus*. Univariate analysis found that only hospitalization in the past 12 months was significantly associated with the risk of being a *S. aureus* carrier (OR=3.0, 95% CI 1.28-7.03). Of the 60 participants that carried *S. aureus*, 15 were identified as MRSA. This relates to a 7.4% MRSA carriage rate among generally healthy university students. Univariate analysis found that hospitalization in the past 12 months (OR = 4.2, 95% CI 1.29-13.36) and recent skin infection (OR = 4.4, 95% CI 1.07-18.24) were significantly associated with the risk of being a MRSA carrier. No unique antibiotic susceptibility patterns were identified with the MRSA isolates.

CONCLUSIONS: The carriage rate of *S. aureus* is consistent with similar studies. MRSA carriage in this university study appears high as compared to the general population. Although this study did not confirm a variety of risk factors for carriage of MRSA previously identified by others, university healthcare personnel should be aware of the changing epidemiology of MRSA and preventive measures needed to avoid outbreaks.

ABBREVIATIONS: MRSA= Methicillin resistant *Staphylococcus aureus*; CA-MRSA=Community-associated methicillin resistant *Staphylococcus aureus*; HA-MRSA=Healthcare-associated methicillin resistant *Staphylococcus aureus*; CLS = Clinical Laboratory Science; OR = Odds Ration; CI = Confidence Interval.

INDEX TERMS: Methicillin resistant *Staphylococcus aureus*, MRSA, Community-associated methicillin resistant *Staphylococcus aureus*, CA-MRSA, College healthcare.

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INTRODUCTION

Since the introduction and widespread use of antibiotics, resistant strains of bacteria have become a major healthcare problem[1]. Isolates of *Staphylococcus aureus* with resistance to beta-lactam antibiotics were first reported in the United States in 1961, and have since continued to evolve.[1,2] Methicillin resistant *Staphylococcus aureus* (MRSA) has become one of the major antibiotic-resistant pathogens in recent years, and is capable of causing a wide range of skin and invasive infections including endocarditis, pneumonia, osteomyelitis, gastroenteritis, septic arthritis, deep abscess formation, and rarely, necrotizing fasciitis.[3-8] For the past several decades, MRSA has become a serious problem in patients with exposure to the healthcare system, and is responsible for substantial morbidity and mortality in hospitals around the world.[9] Today, healthcare-associated methicillin resistant *Staphylococcus aureus* (HA-MRSA) accounts for approximately 85% of all invasive MRSA infections.[10] Unfortunately, the epidemiology of MRSA seems to be changing.

MRSA has evolved in the community and is unrelated to the evolution of HA-MRSA in hospitals and other settings. These community associated strains, known as community-associated methicillin resistant *Staphylococcus aureus* (CA-MRSA) have begun to appear outside of the healthcare setting, and the rise of serious infections have been seen in non-hospitalized, previous healthy young people.[11] CA-MRSA is easily transmissible, not only between families, but also in larger close-contact communal settings such as prisons, schools, and sports teams.[5,11] Environmental sources, such as the sharing of clothing, sports equipment, towels, razors, and soaps; improper care of skin trauma; crowded living conditions, along with lack of cleanliness and personal hygiene, are identified as possible risk factors for CA-MRSA infections.[1,5,12]

Because nasal carriage (colonization) of *S. aureus* has been identified as a major risk factor for subsequent infections, an understanding of the risk factors for carriage of *S. aureus* and MRSA is crucial to understanding the potential for invasive infections and transmission of such diseases.[3] A variety of studies have examined community prevalence of nasal carriage in subpopulations including hospitals, outpatient settings, jails, and injection drug users.[3,9,13-16] Several studies have been conducted with medical students[17-19] but few studies have examined the characteristics of CA-MRSA in a general student population.[20-22]

The purpose of this study was (1) to measure the nasal carriage rate of *S. aureus* and MRSA, (2) to examine the antibiotic sensitivity of MRSA isolates by microbiological susceptibility testing, and (3) to conduct an univariate analysis in order to identify risk factors significantly associated with nasal carriage of *S. aureus* and MRSA in a population of dormitory and non-dormitory students at a four year public university in Texas. It is anticipated that the findings of this study will be utilized in (1) the development of specific health education and/or promotion activities for those who are at greater risk for acquiring MRSA or who are currently colonized in this university population via a campus-wide program on MRSA awareness, (2) the identification of antibiotic resistance trends occurring in this university population, and (3) to assist university healthcare officials in the control and prevention of transmission of MRSA with respect to risk factors identified in this study.

