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Assessment of risk factors for nasal colonization of *Staphylococcus aureus* and their methicillin-resistant strains among Allied Health Sciences Students of Chandigarh

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Abstract

Staphylococcus aureus being a nasal commensal can cause minor to life threatening serious invasive diseases and it is the most common cause of nosocomial infections. Among *Staphylococcus aureus*, methicillin resistant strains are posing a great challenge for treatment options. Therefore, the purpose of this study was to assess the nasal carriage rate of *Staphylococcus aureus*, their methicillin resistant strains and risk factors. Nasal swabs were cultured and the growth of *Staphylococcus aureus* was identified by standard microbiological methods recommended by American Society for Microbiology (ASM). Modified Kirby-Bauer disk diffusion method was used for antibiotic susceptibility testing. Methicillin resistance was confirmed using cefoxitin and oxacillin disks. Inducible clindamycin resistance was identified using D-zone test. A questionnaire was collected from each of the participants for the assessment of risk factors. Out of 200 participants, nasal carriage of *Staphylococcus aureus* was detected from 30 (15%) subjects. Carriage of *Staphylococcus aureus* and their methicillin resistant strains was significantly associated with nasal diseases ($P < 0.05$). No isolates were found to be resistant to vancomycin and teicoplanin. Methicillin resistance was detected in 8 (4%) isolates. The result of our study indicates that the nasal carriage rate of *Staphylococcus aureus* is comparably high and it needs for the longitudinal surveillance to minimize the transmission of this organism from community to hospital settings.

Introduction

Staphylococcus aureus is a common commensal of humans and its primary habitat is the moist squamous epithelium of the anterior nares. About 20% of the population is always colonized with *S. aureus*, 60% are intermittent carriers, and 20% never carry the organism. As there is considerable evidence that carriage is an important risk factor for invasive infection [1, 2]. A smaller subset of these persons is colonized with methicillin resistant *Staphylococcus aureus* (MRSA) [3].

Staphylococcus aureus can cause a range of illnesses from minor skin infections, such as pimples, impetigo, boils (furuncles), cellulitis, folliculitis, carbuncles, scalded skin syndrome and abscesses, to life-threatening diseases such as pneumonia, meningitis, osteomyelitis, endocarditis, toxic shock syndrome (TSS), and septicemia. It is still one of the four most common causes of nosocomial infections, often causing post surgical wound infections [4]. *Staphylococcus aureus* is primarily coagulase-positive while most other *Staphylococcus* species are coagulase-negative. However, the most common organism in patients with nosocomial bacteremia is coagulase-negative s*taphylococcus* (CoNS) [5].

It is well recognized that nasal carriage of MRSA represents a major risk factor for subsequent infection and transmission of this pathogen [6, 7]. Risk factors for acquiring MRSA include prolonged hospitalization, exposure to antibiotics, and the presence of other patients with MRSA colonization or infection in the hospital. MRSA causes life threatening infections. Mortality from MRSA infection may be greater than that from methicillin-sensitive *Staphylococcus aureus* (MSSA) infections. Besides that, vancomycin, a glycopeptide antibiotic is the only drug useful to treat MRSA infections. The continuous use of vancomycin may promote growth of vancomycin-intermediate *Staphylococcus aureus* (VISA) and vancomycin-resistant *Staphylococcus aureus* (VRSA) [8].

Therefore, this study was conducted to assess the persistent nasal carriage rate of *Staphylococcus aureus*, MRSA, their antimicrobial susceptibility profile and the associated risk factors in the medical students prior to the clinical exposure.

Materials and Methods

This simple and cross-sectional study was carried out at Chandigarh University Mohali Punjab during March to August, 2025. A total of 200 UIAHS students before clinical exposure in the hospital were enrolled in this study.

