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Prevalence and factors associated with *Staphylococcus aureus* nasal colonisation in orthopaedic patients at a tertiary care hospital in Kenya

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***Staphylococcus aureus* is an important organism in orthopaedic practice as it is the most common cause of orthopaedic infections including surgical site infections (SSIs), osteomyelitis and septic arthritis. Carriers of *S. aureus* are predisposed to developing invasive staphylococcal infections. Knowledge of a patient's carrier status before surgery together with interventions to eliminate the carrier state have been shown to reduce post-operative infections by *S. aureus*. A cross-sectional study carried out at Kenyatta National Hospital orthopaedic wards from 1 June 2019 to 30 September 2019. To determine the prevalence and factors associated with nasal colonisation by *S. aureus* among patients who have been admitted to undergo surgery. Consecutive sampling was done until the required sample size was achieved. Nasal swabs were taken from patients at admission for culture. Data concerning comorbid conditions as well as healthcare associated risk factors was collected. The overall prevalence of colonisation by *S. aureus* at admission was found to be 24.7% whereas the overall prevalence of colonisation by Methicillin Resistant *S. aureus* (MRSA) was found to be 3.03%. The prevalence of colonisation by *S. aureus* is high amongst patients being admitted to orthopaedic wards at Kenyatta National Hospital when compared with previous studies and amongst these are those who are colonised by MRSA. The prevalence of MRSA calls for the need of screening programmes to curtail spread within hospital and community settings.**

Key words: *Staphylococcus aureus*, prevalence, nasal colonization, associated factors.

INTRODUCTION

Methicillin-resistant *Staphylococcus aureus* (MRSA) was first documented in 1960 and was mainly found in hospital settings with a few community outbreaks. Currently, the prevalence of MRSA is increasing exponentially and has become a global concern. Knowledge of a patient's *S. aureus* carrier status and subsequent decolonisation has been shown to decrease the occurrence of infective complications after orthopaedic surgery with between 56 and 75% reduction of *S. aureus* surgical site infections (SSIs), 29 and 100% reduction of SSIs due to MRSA and 29 and 81% reduction in all SSIs (Chen et al., 2013; Jeans et al.,

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2018; Ning et al., 2020).

In patients who develop *S. aureus* infections bacteria cultured from the site match (by phage typing) those from the nares in 85% of the cases suggesting an endogenous source of infection (Reighard et al., 2009). Kalmeijer et al. (2000) identified nasal carriage of *S. aureus* as the only independent risk factor for *S. aureus* SSI after orthopaedic implant surgery. Staphylococcal infections after orthopaedic operations are associated with greater mortality rates and increased healthcare expenditure as a result of the need for revision procedures and greater length of stay in hospital (Schmidt et al., 2015).

Results from this study will provide baseline data on the magnitude of *S. aureus* colonisation in orthopaedic patients as well as identify factors predictive of nasal colonisation.

This study aimed to determine the prevalence of nasal colonisation by *S. aureus* among orthopaedic patients being admitted for surgery as well as the risk factors associated with nasal colonisation by Methicillin Resistant *S. aureus* (MSSA) and Methicillin Sensitive *S. aureus* (MRSA).

METHODOLOGY

This cross-sectional study was conducted at Kenyatta National Hospital (KNH) Orthopaedic Wards. KNH is a metropolitan, tertiary, teaching and referral hospital situated at about 5 km from Nairobi city centre. It has a 2000 bed capacity with the orthopaedic wards having a capacity of approximately 300 patients. KNH is a major referral hospital serving East and Central Africa.

Patients aged 18 years and above admitted to the orthopaedic wards between 1st June 2019 and 30th September 2019 and had been assigned for surgery in which orthopaedic implants were to be used.

The study excluded:

(1) Patients who were currently receiving antibiotics or had been on antibiotics during the preceding two weeks.
(2) Patients in whom nasal manipulation is contraindicated.
(3) Patients with active MRSA or MSSA infections.
(4) Patients with upper respiratory tract infections.