MATERIALS AND METHODS

Sample and Data Acquisition

A cross-sectional design was applied to determine the rate of *S. aureus* and MRSA carriage in university students and to describe exposures (risk factors) associated with carriage. Clinical Laboratory Science (CLS) personnel at the university recruited college students by notification during dorm hall meetings, classroom lectures, and random encounters for participation. Investigators incorporated a purposive sampling strategy with the final sample consisting of dormitory and non-dormitory students over the age of 18 who had been previously enrolled

for at least one long semester. A long semester at this institution is approximately three and a half months. Previous enrollment for at least one long semester aided the research design by serving as a criterion to standardize the students' exposure to university risk factors. All student participation was voluntary, and participants first authorized informed consent documents. The institutional review board of Texas State University–San Marcos approved all procedures and protocols. Only students who understood English were asked to participate. CLS personnel obtained questionnaire information (Figure 1) and nasal swabs from students who elected to participate. Data collection (i.e., nasal swabs and questionnaires) occurred from December 2007 to July 2008. The questionnaire was administered to collect general demographic information including age, ethnicity, and gender. Additionally, risk factor information about possible MRSA exposure, knowledge of MRSA, hospital admission and work, intravenous drug use, dorm living status, and athletic involvement was collected. BactiSwabs (Remel Inc., Lenexa, KS) were used (both anterior nares) for demonstration to participants by CLS personnel and subsequently self-administered by each participant. No identifying information was collected from the informed consent, questionnaire, or swab. Specimens were then transported to the Texas State University CLS laboratory for specimen processing.

Laboratory Analysis

Nasal swab specimens were screened for *S. aureus* and MRSA using the standard media mannitol salt agar (MSA) and oxacillin-resistant screening agar (Becton Dickinson BBL, Franklin Lakes, NJ), Dry Spot Staphytect Plus test kits (Oxoid Limited, Lenexa, KS), and Dropit catalase reagent (Key Scientific Products, Round Rock, TX). Positive colony growth on oxacillin agar was confirmed as MRSA by Vitek 2 (bioMérieux, Hazelwood, MO) susceptibility testing at CTMC (CTMC, San Marcos, TX) using Vitek GN19 susceptibility cards. Cards were inoculated and incubated in the Vitek 2 per manufacturer recommendations and results were analyzed by the advanced expert system, software version R04.03. All tests were performed according to the manufacturer's instructions. All growth on MSA or Oxacillin Agar not consistent with *S. aureus* or MRSA was discarded.

S. aureus, MRSA, and *S. epidermidis* specimens were provided by CTMC as confirmed by Vitek 2 analysis and were used as positive and negative controls during inoculation of all microbiological testing. Because no medical intervention is indicated for MRSA carriage, laboratory results were not reported to students.

Data Screening

CLS personnel entered questionnaire and laboratory results into an Excel database (Microsoft, Redmond, WA) for initial data collection. Prior to conducting our analyses, the total data set (N = 203) was screened for missing and/or out of range values, sparse cell frequency counts, and the sample size to number of cells ratio using SPSS (version 15.0, SPSS Inc., Chicago, IL). There were no missing data points, or empty cells and the sample size was greater than five times the number of cells for all analyses except ethnicity.[23-24] A chi square and odds ratio (OR) analysis with 95% confidence intervals (CI) was conducted on the total sample (N=203) and subsequently on the MRSA isolates (N = 15). To account for sparse cell frequencies with certain categories, the variable, ethnicity, was coded for Caucasian versus non-Caucasian (African American, Asian, Hispanic, and other) and age was coded as 18-23 years versus 24 years and above.[23-24]