Data collection

The participants were described about the *Staphylococcus aureus*, MRSA, MSSA, nasal colonization and importance of this study. After obtaining the appropriate written consent the participants were requested to complete a questionnaire on basic demographic characteristics (age, sex, ethnicity, the primary job of the participants' household member, number of family members, family income, family education), any potential risk factors (history of hypertension, renal disease, pulmonary disease, gastro-intestinal disease, nasal disease, recent hospitalization, recent surgery, recent visit to OPD, any recent medication, recent antibiotic use) and habitual factors (alcohol consumption, smoking habit, recent visit to public amusement palaces, tattoo or acupuncture, contact with live stock, contact with pet and type of residence) during first set of swab collection.

In addition, detailed and illustrated instructions on how to collect a nasal swab were provided to the participants.

Exclusion criteria

The participants were excluded if they were receiving either intranasal antibiotic ointment including mupirocin, or antistaphylococcal antibiotics including clindamycin, cephalexin, cefazolin, oxacillin, dicloxacillin, trimethoprim/sulfamethoxazole, linezolid or vancomycin.

Sample collection

Duplicate (two weeks apart) nasal swabs were collected from both anterior nares of the students. Aseptic technique was followed while collecting the swab samples. After collection the swab samples were transported immediately to the laboratory and processed for bacteriological profile within half an hour of collection.

Microbiological study

Swab processing

For the isolation and identification of *Staphylococcus* species from the swab samples, several media used were 5% blood agar (BA), chocolate agar (CHA), MacConkey agar (MA), DNase agar and mannitol salt agar (HiMedia Laboratories Pvt. Limited, India) and the tests used were catalase and coagulase. The collected swab samples were inoculated onto different culture media. The CHA plates were incubated in a CO2 incubator (10% CO2) at 37°C for 24 hours. The BA and MA plates were incubated at 37°C for 24 hours in an aerobic atmosphere. *Staphylococcus aureus* and coagulase negative *Staphylococcus* species were identified by standard microbiological methods recommended by American Society for Microbiology (ASM) [9]. A purity plate was employed to ensure that the inoculum used for the biochemical tests was pure. Only isolates from the persistent carriage were further evaluated in this study.

Antibiotic susceptibility testing

All the *Staphylococcus aureus* isolates were subjected for antibiotic susceptibility testing by modified Kirby-Bauer disk diffusion method in compliance with Clinical and Laboratory Standards Institute (CLSI) guidelines using Mueller- Hinton agar standard media. The inhibition zone standards for antimicrobial susceptibility were considered from tables for interpretative zone diameters of CLSI [10]. Antibiotic disks (HiMedia Laboratories, Pvt. Limited, India) used were: penicillin G (10U), ciprofloxacin (5 µg), gentamicin (10 µg), amikacin (30 µg), erythromycin (15 µg), co-trimoxazole (25 µg), tetracycline (10 µg), rifampicin (15 µg), vancomycin (30 µg), teicoplanin (30 µg), cefoxitin (30 µg), oxacillin (1 µg) and clindamycin (2 µg).

Identification of methicillin resistant strains

Identification of methicillin resistance in *Staphylococcus aureus* was carried out by using oxacillin (1 µg) and cefoxitin (30 µg) disks. Plates were incubated at 35°C. Plates containing oxacillin disk were read following a 24-hour incubation period. The diameter of the zone of inhibition (ZOI) of growth was recorded and interpreted as susceptible or resistant according to the criteria of CLSI. *Staphylococcus* isolates were deemed methicillin resistant when the ZOI was ≤ 10 mm with the oxacillin disk or ≤ 21 mm with the cefoxitin disk [11].

Identification of inducible clindamycin resistance in staphylococcal strains

Identification of Inducible macrolide-lincosamide-streptogramin B (iMLSB) resistance in *Staphylococcus aureus* was performed by disk approximation test. Disk approximation testing involved placing clindamycin (CLI) and erythromycin (ERY) disks approximately 15 mm apart (measured edge to edge) on a Mueller-Hinton agar plate that was inoculated with an *S. aureus* isolate; the plate was then incubated for 16 to 18 hours. A flattening of the zone of inhibition around the CLI disk proximal to the ERY disk (producing a zone of inhibition shaped like the letter D) is considered a positive result and indicates that the ERY has induced CLI resistance (a positive "D-zone test") [11].