All eligible patients were enrolled until the required sample size was obtained.

Sample size

Kenyatta National Hospital has 3 orthopaedic wards that each has a theatre list with approximately 3 patients per day. Going by previous ward records the study envisages a population of 500 patients within the study period (assuming a recruitment success rate of 2 patients per ward per day). The sample size was calculated using Krejcie and Morgan (1970) formula as follows:

$$s = Z^2(1 - \infty/2) \times NP(1 - P) / d^2 (N - 1) + Z^2(1 - \infty/2) P(1 - P)$$

where s = sample size to be determined, Z^2 $(1-\infty/2)$ is the standard error of the mean corresponding to a 95% confidence interval and the corresponding value from a t-table is 1.96, N = Estimated population size, P is the expected prevalence of the event to occur. Value of P was 0.3. d is the target margin of error which will be 5% (0.05) to increase precision.

Therefore, the sample size becomes:

$$s = 1.96^2 \times 500 \times 0.3 (1 - 0.3) / 0.05^2 \times 499 + 1.96^2 \times 0.3 \times 0.7$$

Hence s = 198.

Data collection and analysis

Patients were recruited into the study; data was collected using a questionnaire administered by the interviewer and nasal swab samples taken within 24 h of their admission to the orthopaedic wards.

All enrolled patients were interviewed using a questionnaire, which assessed patient biodata and socio demographic information, co morbidities and risk factors for colonisation by *S. aureus.* Participant's weight and height were measured to calculate body mass index (BMI). They were then examined for wounds (such as abrasions, lacerations, draining sinuses, etc.) and signs of soft tissue infection as evidenced by redness or a purulent discharge. This study utilized single site swabbing due to financial limitations. However, this study is useful as it determined the prevalence of nasal colonisation with *S. aureus* within 24 h of admission to reduce chances of nosocomial transmission. All samples were taken by qualified personnel.

RESULTS

Nasal swab collection was adapted from CDC guidelines for collection of specimens using sterile cotton swabs moistened with sterile water for patient comfort (US Centers for Disease Control and Prevention, 2011). The entire procedure was done by a trained laboratory technician.

The swabs were then inoculated onto sheep blood agar (Oxoid Ltd. Hampshire, UK) within 1 h of sample collection. Plates were incubated at 37°C and examined for growth after 24 to 48 h. Isolates were confirmed as *S. aureus* based on colonial morphology, Gram staining, coagulase and catalase tests. Microscopy was done at University of Nairobi Paediatrics Laboratory.

Data was entered into an excel sheet and analysed using Statistical Package for the Social Sciences (SPSS) version 25. The risk factors and sociodemographic characteristics were analysed at univariate and multivariate levels with the use of Chi square tests. Odds ratio as well as 95% confidence intervals were calculated. A p-value < 0.05 was considered significant. Analysis of results was done with the help of a statistician. The Paediatrics Laboratory, University of Nairobi was used.

Ethical considerations

WHO International ethical guidelines for biomedical research involving human subjects were followed throughout the study. Ethical approval was sought prior to commencing the study from the KNH/UON Ethics, Research and Standards Committee and the Department of Orthopaedic Surgery, University of Nairobi. Written

Table 1. Characteristics of the study participants.