Data Analysis

A cross-sectional design was utilized to determine the carriage rates of *S. aureus* and MRSA in university students and to describe any risk factors associated with each, respectively. The questionnaire was designed to ascertain student demographics (age, gender, and ethnicity), health care exposures (kidney dialysis, surgery, hospitalization, occupation, IV drug use, antibiotic use, or catheter), living condition (campus dormitory, non-dormitory, athletic participation, or jail history), and history of skin infection (skin infection, boil or sore with pus, been told by a doctor that they had MRSA, or heard of MRSA or antibiotic resistant staphylococcus).

The students together as a university sample were analyzed using SPSS by univariate analysis on each variable listed in the questionnaire with *S. aureus* carriage being the outcome (dependent) variable. The analysis of each independent variable was then subsequently examined with MRSA being the outcome variable. Odds ratios with associated 95% confidence intervals were calculated and reported. The statistical significance of factors was evaluated using an alpha level of 0.05. A Multivariate analysis for significant variable associations using logistic regression (Enter method) did not identify a valid multivariable model for explanation.[23-24]

Each MRSA isolate was tested for susceptibility, intermediate resistance, or resistance to a panel of antibiotics. The analysis was conducted by the Vitek 2 and data was examined for any unique trends or outliers as identified by standardized results.

Figure 1. Questionnaire for risk factors to *Staphylococcus aureus* and Methicillin Resistant *Staphylococcus aureus* (MRSA)

Age

Gender (Circle)	
Male	Female

Ethnicity (Circle)				
Hispanic	African-American	Caucasian	Asian	Other

INFECTIONS:

1	In the past 12 months, have you had a skin infection, boil, or sore?	Yes	No	Don't know/ Prefer not to answer
2	In the past 12 months, has a doctor told you that you have a skin infection called MRSA, "mersa," or antibiotic resistant Staph?	Yes	No	Don't know/ Prefer not to answer
3	Have you ever heard of MRSA, "mersa," or antibiotic resistant Staph?	Yes	No	Don't know/ Prefer not to answer

If so, how did you hear about it?

_____

HEALTHCARE

4	In the past 12 months, have you been a patient in the hospital?	Yes	No	Don't know/ Prefer not to answer
5	In the past 12 months, have you had surgery?	Yes	No	Don't know/ Prefer not to answer
6	In the past 12 months, have you worked in a healthcare facility?	Yes	No	Don't know/ Prefer not to answer
7	In the past 3 months, have you taken any antibiotics?	Yes	No	Don't know/ Prefer not to answer
8	In the past 12 months, have you used intravenous drugs?	Yes	No	Don't know/ Prefer not to answer

LIVING CONDITIONS

9	Are you currently living in a dorm?	Yes	No	Don't know/ Prefer not to answer
10	In the last 6 months, have you lived in a dorm?	Yes	No	Don't know/ Prefer not to answer
11	In the past 12 months, have you been in jail?	Yes	No	Don't know/ Prefer not to answer
12	In the past 12 months, have you participated in athletics?	Yes	No	Don't know/ Prefer not to answer

RESULTS

Study Population

A total of 203 participants volunteered to participate in this study. The subject's ages ranged from 18 to 52 years old (mean = 22, median = 21). The age group of 18-23 (158, 78%) was greater than the 24+ age group (45, 22%). The male to female ratio was 81 (40%) to 122 (60%), respectively. Ethnically, Caucasians (136, 67%) and Hispanics (41, 20.2%) made up the majority of the population (87.2%). African Americans (10, 5%), Asians (7, 3.4%) and others (9, 4.4%) made up the remainder of the ethnicity of our population sample. There were 108 (53.2%) dorm students that participated in this study. Of those, 34 (31.5%) were positive for *S. aureus* colonization, and seven (6.5%) were positive for MRSA colonization.