Staphylococcus aureus ATCC 25923 was used as a control organism for antibiotic sensitivity testing. *Staphylococcus aureus* ATCC 43300 and ATCC 25923 were used as positive and negative controls for methicillin resistance.

Analysis

Statistical analysis was performed using SPSS-11.5 version. Differences in proportions were assessed by Chi-square test. P values < 0.05 were considered statistically significant.

Ethical aspects

The written informed consent was obtained from each participant included in this study. The permission of this study was taken from the head of the department of microbiology. Ethical approval was obtained from the Institutional Ethical Committee (IEC) of Chandigarh University Mohali, Punjab.

Results

Participant’s characteristics

The nasal swabs of all the 200 participated medical students were sent to the bacteriology laboratory along with the questionnaire. The study population included 105 (52.5%) male and 95 (47.5%) female participants. Among the total included participants, 161 belonged to urban type of residence, 39 belonged to family associated with health care profession, 168 participants were using public transportation to travel, 60 belonged to family having pets, 44 were having upper respiratory tract infections (URTI), 50 visited out-patient departments (OPD), 42 had medication, 51 had used antibiotics and 29 visited their family member admitted to hospital, in last 3 months as depicted in Table 1.

Table 1
Characteristics of all participants

Characteristics	Categories	No. of participants (%)
Sex	Male	105 (52.5)
	Female	95 (47.5)
Residence	Rural	39 (19.5)
	Urban	161 (80.5)
No. of family members	Up to 4	106 (53.0)
	5–10	91 (45.5)
	> 10	3 (1.5)
Profession of family	Health care	39 (19.5)
	Others	161 (80.5)
Family income	Low	15 (7.5)
	Middle	154 (77.0)
	High	31 (15.5)
Family education	Illiterate	2 (1.0)
	Primary	7 (3.5)
	High school	23 (11.5)
	College	168 (84.0)
Vehicle used by participant	Public	168 (84.0)
	Personal	32 (16.0)
Vehicle used by participant's family members	Public	82 (41.0)
	Personal	118 (59.0)
Recent visit to public amusement places	Yes	106 (53.0)
	No	94 (47.0)
Tattoo or acupuncture	Yes	0
	No	200 (100)
Alcohol consumption habit	Yes	5 (2.5)
	No	195 (97.5)
Smoking habit	Yes	0
	No	200 (100)
Contact with livestock	Yes	26 (13.0)
	No	174 (87.0)
Contact with pets	Yes	60 (30.0)

Characteristics	Categories	No. of participants (%)
	No	140 (70.0)
Hypertension	Yes	4 (2.0)
	No	196 (98.0)
Renal disease	Yes	1 (0.5)
	No	199 (99.5)
Pulmonary disease	Yes	1 (0.5)
	No	199 (99.5)
Gastro-intestinal disease	Yes	17 (8.5)
	No	183 (91.5)
Nasal disease	Yes	44 (22.0)
	No	156 (78.0)
Recent surgical procedures	Yes	2 (1.0)
	No	198 (99.0)
Recent admission to hospital	Yes	8 (4.0)
	No	192 (96.0)
Recent visit to out-patient departments	Yes	50 (25.0)
	No	150 (75.0)
Recent medication	Yes	42 (21.0)
	No	158 (79.0)
Recent antibiotic use	Yes	51 (25.5)
	No	149 (74.5)
Recent visit to hospital admitted family members	Yes	29 (14.5)
	No	171 (85.5)

Frequency of nasal carriage of Staphylococcus aureus and associated risk factors

Staphylococcus aureus was detected in 30 (15%) participants (male 14 and female 16) from the first set of nasal swabs (persistent) and it was detected in 32 participants from second set of nasal swabs (2 as intermittent carriages). Out of 30 participants (persistent cases), 22 belonged to urban type of residence, 25 participants were using public vehicle for transportation, 11 of them were having upper respiratory tract infection, 7 had medication and 8 used antibiotics in last 3 months as shown in Table 2.

Table 2
Characteristics of participants with positive *Staphylococcus aureus* growth (N = 30).

