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An evaluation of risk factors for *Staphylococcus aureus* colonization in a pre-surgical population

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Abstract

Staphylococcus aureus (SA) colonization has significant implications in healthcare-associated infections. Here we describe a prospective study conducted in pre-surgical outpatients, done with the aim of identifying demographic and clinical risk factors for SA colonization. We found younger age to be a potential predictor of SA colonization.

INTRODUCTION

Staphylococcus aureus (SA) causes 15% of all healthcare-associated infections [1]. It can lead to serious infections like bacteremia and surgical site infections that have significant implications on healthcare costs, length of hospitalizations and mortality. Carriers of SA have been known to have a higher risk of developing SA infections [2]. In this setting, strategies to identify likely carriers would be a step towards decreasing SA infections, by implementing decolonization protocols in identified carriers [1]. In this study, we analysed data collected on a group of pre-surgical outpatients at a university medical centre to identify risk factors that made them more prone to SA colonization. We selected pre-surgical patients as our population of interest as they provide a unique opportunity to intervene with a decolonization protocol before surgery, potentially preventing post-operative wound infections.

METHODS

This was a secondary analysis of a prospective study conducted from August 2011 to September 2016. The larger protocol compared SA decolonization protocols. In this analysis we aimed to evaluate risk factors for SA colonization. Participants were enrolled at the University of Minnesota Medical Centre (UMMC) at Minneapolis, Minnesota, USA. Participants were recruited via convenience sampling. Outpatients in the UMMC orthopaedic, urologic, neurologic, colorectal, cardiovascular and general surgery clinics who were to undergo elective surgery were approached by study personnel and offered study participation. Inclusion criteria included: (1) anticipated surgery >/=10 days after enrollment to allow completion of study procedures, (2) age >/=18 years, (3) ability to complete the decolonization protocol pre-operatively as an outpatient and (4) no antibiotic therapy within 7 days prior to the cultures. Exclusion criteria included (1) inability to give informed consent, (2) surgery anticipated within 10 days after the cultures and (3) allergy to mupirocin or chlorhexidine gluconate that were to be used for the decolonization protocol. All participants provided written informed consent prior to study inclusion. Nasal, throat, axillary and perianal swabs were obtained and cultured for SA. Participants whose cultures detected presumptive SA at any site and who met eligibility criteria were included. Swab cultures and antimicrobial susceptibility testing of presumptive SA isolates were done at UMMC Infectious Diseases Diagnostic Laboratory.

Culture methods

Swabs were inoculated onto 5% sheep blood agar plates with and without colistin/nalidixic acid. Plates were incubated at 35 °C and inspected at 18–24 h, then were held at room temperature and reinspected at 48 h. Suspect colonies were tested for production of catalase (using hydrogen peroxide; if positive, *Staphylococcus*) and coagulase and/or protein A (using the Staphaurex

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Abbreviations: MRSA, methicillin resistant *Staphylococcus aureus*; MSSA, methicillin sensitive *Staphylococcus aureus*; ROC, receiver operating characteristic; SA, *Staphylococcus aureus*; UMMC, University of Minnesota Medical Center.

Table 1. Screening characteristics by any SA carrier status and MRSA carrier status; values presented are mean (SD) or N (%) where indicated