S. aureus and MRSA Colonization, Risk Factor Analysis, and Susceptibility

Of the 203 participants who were screened, 60 (29.6%) carried *S. aureus*. Univariate analysis found that only hospitalization in the past 12 months (p=.009) was significantly associated with the risk of being a *S. aureus* carrier (OR=3.0, 95% CI 1.28-7.03). All other risk factors were not statistically significant. Although not significant, there was a moderate association with surgery in the past 12 months and risk of *S. aureus* colonization (OR=1.9, 95% CI 0.62-5.66).

Of the 60 participants that carried *S. aureus*, 15 were identified as MRSA. This relates to a 7.4% MRSA colonization rate among generally healthy, university students. Univariate analysis found that hospitalization in the past 12 months (OR = 4.2, 95% CI 1.29-13.36) and recent skin infection (OR = 4.4, 95% CI 1.07-18.24) were significantly associated with the risk of being a MRSA carrier (p=.026 and .011, respectively). All other risk factors were not statistically significant. There was a moderate elevation of odds ratio (OR = 4.0) and significant chi-square value (p=.038) for surgery in the past 12 months and risk of MRSA colonization. However, this result was deemed not significant due to confidence intervals including one (95% CI = 0.982-16.288). Results of univariate analysis for *S. aureus* and MRSA are listed in Tables 1 and 2, respectively.

Antibiotic susceptibility characteristics of MRSA isolates are shown in Table 3. Only 14 MRSA isolates were analyzed for antibiotic susceptibility; one sample could not be cultured due to contamination. No unique patterns were observed with the antibiotic susceptibility testing. All isolates were 100% resistant to beta lactam antibiotics. Vancomycin, linezolid, gentamicin, moxifloxacin, quinupristin/dalfopristin, and rifampicin were 100% effective (susceptible). Interestingly, erythromycin was 86% resistant to all isolates.

Table 1. Univariate analysis of *S. aureus* colonization risk factors

				95% Confidence Interval	
Risk Factors	Raw Data[D]	p Value	Odds Ratio	Low	Upper
AGE[A]	in text	.630	1.2	.571	2.522
GENDER	in text	.337	1.3	.732	2.484
ETHNICITY[B]	in text	.214	1.5	.783	2.969
SKIN INFECTION[C]	4	.921	1.1	.314	3.596
HOSPITAL PT	13	.009	3.0	1.277	7.029*
SURGERY	6	.258	1.9	.621	5.658
WORK HEALTHCARE	24	.769	1.1	.591	2.038
ANTIBIOTIC USE	18	.754	0.9	.465	1.740
IV DRUGS	1	.628	0.6	.064	5.319
DORM	36	.243	1.4	.780	2.652
JAIL	1	.874	1.2	.108	13.667
ATHLETICS	26	.854	1.1	.575	1.952

A. Age categorized into traditional (18-23 years old) and nontraditional (24+ years old).
B. Ethnicity categorized into Caucasian and non-Caucasian (Hispanic, African American, Asian, Other).
C. Skin infection includes recent skin infection and skin infection with MRSA.
D. Raw number of participants who admitted to the risk factor and who were colonized with *S. aureus*. (Demographic raw numbers are broken down in the results section.)

DISCUSSION

According to the National Health and Nutrition Examination Survey (NHANES) conducted from 2003-2004, the prevalence of colonization with *S. aureus* and MRSA in the civilian non-institutionalized population of the United States was 28.6% and 1.5% respectively.[25] The present Texas study identified a carriage rate of 29.6% *S. aureus* in a university student population which is consistent with the NHANES data. However, the 7.4% MRSA carriage rate among the student population is much higher then the 1.5% carriage rate of the NHANES population. Several different subpopulations have been assessed for CA-MRSA colonization rates including homeless and runaway youths[26], 6.2%; an American Indian clinic population[27], 1.9%; Texas county jail inmates[16,] 4.5%; children at well-child checkups[28], 9.2%, and a college football team with outbreak history[29], 8.0%. The Texas university MRSA carriage rate in this study population compares most closely with the 8.0% carriage rate found in a college football team. Since people are generally unaware of their MRSA carriage status and because the *S. aureus* carriage rate mirrored that of the general population, the authors feel confident that the overall MRSA carriage rate was not unduly biased.