Characteristics	Categories	No. of participants (%)	P-values
Sex	Male	14 (46.7)	0.488
	Female	16 (53.3)	
Residence	Rural	8 (26.7)	0.283
	Urban	22 (73.3)	
No. of family members	Up to 4	17 (56.7)	
	5–10	12 (40.0)	
	> 10	1 (3.3)	
Profession of family	Health care	4 (13.3)	
	Others	26 (86.7)	
Family income	Low	1 (3.3)	
	Middle	25 (83.4)	
	High	4 (13.3)	
Family education	Illiterate	0	
	Primary	1 (3.3)	
	High school	6 (20.0)	
	College	23 (76.7)	
Vehicle used by participant	Public	25 (83.3)	
	Personal	5 (16.7)	
Vehicle used by participant's family members	Public	12 (40.0)	0.904
	Personal	18 (60.0)	
Recent visit to public amusement places	Yes	12 (40.0)	0.122
	No	18 (60.0)	
Tattoo or acupuncture	Yes	0	
	No	30 (100)	
Alcohol consumption habit	Yes	1 (3.3)	
	No	29 (96.7)	
Smoking habit	Yes	0	
	No	30 (100)	
Contact with livestock	Yes	2 (6.7)	0.263
	No	28 (93.3)	
Contact with pets	Yes	9 (30.0)	1.0

Characteristics	Categories	No. of participants (%)	P-values
	No	21 (70.0)	
Hypertension	Yes	1 (3.3)	
	No	29 (96.7)	
Renal disease	Yes	1 (3.3)	
	No	29 (96.7)	
Pulmonary disease	Yes	1 (3.3)	
	No	29 (96.7)	
Gastro-intestinal disease	Yes	1 (3.3)	
	No	29 (96.7)	
Nasal disease	Yes	11 (36.7)	**0.035**
	No	19 (63.3)	
Recent surgical procedures	Yes	0	
	No	30 (100)	
Recent admission to hospital	Yes	0	
	No	30 (100)	
Recent visit to out-patient departments	Yes	4 (13.3)	
	No	26 (86.7)	
Recent medication	Yes	7 (23.3)	0.734
	No	23 (76.7)	
Recent antibiotic use	Yes	8 (26.7)	0.874
	No	22 (73.3)	
Recent visit to hospital admitted family members	Yes	6 (20.0)	
	No	24 (80.0)	

Antimicrobial susceptibility testing profile

Table 3 provides the antimicrobial resistance profile of 30 *Staphylococcus aureus* strains isolated from 200 participated medical students. Among 30 tested isolates, resistance to ciprofloxacin was most common (36.7%) and frequent resistance was also noted with gentamicin (33.3%), erythromycin (33.3%) and chloramphenicol (30%). Out of 30 tested isolates, 8 (26.7%) isolates were resistant to methicillin by cefoxitin and oxacillin disc method and 4 (13.3%) isolates were found to have inducible clindamycin resistance by D-zone test. No isolates were found resistant to vancomycin and teicoplanin in this study.

Table 3
Antibiotic resistant pattern of *Staphylococcus aureus* (N = 30)

Antibiotics	Resistant frequency	Percentage
Penicillin G	22	73
Ciprofloxacin	11	36.7
Gentamicin	10	33.3
Amikacin	3	10
Erythromycin	10	33.3
Cotrimoxazole	6	20
Tetracyclin	6	20
Rifampicin	6	20
Vancomycin	0	0
Teicoplanin	0	0
Cefoxitin	8	26.7
Oxacillin	8	26.7
Clindamycin	8	26.7

MRSA and associated risk factors

MRSA was detected in 8 (4%) cases. Males were more likely to carry MRSA (62.5%) but association was not significant (P = 0.295). However, URTI, recent visit to public amusement places, contact with pet (dog) and rural type of residence were listed as significant contributing risk factors for MRSA colonization as illustrated in Table 4.

Table 4
Characteristics of MRSA positive cases (N = 8).