Characteristic	Males	Females	Total
Population size, *S. aureus* carriage and age			
Number of Participants	167 (84.3)	31 (15.7)	198 (100)
Age, years, mean (range)	34 (18-88)	39(19-68)	35 (18-88)
Education			
Primary	61 (36.5)	10 (32.3)	71 (35.9)
Secondary	82 (49.1)	14 (45.2)	96 (48.4)
Tertiary	24 (14.4)	7 (22.6)	31 (15.7)
Body Mass Index (BMI)			
Underweight	37 (22)	2 (6)	39 (20)
Normal	106 (63)	12 (39)	118 (60)
Overweight	19 (11)	9 (29)	28 (14)
Obese	5 (3)	8 (26)	13 (7)
Risk factors for *S. aureus* (MRSA and MSSA) colonisation			
Smoking	42 (25.1)	1 (3.2)	43 (21.7)
Diabetes	4 (2.4)	4 (12.9)	8 (4)
HIV	6 (3.6)	6 (19.4)	12 (6.1)
Admitted to a healthcare facility in the past one year	16 (9.6)	4 (12.9)	20 (10.1)
Used any antibiotics in the past 3 months	59 (35.3)	16 (51.6)	75 (37.9)
Skin or soft tissue infections in the past one year	12 (7.2)	5 (16.1)	17 (8.6)
Previously admitted to ICU	1 (0.6)	0	1 (0.5)
Open wounds	64 (38.3)	11 (35.5)	75 (37.9)
Outpatient clinic in the past one year	29 (17.4)	15 (48.4)	44 (22.2)
Household members ≤ 4	121 (72.5)	20 (64.5)	141 (71.2)
Household members > 5	46 (27.5)	11 (35.50	57 (28.8)
Soft tissue infection	14 (8.4)	5 (16.1)	19 (9.6)

[1]Unless otherwise indicated, data are no. (%) of participants by gender.

informed consent prior to participant enrolment was obtained. Strict confidentiality was observed throughout the period of the study.

Patient characteristics

A total of 198 patients were recruited into the study from 1st June 2019 to 30th September 2019. Of these 167 were male and 31 were female. The male to female ratio was 5.4:1. The mean age was 35, ranging from 18 to 88 years.

Forty-three (21.7%) patients were smokers, eight (4%) were diabetic and 12 (6.1%) were (Human Immunodeficiency virus) HIV positive. Of the 198 patients, 20 (10.1%) had been admitted to a healthcare facility in the past year, 44 (22.2%) had attended a form of outpatient clinic in the past year and 75 (37.9%) had used antibiotics in the preceding 3 months prior to admission. Majority of patients (48.4%) had attained at least secondary school level education and 118 (60%) were of normal BMI (Table 1).

Nasal carriage of *S. aureus*

A total of 49/198 patients had *S. aureus* isolated from the nasal swab samples collected on admission to the hospital. Of the 49, 43 (87.8%) were MSSA and 6 (11.9%) were MRSA. The overall prevalence of MRSA among the study participants was 6/198 (3.03%) whereas the overall prevalence of *S. aureus* nasal colonisation was 49/198 (24.7%). The mean age for the patients colonised by *S. aureus* was 34.8 (SD=9.7) years, those colonised with MRSA was 32.0 (SD=9.1) years, while those colonised with MSSA was 35.2 (SD=9.8). Majority of those colonised by MSSA had heavy growth of the bacteria whereas those colonised by MRSA predominantly had light growth of bacteria.

Of the patients colonised by MRSA, one was female and 5 were male. Only one had no risk factors, 4 had previously visited an outpatient clinic and had antibiotics

Table 2. Characteristics of study participants with MRSA and MSSA.