Screening characteristic	Non-SA carriers	SA carriers	MSSA carrier	MRSA carrier
	(*N*=300)	(*N*=127)	(*N*=118)	(*N*=14)
Female	151 (50.3%)	58 (45.7%)	54 (45.8%)	5 (35.7%)
Age (yrs.)	58.8 (13.4)	54.5 (13.7)	55.7 (13.6)	50.5 (20.5)
BMI	30.1 (6.58)	31.0 (7.42)	30.9 (7.5)	31.9 (8.3)
Race:				
African American	13 (4.3%)	8 (6.3%)	6 (5.1%)	2 (14.3%)
American Indian/Alaska Native	0 (0.0%)	1 (0.8%)	0 (0.0%)	1 (7.1%)
Asian	5 (1.7%)	1 (0.8%)	1 (0.8%)	0 (0.0%)
Hispanic or Latino	2 (0.7%)	2 (1.6%)	2 (1.7%)	0 (0.0%)
White	276 (92.0%)	111 (87.4%)	105 (89.0%)	11 (78.6%)
Hispanic or Latino (Ethnicity Only)	6 (2.0%)	2 (1.6%)	2 (1.7%)	0 (0.0%)
Type of Surgery:				
General	41 (13.7%)	21 (16.5%)	21 (17.8%)	2 (14.3%)
Cardiovascular	2 (0.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Neurosurgical	78 (26.0%)	24 (18.9%)	19 (16.1%)	5 (35.7%)
Orthopaedic	156 (52.0%)	74 (58.3%)	70 (59.3%)	7 (50.0%)
Urological	22 (7.3%)	8 (6.3%)	8 (6.8%)	0 (0.0%)
Colorectal	1 (0.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
No. of people living with subject	1.52 (3.09)	1.5 (1.34)	1.45 (1.27)	1.77 (1.79)
Amount of Daily Living Assistance:				
None	285 (95.0%)	118 (92.9%)	110 (93.2%)	12 (85.7%)
Some	12 (4.0%)	7 (5.5%)	6 (5.1%)	1 (7.1%)
Complete	1 (0.3%)	1 (0.8%)	1 (0.8%)	0 (0.0%)
Self-bathes	292 (97.3%)	120 (94.5%)	112 (94.9%)	12 (85.7%)
Healthcare worker	52 (17.3%)	17 (13.4%)	15 (12.7%)	2 (14.3%)
Previous soft tissue skin infections:				
MSSA	4 (1.3%)	3 (2.4%)	2 (1.7%)	1 (7.1%)
MRSA	10 (3.3%)	6 (4.7%)	5 (4.2%)	1 (7.1%)
Unknown *Staph aureus*	6 (2.0%)	1 (0.8%)	1 (0.8%)	0 (0.0%)
Other	17 (5.7%)	8 (6.3%)	6 (5.1%)	2 (14.3%)
None	264 (88.0%)	109 (85.8%)	104 (88.1%)	9 (64.3%)
Previous non-soft tissue skin infection	1 (0.3%)	2 (1.6%)	1 (0.8%)	1 (7.1%)
Eczema	20 (6.7%)	8 (6.3%)	6 (5.1%)	2 (14.3%)
Other Chronic Skin Condition	36 (12.0%)	13 (10.2%)	11 (9.3%)	2 (14.3%)
Diabetes Mellitus	35 (11.7%)	17 (13.4%)	16 (13.6%)	1 (7.1%)
Has foreign implants	144 (48.0%)	58 (45.7%)	52 (44.1%)	8 (57.1%)
Corticosteroids	6 (2.0%)	5 (3.9%)	4 (3.4%)	1 (7.1%)
Has had radiation therapy	11 (3.7%)	5 (3.9%)	5 (4.2%)	0 (0.0%)
Autoimmune disease	16 (5.3%)	9 (7.1%)	8 (6.8%)	1 (7.1%)