Characteristics	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	P-value
Sex	Male	Male	Female	Male	Male	Male	Female	Female	0.295
Co-morbidities	URTI,	URTI	GIT disease	URTI	URTI, GIT disease	No	URTI, Renal	URTI	**0.009**
Recent visit to OPD	No	No	Yes	No	Yes	No	Yes	Yes	
Recent antibiotic use	No	Yes	Yes	No	Yes	No	Yes	Yes	
Recent visit to hospital admitted family members	No	Yes	No	No	No	No	No	No	0.536
Alcohol consumption	Yes	No	No	No	No	No	No	No	
Recent visit to public amusement places	Yes	No	Yes	No	Yes	Yes	Yes	Yes	**0.018**
Contact with pet	Yes, dog	Yes, dog	Yes, dog	No	No	Yes, dog	Yes, dog	Yes, dog	**< 0.05**
Type of residence	Urban	Rural	Urban	Rural	Rural	Rural	Urban	Rural	**0.007**
Vehicle used by participants	Public	Personal	Personal	Public	Public	Public	Public	Personal	
Vehicle used by participant's family member	Personal	Personal	Personal	Public	Public	Public	Personal	Personal	0.866
Profession of family	Other than health care	Other than health care	Other than health care	Health care	Other than health care	Other than health care	Other than health care	Health care	0.257
No. of family members	5–10	Up to 4	Up to 4	5–10	5–10	Up to 4	5–10	5–10	
Family income	Middle	Middle	Middle	Middle	Middle	Middle	Middle	Middle	0.140
Family education	College	College	College	High school	College	College	College	College	

Discussions

In this study, 200 medical students of age between 18 and 25 years, before clinical exposure were enrolled. The result of our study indicate that majority of the participants (80.5%) were from urban area. Now a day most of the populations are moving to urban area in search of better life style, availability of jobs, better medical facilities and better education facilities. So, these are the main factors attracting the people from rural to urban area. Urbanization rapidly spread across

the Western world and, since the 1950s, it has begun to take hold in the developing world as well [12]. UN World Urbanization Prospects report projected that the figure of global proportion of urban population is likely to rise to 60% (4.9 billion) by 2030 [13]. Medical profession enjoys certain rights and privileges that are granted by societies and its representatives and agencies [14]. In this study 19.5% of the participants belonged to family of which at least one member was associated with health care profession. As pets are being considered as close friend to humans now a day, in this perspective, in current study 60 (30%) participants belonged to family having pets (mostly dog). Common cold (upper respiratory tract infection) is common in Nepal and thus, 44 (22%) of the participants were having upper respiratory tract infections (URTI) during this study.

Although *Staphylococcus aureus* can be present on the skin of the host, a large proportion of its carriage is through the anterior nares of the nasal passages [15]. The ability of the nasal passages to harbor *Staphylococcus aureus* results from a combination of a weakened or defective host immunity and the bacteria's ability to evade host innate immunity [16]. Approximately 20% of individuals almost always carry one type of strain and called persistent carriers [17]. In this study also we detected 15% nasal carriage of *Staphylococcus aureus* in medical students (male 14 and female 16). Similar rate of nasal carriage of *Staphylococcus aureus* was also detected by Neela et al. and Nordin et al. (12.4%) from Malaysia [18, 19]. The observed prevalence rate also corroborates with the reported rate of 18.4% by Habib et al. from Iraq [20]. The carriage of *Staphylococcus aureus* is an important source of nosocomial infection and community-acquired methicillin-resistant *Staphylococcus aureus* (MRSA) [15].

In this study, a significant association was observed between the *Staphylococcus aureus* carrier and urban type of residence and use of public vehicle for transportation. The present analysis found that 73.3% of the student positive for nasal *Staphylococcus aureus* belonged to urban type of residence and 83.3% were using public vehicle for transportation. This may be due to the changing pattern of life style in urban area like shopping malls, theatres, parties and public vehicles bring peoples to be in close contact and the door handles of public vehicles also act as fomite that provide the chance to transmit the organisms from one person to the others. Habit of shaking hands in urban area also acts as a significant way to transmit the organism from person to person.