Characteristics	N	Colonised n (%)	
		MRSA	MSSA
Age			
18-30	19	2 (33.3)	17 (39.5)
31-60	29	4 (66.7)	25 (58.1)
>60	1	0 (0.0)	1 (2.3)
Sex			
Male	42	5 (83.3)	37 (86)
Female	7	1 (16.7)	6 (14)
Education			
Primary	19	2 (33.3)	17 (39.5)
Secondary	22	2 (33.3)	20 (46.5)
Tertiary	8	2 (33.3)	6 (14.0)
Body mass index (BMI)			
<17.5	4	3 (75.0)	1 (25.0)
17.5 - <20.0	10	8 (80.0)	2 (20.0)
20.0 - <22.5	17	15 (88.2)	2 (11.8)
22.5 - <25.0	5	5 (100.0)	0 (0.0)
25.0 - <27.5	5	4 (80.0)	1 (20.0)
27.5 - <30.0	3	3 (100.0)	0 (0.0)
≥30.0	5	5 (100.0)	0 (0.0)
Risk factors for colonisation			
Smoking			
Yes	13	13 (100.0)	0 (0.0)
No	36	30 (83.3)	6 (16.7)
Diabetes			
Yes	1	1 (100.0)	0 (0.0)
No	48	42 (87.5)	6 (12.5)
HIV			
Yes	2	1 (50.0)	1 (50.0)
No	47	42 (89.4)	5 (10.6)
Admitted to a healthcare facility in the past one year			
Yes	5	5 (100.0)	0 (0.0)
No	44	38 (86.4)	3 (13.6)
Used any antibiotics in the past 3 months			
Yes	20	16 (80.0)	4 (20.0)
No	29	27 (93.1)	2 (6.9)
Skin or soft tissue infections in the past one year			
Yes	3	2 (66.7)	1 (33.3)
No	46	41 (89.1)	5 (10.9)
Previously admitted to ICU			
Yes	0	(0.0)	0 (0.0)
No	49	43 (87.8)	6 (12.2)

Table 2. Contd.

Open wound			
Yes	18	16 (88.9)	2 (11.1)
No	31	27 (87.1)	4 (12.9)
Outpatient clinic in the past one year			
Yes	12	8 (66.7)	4 (33.3)
No	37	35 (94.6)	2 (5.4)
Household members			
≤4	37	32 (86.5)	5 (13.5)
>4	12	11 (91.7)	1 (8.3)
Soft tissue infection			
Yes	3	2 (66.7)	1 (33.3)
No	46	41 (89.1)	5 (10.9)

in the past 3 months. None of the patients colonised by MRSA had been admitted in the past year (Table 2).

Risk factors associated with *S. aureus* colonisation

Univariate and multivariate analysis of risk factors for nasal carriage was done. Statistically significant findings were found on multivariate analysis as pertains to BMI whereby patients who were underweight (BMI <18.5) were less likely to be colonised than obese patients (BMI ≥ 30) (OR 0.2 [95% CI 0.0-0.9]). None of the other risk factors for colonization were found to be significant in the study.

Male patients were slightly more likely to be carriers of *S. aureus* than female patients (OR 1.2 [95% CI 0.5-2.9]). Non-smokers were less likely to be carriers when compared with smokers (OR 0.7 [95% CI 0.7-3.0]). Persons from households with less than 4 persons were also more likely to be colonised compared with persons from houses with more than 4 persons (OR 1.3 [95% CI 0.6 - 2.8]).

In contrast to currently available literature, patients who were HIV positive, diabetic, had open wounds or soft tissue infections were less likely to be colonised; however, these findings did not reach statistical significance.

Patients who had no history of antibiotic use in the prior 3 months or had not visited an outpatient facility in the past year were less likely to be colonised (OR 0.8). There was no effect of prior admission to a healthcare facility (OR 1). Table 3 summarises the findings.

DISCUSSION

Prevalence of *S. aureus* colonisation

The overall prevalence of colonisation by *S. aureus* was 24.7% whereas the MRSA prevalence was 3.03%. These findings are in line with those of Kluytmans et al. (1997) who did a review of *S. aureus* carriage and found a mean carriage rate of 35.7% among patients on admission with a wide range of 10.2 to 85.0%.

The carriage rate is higher compared to that found in some previous studies. Aiken et al. (2014) reported a 10.1% carriage rate when screening inpatients in Kenya while Nelwan et al. (2018) in Indonesia reported a 15.6% carriage rate when screening elective surgery patients whereas Egyir et al. (2018) found a 17% carriage rate among inpatients in paediatric and surgical wards in Ghana. The differences may be explained by the fact that Aiken et al. (2014) used a different sampling technique in which he did repeated ward surveys of the inpatients, whereas Egyir et al. (2018) included paediatric patients in their study which differs from the present study in which we only recruited adult patients.