The commonly known risk factors of MRSA are well recognized, typically being healthcare-associated, including hospital admission, recent surgery, intravenous drug use, and working in a healthcare environment.[1,30-32] Univariate analysis in the Texas university study revealed hospitalization to be strongly associated with *S. aureus* and MRSA nasal carriage. Recent skin infection was also significantly associated with the risk of being a MRSA carrier. The Texas university findings echo previous studies and the known risk factors associated with a healthcare environment. Additionally, the MRSA isolates in this study did not reveal any unusual resistance patters; all isolates were resistant to beta lactam antibiotics and susceptible to non-beta lactam drugs. Interestingly, erythromycin exhibited 86% resistance to the isolates.

This study did not confirm a variety of other risk factors for nasal carriage of *S. aureus* previously identified.[10,11,20,33-36] The authors believe this may be due to the fact that most of the previous studies were in medical students and not a healthy, general college population. Like this study, a study in a Hawaiian community college found no significant association with *S. aureus* carriage and ethnicity, gender, recent antibiotic use, or prior *S. aureus* infections.[21] A student community study of preclinical medical students and undergraduate students conducted from 2000-2002 reported significant associations with *S. aureus* carriers and males as well as older age.[20] This study found no significant associations with these risk factors.

Table 2. Univariate analysis of MRSA colonization risk factors

			95% Confidence Interval		
Risk Factors	Raw Data[D]	p Value	Odds Ratio	Low	Upper
AGE[A]	in text	.285	0.5	.176	1.683
GENDER	in text	.561	1.4	.475	3.929
ETHNICITY[B]	in text	.090	3.5	.758	15.815
SKIN INFECTION[C]	3	.026	4.4	.073	18.243*
HOSPITAL PT	5	.011	4.2	1.289	13.364*
SURGERY	3	.038	4	.982	16.288
WORK HEALTHCARE	5	.623	0.8	.249	2.303
ANTIBIOTIC USE	5	.965	1.0	.33	3.136
IV DRUGS	0	.516	1.0	.949	.997
DORM	7	.535	0.7	.260	2.138
JAIL	1	.086	6.6	.561	77.009
ATHLETICS	9	.161	2.1	.726	6.212

A. Age categorized into traditional (18-23 years old) and nontraditional (24+ years old).
B. Ethnicity categorized into Caucasian and non-Caucasian (Hispanic, African American, Asian, Other).
C. Skin infection includes recent skin infection and skin infection with MRSA.
D. Raw number of participants who admitted to the risk factor and who were colonized with *MRSA*. (Demographic raw numbers are broken down in the results section.)

The investigators of this project initially intended to examine the crowded and perhaps unsanitary conditions of university residence halls and their association with *S. aureus* and MRSA carriers. It could be anticipated that these types of close-quarter living conditions would increase the risk of *S. aureus* and MRSA colonization. However, this study found no significant differences between the colonization rates of dorm students and the colonization rates of non-dorm students. A study on Nigerian students found similar results stating that the number of people with whom the subjects shared a room did not seem to affect the rate of nasal carriage.[22]

There were several limitations to this study. Samples were collected from one university and not all dorms on the campus were sampled. It is also important to note that the investigators conducted a small pilot study (N = 203) and thus results should not be generalized to the entire student population. This may not be representative of other universities or other shared campus living quarters. The self administered questionnaire and self administered nose swab could have led to inaccuracies in the risk factor data collected and the colonization rates of MRSA. Students completing the questionnaire may have been lacking the knowledge to accurately complete and answer the risk assessment questions. For instance, several students questioned whether oral contraceptives and aspirin were considered antibiotics, and other students might not have considered insulin or other IV therapy as recent IV drug use.