In our study, the nasal carriage of *Staphylococcus aureus* did not find any statistically significant association with the clinical factors such as medication (23.3%) and antibiotic use (26.7%) in last 3 months, however upper respiratory tract (nasal) infections (36.7%), showed significant association with *Staphylococcus aureus* nasal carriage. To our knowledge, a relationship between URTI and nasal carriage has not been studied in any study before in Nepal; however, studies from other settings have reported increased spread of *Staphylococcus aureus* during an episode of URTI [21]. In a study conducted by Nordin et al., 22.5% cases of nasal carriage were associated with URTI and 9.9% cases were associated with recent antibiotic use [19].

Staphylococcus aureus can survive on dogs [22] and cats [23]. Some believe health-care workers' dogs should be considered a significant source of antibiotic-resistant *Staphylococcus aureus*, especially in times of outbreak [22]. *Staphylococcus aureus* is one of the causal agents of mastitis in dairy cows. Its large polysaccharide capsule protects the organism from recognition by the cow's immune defenses [24]. In our study, we found that 30% of the nasal carriers of *Staphylococcus aureus* have had contact with pet much lower than the result of Miller et al. (77%) from Virginia [25]. The lower rate of our study may be due to the uncommon practice of domesticating pet in Nepal.

This study demonstrated that overall rates of resistance to commonly prescribed antibiotics in *Staphylococcus aureus* isolates were below 50% with the exception of penicillin. Staphylococcal resistance to penicillin is mediated by penicillinase (a form of β-lactamase) production, an enzyme that cleaves the β-lactam ring of the penicillin molecule, rendering the antibiotic ineffective. A high proportion of isolates (73%) were resistant to penicillin in current study. This was expected as it has been recognized that only a small proportion of the Staphylococcus aurues lineages do not

produce beta-lactamases [26–29]. Similarly, as high as 92% of isolates were found to be resistant to ampicillin in a study conducted by Prates et al. [30].

Ciprofloxacin is the most widely used of the second-generation quinolone antibiotics that came into clinical use in the late 1980s and early 1990 [31, 32]. In 2010, over 20 million outpatient prescriptions were written for ciprofloxacin, making it the 35th-most commonly prescribed drug, and the 5th-most commonly prescribed antibacterial in the United States [33]. As a result of its widespread use to treat minor infections readily treatable with older, less broad-spectrum antibiotics, many bacteria have developed resistance to this drug in recent years, leaving it significantly less effective than it would have been otherwise [34, 35]. We identified ciprofloxacin resistance rate of 36.7% in this study much higher rate than the study of Prates et al. (8.8%) from Brazil [30].

Aminoglycoside antibiotics, such as kanamycin, gentamicin, streptomycin etc., were once effective against staphylococcal infections until strains evolved mechanisms to inhibit the aminoglycosides' action, which occurs via protonated amine and/or hydroxyl interactions with the ribosomal RNA of the bacterial 30S ribosomal subunit [36]. As a consequence of low cost and easy availability, there has been indiscriminate use of aminoglycosides in Nepal less effective. We identified gentamicin resistance rate of 33.3% and amikacin resistance rate of 10%. Similarly, 25% isolates resistant to gentamicin was detected by Sharma et al. [37] and a lower rate of amikacin resistnce (4%) was also detected in a study from Brazil [30].

Erythromycin has been used extensively for the treatment of both minor and more serious staphylococcal infections. As a consequence, its role today is increasingly limited due to increasing resistance, which poses a great therapeutic challenge. One third (33.3%) of our isolates were resistant to erythromycin. Similarly, trimethoprim-sulfamethoxazole (co-trimoxazole) can be an alternative treatment choice, particularly for non-multi-resistant MRSA infections, although emergence of resistance has been previously observed. This may be due to excessive use of this drug for many other infections and over-the-counter availability of antimicrobials in the developing world for the treatment of many other infections. In our study, we identified 20% isolates resistant to co-trimoxazole in agreement with the reported result of Soltani et al. from Iran [38].