Joachim et al. (2017) in Tanzania found a higher overall nasal carriage rate of 34.5% whereas Kolawole et al. (2013) in Nigeria reported a higher carriage rate of 31.8%. The higher prevalence reported by Joachim et al. (2017) could be due to the collection of a second swab 48 to 72 h after admission whereas Kolawole et al. (2013) utilised Polymerase Chain Reaction (PCR) to identify carriers. Both methods have been shown to increase detection rates of carrier status.

The overall MRSA prevalence matches that of Troillet et al. (1998) who found a carriage rate of 2.6% when nasal swabs were taken and 3.1% when nasal and wound swabs were taken for culture and sensitivity at admission.

Aiken et al. (2014) reported a higher proportion of MRSA at 6.9% when compared with the 3.03% that we got in the current study. The difference may be explained by the fact that Aiken et al. (2014) used a different sampling technique in which he did repeated ward surveys of the inpatients. On the other hand, Joachim et

Table 3. Univariate and multivariate association between colonisation and risk factors.

Characteristic	N=198	Colonization [n (%)]	Univariate p-value; OR (95% CI)	Multivariate p-value; OR (95% CI)
Age				
18-30	82	19 (23.2)	0.594; 1.8 (0.2 -16.0)	0.909; 1.2 (0.1 -12.7)
31-60	109	29 (26.6)	0.481; 2.2 (0.3-18.8)	0.785; 1.4 (0.1 -14.3)
>60	7	1 (14.3)	1.0	1.0
Sex				
Male	167	42 (25.1)	0.761; 1.2 (0.5-2.9)	0.711; 1.2 (0.4 -3.8)
Female	31	7 (22.6)	1.0	1.0
BMI				
<18.5	39	6 (15.4)	0.087; 0.3 (0.1 -1.2)	0.037; 0.2 (0.0 -0.9)
18.5-24.9	118	30 (25.4)	0.319; 0.5 (0.2 -1.8)	0.150; 0.3 (0.1 -1.5)
25-29.9	28	8 (28.6)	0.528; 0.6 (0.2 -2.6)	0.312; 0.4 (0.1 -2.2)
>=30	13	5 (38.5)	1.0	1.0
Household Members				
≤4	141	37 (26.2)	0.445; 1.3 (0.6-2.8)	0.241; 1.6 (0.7 -3.6)
>4	57	12 (21.1)	1.0	1.0
Diabetes				
Yes	8	1 (12.5)	1.0	1.0
No	190	48 (25.3)	0.426; 2.4 (0.3 -19.7)	0.358; 3.3 (0.3 -41.5)
HIV				
Positive	12	2 (16.7)	1.0	1.0
Negative	186	47 (25.3)	0.508; 1.7 (0.4 -8.0)	0.213; 3.2 (0.5 -20.3)
Open wound				
Yes	75	18 (24.0)	1.0	1.0
No	123	31 (25.2)	0.849; 1.1 (0.5 -2.1)	0.678; 1.2 (0.6 -2.4)
Soft tissues infection				
Yes	19	3 (15.8)	1.0	1.0
No	179	46 (25.7)	0.481; 1.6 (0.4 -5.8)	0.406; 1.8 (0.4 -7.5)
Smoking				
Yes	43	13 (30.2)	1.0	1.0
No	155	36 (23.3)	0.348; 0.7 (0.3 -1.5)	0.381; 0.7 (0.3 -1.6)
Education				
Primary	71	19 (26.8)	0.92; 1.1 (0.4 -2.7)	0.849; 1.1 (0.4 -3.1)
Secondary	96	22 (22.9)	0.742; 0.9 (0.3 -2.2)	0.723; 0.8 (0.3 -2.3)
Tertiary	31	8 (25.8)	1.0	1.0
Admitted to a healthcare facility in the past 1 year				
Yes	20	5 (25.0)	1.0	1.0
No	178	44 (24.7)	0.978; 1.0 (0.3 -2.9)	0.948; 1 (0.3 -3.5)
Used any antibiotics in the past 3 months				
Yes	75	20 (26.7)	1.0	1.0
No	123	29 (23.6)	0.625; 0.8 (0.4 -1.6)	0.405; 0.7 (0.3 -1.6)

Table 3. Contd.