Because this study was cross-sectional and anonymous, the authors weren't able to examine intermittent versus persistent carriage of *S. aureus* and MRSA. Participants who may have been intermittently colonized may not have been detected in this study. Additionally, positively identified MRSA samples could not be further studied and detailed histories of past colonization risk factors could not be investigated. Finally, the investigators were not able to conduct genetic analysis (e.g. PFGE) of MRSA isolates to characterize strains that may be significant. Regrettably, the MRSA isolates became contaminated or perished at a secondary laboratory. It is anticipated that a future study will be conducted to include a larger sample size with genetic analysis included.

Table 3. Antibiotic susceptibility of MRSA isolates

	Isolates[B]														RXN[C]		
Abx[A]	5	22	50	85	91	104	126	135	152	159	163	187	197	201	%S	%R	%I
BP	R	R	R	R	R	R	R	R	R	R	R	R	R	R	0	100	0
CFS	R	R	R	R	R	R	R	R	R	R	R	R	R	R	0	100	0
CIP	R	S	R	S	S	S	S	S	I	R	S	S	R	S	64	29	7
CLIN	R	S	R	R	S	S	S	S	R	S	S	S	R	S	64	36	0
ERY	R	R	R	R	R	R	R	S	R	R	R	R	R	S	14	86	0
GEN	S	S	S	S	S	S	S	S	S	S	S	S	S	S	100	0	0
LF	I	S	I	S	S	S	S	S	I	I	S	S	I	S	64	0	36
LZ	S	S	S	S	S	S	S	S	S	S	S	S	S	S	100	0	0
MXF	S	S	S	S	S	S	S	S	S	S	S	S	S	S	100	0	0
NF	S	I	S	S	S	S	S	S	S	S	S	S	S	S	93	0	7
Q/DF	S	S	S	S	S	S	S	S	S	S	S	S	S	S	100	0	0
R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	100	0	0
TET	R	R	R	R	S	S	S	S	S	S	S	S	S	S	71	29	0
TMP	S	S	S	R	S	S	R	S	S	R	S	S	S	S	79	21	0
VAN	S	S	S	S	S	S	S	S	S	S	S	S	S	S	100	0	0
OX	R	R	R	R	R	R	R	R	R	R	R	R	R	R	0	100	0

A. Abbreviated antibiotics: BP = benzylpenicillin; CFS = cefoxitin screen; CIP = ciprofloxacin; CLIN = clindamycin; ERY = erythromycin; GEN = gentamicin; LF = levofloxacin; LZ = linezolid; MXF = moxifloxacin; NF = nitrofurantoin; Q/DF = quinupristin/dalfopristin; R = rifampicin; TET = tetracycline; TMP = trimethoprim; V = vancomycin; OX = oxacillin

B. Isolate numbers (14 total MRSA isolates; 1 isolate unable to grow due to contamination); R = resistant, S = susceptible, I = intermediate

C. RXN = Total percentage of MRSA isolates identified as S, R or I

Due to convenience, some of our participants were selected from other health profession majors. A majority of these students have worked in healthcare facilities, and this may have created a bias towards *S. aureus* and MRSA carriage rates. Further studies should look at randomly selected healthy members of a university to expand upon the knowledge of various carriage rates among schools and should examine other risk factors to help understand how MRSA and *S. aureus* are transmitted in the community along with risk assessment. Additionally, surveillance studies should be conducted to examine the community in the dorms alone to better assess the risk factors of living in close contact quarters over a period of time. This may augment the evaluation of how *S. aureus* and MRSA are transmitted through the community.

CONCLUSION

The purpose of this study was to identify the more commonly associated risk factors associated with *S. aureus* and MRSA carriage in a general university population. The investigators identified a strong association with past hospitalization for *S. aureus* colonization; past hospitalization and recent and skin infection with MRSA colonization. No significance for MRSA carriage was identified between dormitory and non-dormitory students. CA-MRSA, along with HA-MRSA, has emerged as a growing world-wide problem in the past decade(s). Common-sense approaches to prevention, along with intelligent use of the laboratory (culture of wounds, antibiotic susceptibility testing, etc.) and available antimicrobials, can protect individuals from this new threat. University officials should be aware of the potential transmission risk and outbreak scenario that could develop in the rich environment of student living and recreation. Finally, research is desperately needed in the area of knowledge, awareness, and the learning needs (gaps in knowledge) of the general public with respect for MRSA and other antibiotic resistant organisms.