All of our isolates had retained susceptibility to vancomycin and teicoplanin, consistent with other studies [30, 37, 20], confirming that glycopeptides should be used as empiric therapy for serious staphylococcal infections while waiting for susceptibility testing results to come through [39]. This is likely related to low usage of these agents in Nepal due to high cost. Concerningly, however, lineages with increased resistance to teicoplanin have been observed overseas [40–43]. Interestingly, the sensitivity to vancomycin has been found in virtually all isolates of *Staphylococcus aureus* in many studies worldwide [44, 45]. Thus, vancomycin could be a wise choice for the management of MRSA.

Today, *Staphylococcus aureus* has become resistant to many commonly used antibiotics. In the UK, only 2% of all *Staphylococcus aureus* isolates were reported sensitive to penicillin, with a similar picture in the rest of the world. The β-lactamase-resistant penicillin's (methicillin, oxacillin, cloxacillin, and flucloxacillin) were developed to treat penicillin-resistant *Staphylococcus aureus*, and are still used as first-line treatment. Methicillin was the first antibiotic in this class to be used (it was introduced in 1959), but only two years later, the first case of MRSA was reported in England [46]. Despite this, MRSA generally remained an uncommon finding, even in hospital settings, until the 1990s, when there was an explosion in MRSA prevalence in hospitals, where it is now endemic [47]. Two different methods, the cefoxitin disk method and oxacillin disc methods both were employed for the detection of MRSA in this study. According to CLSI, the cefoxitin disk test is comparable to the oxacillin disk test for the prediction of mecA-mediated resistance to oxacillin. The cefoxitin disk test is easier to read and thus is the preferred method. Besides, cefoxitin is an inducer of the mecA gene [11]. Results of the present study indicate that 8 (4%) of medical students in central Nepal harbored the MRSA in their nares. Similarly, 6% MRSA carriage rate in medical students before clinical exposure was also detected by Rao et al. from India [48].

Clindamycin is one of the drugs of choice in *Staphylococcus aureus* infections. Macrolide-resistant isolates of *Staphylococcus aureus* may have constitutive or inducible resistance to clindamycin (due to methylation of the 23S rRNA encoded by the erm gene also referred to as MLSB i.e., Macrolide, Lincosamide and type B Streptogramin resistance) or may be resistant only to macrolides (due to efflux mechanism encoded by the msrA gene) [11]. As the presence of an erm gene encoding for inducible resistance may result in treatment failure [49], it is important to perform its testing. We identified 4 (13.3%) D-zone test positive isolates, indicating inducible resistance to clindamycin.

Spread of *Staphylococcus aureus* (including MRSA) is generally through human-to-human contact, although recently some veterinarians have discovered the infection can also be spread through pets [50]. From our study we also reported that 75% of MRSA carriers have had contact with pet especially dog. In a case control study by Miller et al., 73% of MRSA cases were having pet (cat, dog and other rodents) [25]. A significant association was also observed between the carriers of MRSA and URTI in this study. High proportion of MRSA carriers (75%) was associated with URTI. Rural type of residence and visit to public amusement places also significantly contributed for the colonization of MRSA in study population.

Our study has limitations; we selected a limited pool of antibiotics for susceptibility testing and did not do molecular studies to confirm MRSA isolates due to financial constraints.

Conclusions

The result of this study demonstrates the comparably high rates of nasal carriage of *Staphylococcus aureus* and their methicillin resistant strains in the community setting apart from the people attending hospitals. This study proves that the nasal carriage of *Staphylococcus aureus* can be high in community setting indicating that carriage of this organism and their methicillin resistance strains can play a key role in the epidemiology and pathogenesis of community associated infections. From this study, we recommend the longitudinal surveillance of nasal carriage of *Staphylococcus aureus* should be made an essential protocol to minimize the transmission of this organism from community to hospital setting.

SA conceived the design of the study and performed the experiments with help from SS. HPN, RG and MLC guided the necessary laboratory tests. SA prepared the final draft of the manuscript and MLC, SRA and HPN guided the manuscript preparation.

Declarations

Acknowledgment

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