Outpatient clinic in the past 1 year				
Yes	44	12 (27.3)	1.0	1.0
No	154	37 (24.0)	0.660; 0.8 (0.4 -1.8)	0.633; 0.8 (0.3 -2.1)
Previously admitted to ICU				
Yes	1	0 (0.0)	1.0	1.0
No	197	49 (24.9)	-	-

al. (2017) in Tanzania found a MRSA carriage rate of 8.5%. The difference in MRSA carriage rates could be explained by the different populations studied, Joachim et al. (2017) was studying prevalence at admission among medical patients who are more likely to be chronically ill and therefore more likely to be colonised by MRSA as a result of repeated antibiotic exposure and visits to healthcare facilities which are both risk factors for colonisation by MRSA.

Egyir et al. (2018) in Ghana found a MRSA prevalence of 3.6%. The difference in results may be explained by the different populations studied as Egyir et al. included paediatric patients.

Kolawole et al. (2013) in Nigeria reported MRSA prevalence of 3.7% when testing patients on admission to surgical wards. The higher prevalence may be explained by the fact that nasal and cutaneous sites were tested on admission and extra nasal testing has been shown to increase detection rates of the carrier status.

While the MRSA prevalence in this study is 3.03% on admission there remains the possibility of spread of MRSA within the ward to other patients especially with the overcrowding, bed sharing, understaffing and poor infection control adherence sometimes witnessed in orthopaedic wards. Clements et al. (2018) showed that overcrowding and understaffing led to failure to control MRSA leading to increased hospital stay, bed blocking hence worsening overcrowding and leading to a vicious cycle characterized by further infection control failure.

Risk factors associated with colonisation by *S. aureus*

Statistically significant findings were found on multivariate analysis as pertains to BMI whereby patients who were underweight (BMI <18.5) were less likely to be colonised than obese patients (BMI ≥ 30) (OR 0.2 [95% CI 0.0-0.9]).

The other risk factors for colonisation by MSSA and MRSA did not reach significance. Joachim et al in a similar study in Tanzania with 258 patients also found no association between risk factors and colonisation. Smoking was found to predispose to colonisation contrary to results by Sivaraman et al. (2009). Diabetics, HIV positive patients, patients with soft tissue infections and patients with open wounds were found to be less likely to be colonised contrary to what is reported in the literature (Troillet et al., 1998; Immergluck et al., 2017; Amir et al., 1995). Patients who had no history of antibiotic use in the prior 3 months or had not visited an outpatient facility in the past year were less likely to be colonised. This and the lack of significance of other findings in this study may be due to the smaller sample size and unique characteristics of the cohort, that is, predominantly young adult men with no comorbidities. This may also be due to poor recall on the part of the patients e.g. majority of respondents who said they had antibiotics prior to admission could not tell us which antibiotic they had been using. Additionally, some of the risk factors such as diabetes, HIV, prior admission to ICU, admission to a nursing home or taking care of a bedridden patient had a small number of patients and in some cases no patients responding positively possibly contributing to the lack of association as some of these are important risk factors for colonisation by MSSA and MRSA.

Conclusion

The prevalence of colonisation by *S. aureus* is high amongst patients being admitted to the orthopaedic wards at KNH when compared with previous local studies and amongst these are patients who are already colonised by MRSA.

Recommendations

(1) Routine decolonisation of orthopaedic patients prior to surgery with intranasal mupirocin or nasal povidone iodine and chlorhexidine body washes.
(2) Need for more research to determine if those with MSSA and MRSA have higher infection rates.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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