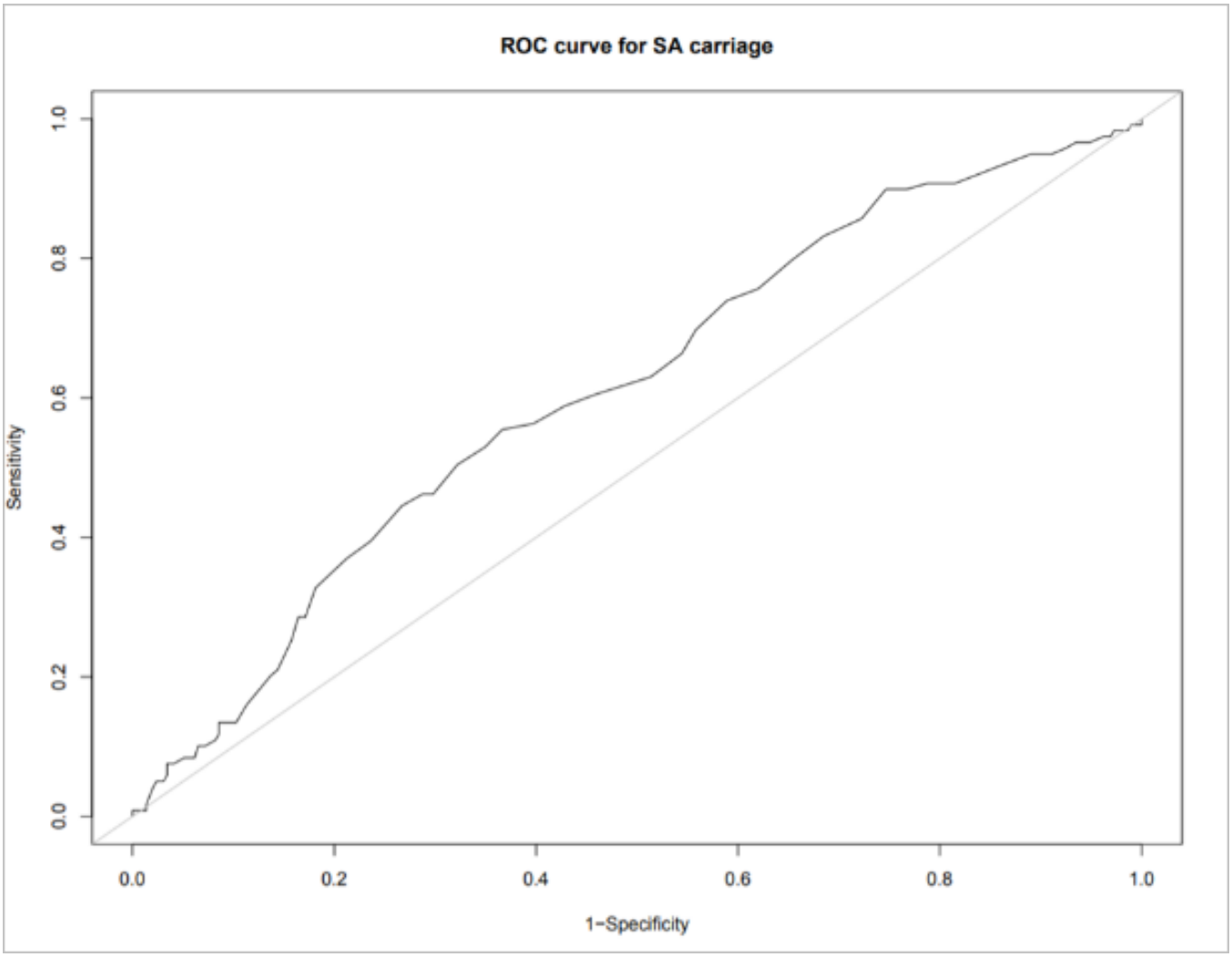

Fig. 1. ROC curve for Age (in years) and SA carriage.

assay [Remel]; if positive, presumptive SA). Catalase-positive, Staphaurex-negative colonies that resembled SA underwent a tube coagulase test (if positive, presumptive SA). Susceptibility testing of presumptive SA isolates was done using the Vitek 2 instrument (bioMérieux).

Statistical methods

Penalized logistic regression with a Lasso penalty was used as a variable selection tool to identify demographic and clinical risk factors for SA carriage [3]. Lambda was chosen to minimize the test mean squared error across ten-fold cross validation. Confidence intervals were obtained via bootstrapping and predictive performance of the final model was assessed by an ROC (Receiver Operating Characteristic) curve. Variables considered for risk factor analysis included age, sex, race (white or other), ethnicity, BMI, number of roommates, amount of daily assistance required, ability to self-bathe, employment in healthcare, playing a sport, history of skin infections (MSSA, MRSA, other, none), eczema, other chronic skin conditions, diabetes mellitus, foreign implants, current or former cancer diagnosis, radiation therapy, autoimmune disease and use of corticosteroids. All analyses were conducted using R version 3.5.1 [4]. The University of Minnesota Human Subjects Protection Programme approved the study protocol (IRB ID: 1106 M01086).

RESULTS

Cultures were obtained from 427 patients. A total of 127 participants (29.7%) confirmed positive for SA at one or more body sites. Of these SA carriers, 89% were colonized with MSSA and 10.2% with MRSA, one patient with both (Table 1). Overall,

48.6% identified as female. Mean age of our population was 55 years. Mean BMI was 30.9. Average number of people living with participants was 1.58.

Age was selected as an important predictor of SA carriage with an odds ratio of 0.986 (95%CI: 0.985, 0.989), indicating that younger age was associated with a higher risk of SA colonization. Fig. 1 graphically shows the results of our analysis in an ROC curve. Age had a sensitivity and specificity of 58%. The penalized model selected unadjusted age as an important predictor of SA carriage and this association was found to be statistically significant (P<0.001).

Gender, race, ethnicity, number of cohabitants, healthcare work, self-bathing and amount of daily assistance required were not found to be associated with SA colonization. We also did not find any association between SA colonization and past medical history of diabetes mellitus, autoimmune disease, corticosteroid use, previous skin and soft tissue infections, radiation therapy, foreign implants, eczema or other chronic skin conditions (Table 1).

DISCUSSION

Surgical infections have significant morbidity, mortality and cost implications. Studies have shown that preoperative SA decolonization can reduce the rates of SA surgical infections [1]. We aimed to evaluate clinical and demographic risk factors for SA colonization.

We found age to be a potential predictor of SA colonization, with indication that younger age may perhaps be associated with a higher risk of SA colonization. This is contrary to what one tends to assume about age and SA colonization: that older individuals are more likely be SA carriers. However, we found that this trend has been described in a remarkable number of previous studies as well [5–16]. Older adults may be at increased risk for infection compared to younger adults, due to an increased frequency of comorbid conditions, as well as age-related immune system changes [17]. They also tend to have invasive infections and outcomes tend to be worse. This likely explains our inclination to assume that older adults are more likely to be colonized as well, which it appears to perhaps not necessarily be the case, based on our and other above findings.

There are important limitations to this study. We recruited patients by approaching them during their outpatient surgery clinic visits once they had elective surgeries scheduled. This recruitment method, though convenient, meant we also had patients who declined to participate. Reasons for declining participation included being pressed for time, required additional effort, and being disinclined to participate in the rectal swabs that the protocol required, among others. We therefore do not have information on the non-participants and how similar or different they were to the participants. It is also to be noted that age had a sensitivity and specificity of only 58% in our study, suggesting that some important explanatory variables were not measured. However, our penalized model selected unadjusted age as an important predictor of SA carriage and this association was found to be statistically significant (P<0.001). Therefore, even with these limitations, we feel this study contributes to the understanding of SA infections and could be suggestive of potential avenues for further research.

CONCLUSIONS

In this surgical outpatient population, younger age was found to be a potential predictor of SA colonization, although further studies in larger populations are necessary to ascertain the reliability and validity of this association.

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Conflicts of interest
The authors declare that there are no conflicts of interest.

Ethical statement
Study protocol was approved by The University of Minnesota Human Subjects Protection Programme (IRB ID: 1106 M01086).

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