Clin Lab Sci encourages readers to respond with thoughts, questions, or comments regarding this article. Email responses to westminsterpublishers@comcast.net. In the subject line, please type "CLIN LAB SCI 22(2) RE ROHDE". Selected responses will appear in the Dialogue and Discussion section in a future issue. Responses may be edited for length and clarity. We look forward to hearing from you.

REFERENCES

1. Chi C, Wong W, Fung C, and others. Epidemiology of community-acquired *Staphylococcus aureus* bacteremia. J Microbiol Immunol Infect 2004 02;37(1):16-23.
2. Loffler CA, Macdougall C. Update on prevalence and treatment of methicillin-resistant *Staphylococcus aureus* infections. Expert Rev Anti Infect Ther 2007 12;5(6):961-81.
3. Mainous AG, Hueston WJ, Everett CJ, and others. Nasal carriage of *Staphylococcus aureus* and methicillin-resistant *S. aureus* in the United States, 2001-2002. Ann Fam Med 2006 03;4(2):132-7.
4. Gorwitz RJ, Kruszon-Moran D, McAllister SK, and others. Changes in the prevalence of nasal colonization with *Staphylococcus aureus* in the United States, 2001-2004. J Infect Dis 2008 05/01;197(9):1226-34.
5. Banning M. Transmission and epidemiology of MRSA: Current perspectives. Br J Nurs 2005 //2005 May 26-Jun 8;14(10):548.
6. Krziwanek K, Luger C, Sammer B, and others. MRSA in Austria--an overview. Clin Microbiol Infect 2008 03/05;14(3):250-9.
7. Miller LG, Perdreau-Remington F, Rieg G, and others. Necrotizing fasciitis caused by community-associated methicillin-resistant *Staphylococcus aureus* in Los Angeles. N Engl J Med 2005 04/07;352(14):1445-53.
8. Lowy FD. *Staphylococcus aureus* infections. N Engl J Med 1998 08/20;339(8):520-32.
9. Kenner J, O'Connor T, Piantanida N, and others. Rates of carriage of methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* in an outpatient population. Infect Control Hosp Epidemiol 2003 06;24(6):439-44.
10. Centers for Disease and Prevention. *Invasive MRSA.* Retrieved June 1, 2008, from www.cdc.gov/ncidod/dhqp/ar_mrsa_Invasive_FS.html.
11. Weiner R. Methicillin-Resistant *Staphylococcus aureus* on Campus: A New Challenge to College Health. J American College Health 2008 56:4: 347-350.
12. Beam JW, Buckley B. Community-acquired methicillin-resistant *Staphylococcus aureus*: Prevalence and risk factors. J Athl Train 2006 07;41(3):337-40.
13. Huang H, Cohen SH, King JH, and others. Injecting drug use and community-associated methicillin-resistant *Staphylococcus aureus* infection. Diagn Microbiol Infect Dis 2008 04/21;60(4):347-50.
14. Turabelidze G, Lin M, Wolkoff B, and others. Personal hygiene and methicillin-resistant *Staphylococcus aureus* infection. Emerg Infect Dis 2006 03;12(3):422-7.
15. Moran GJ, Krishnadasan A, Gorwitz RJ, and others. Methicillin-resistant *S. aureus* infections among patients in the emergency department. N Engl J Med 2006 08/17;355(7):666-74.
16. Felkner M, Rohde RE, Valle-Rivera AM, and others. Methicillin-resistant Staphylococcus Aureus Nasal Carriage Rate in Texas County Jail Inmates. J Correctional Health Care 2007;13(4):289-95.
17. Stubbs E, Pegler M, Vickery A, and others. Nasal carriage of *Staphylococcus aureus* Australian (pre-clinical and clinical) medical students. J Hosp Infect 1994;27:127-34.
18. Kingdom JC, Joyce SM, Bradley FL, and others. Staphylococcal nasal carriage in medical students with varying clinical exposure. J Hosp Infect 1983;4:75-9.
19. Dunkelberg H. On the incidence of *Staphylococcus aureus* in the throat of medical students. Zentralbl Bakteriol 1976;163:530-35.
20. Bischoff WE, Wallis ML, Tucker KB, and others. *Staphylococcus aureus* nasal carriage in a student community: Prevalence, clonal relationships, and risk factors. Infect Control Hosp Epidemiol 2004 06;25(6):485-91.
21. Morita JE, Fujioka RS, Tice AD, and others. Survey of methicillin-resistant *Staphylococcus aureus* (MRSA) carriage in healthy college students, Hawai'i. Hawaii Med J 2007 08;66(8):213-5.

22. Lamikanra A, Paul BD, Akinwole OB, Paul MO. Nasal carriage of *Staphylococcus aureus* in a population of healthy Nigerian students. J Med Microbiol 1985 04;19(2):211-6.
23. Tabachnick BG, Fidell LS. Using Multivariate Statistics , 5th ed. Boston: Allyn and Bacon; 2007.
24. Mertler C, Vannatta R. Advanced and Multivariate Statistical Methods, 3rd ed. Los Angeles: Pyrczak Publishers; 2005.
25. National Nosocomial Infections Surveillance (NNIS) System. National Nosocomial Infections Surveillance (NNIS) System report: data summary from January 1992-June 2001, issued August 2001. Am J Infect Control 2001;29:404-21.
26. Pan ES, Diep BA, Carleton HA, and others. Increasing prevalence of methicillin-resistant *Staphylococcus aureus* infection in California jails. Clinical Infectious Diseases 2003;36:1384-8.
27. Leman R, Alvarado-Ramy F, Pocock S, and others. Nasal carriage of methicillin-resistant *Staphylococcus aureus* in an American Indian population. Infection Control and Hospital Epidemiology 2004;25:121-5.
28. Creech CB, Kernodle DS, Alsentzer A, and others. Increasing rates of nasal carriage of methicillin-resistant *Staphylococcus aureus* in healthy children. Pediatric Infectious Disease Journal 2005;24:617-21.
29. Nguyen DM, Mascola L, Brancoft E. Recurring methicillin-resistant *Staphylococcus aureus* infections in a football team. Emerg Infect Dis 2005 04;11(4):526-32.
30. Graham PL, Lin SX, Larson EL. A U.S. population-based survey of *Staphylococcus aureus* colonization. Ann Intern Med 2006 03/07;144(5):318-25.
31. Klevens RM, Morrison MA, Nadle J, and others. Invasive methicillin-resistant *Staphylococcus aureus* infections in the United States. JAMA 2007 10/17;298(15):1763-71.
32. Salgado CD, Farr BM, Calfee DP. Community-acquired methicillin-resistant *Staphylococcus aureus*: A meta-analysis of prevalence and risk factors. Clin Infect Dis 2003 01/15;36(2):131-9.
33. Saïd-Salim B, Mathema B, Kreiswirth BN. Community-acquired methicillin-resistant *Staphylococcus aureus*: An emerging pathogen. Infect Control Hosp Epidemiol 2003 06;24(6):451-5.
34. Wertheim HFL, Melles DC, Vos MC, and others. The role of nasal carriage in *Staphylococcus aureus* infections. Lancet Infect Dis 2005 12;5(12):751-62.
35. Centers for Disease Control and Prevention. Methicillin-resistant *Staphylococcus aureus* infections among competitive sports participants—Colorado, Indiana, Pennsylvania, and Los Angeles County, 2000-2003. MMWR Morb Mortal Wkly Rep 2003 08/22;52(33):793-5.
36. Goodman RA, Thacker SB, Solomon SL, and others. Infectious diseases in competitive sports. JAMA 1994 03/16;271(11):862-7.