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Original article

Nasal Carriage and Methicillin Resistance of *Staphylococcus aureus* among High School Students in Eastern Libya, the city of Tobruk

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Abstract
Staphylococcus aureus is a common causative agent of infections, capable of transmitting from asymptomatic carriers to healthy individuals. It can colonize the anterior nasal openings and exhibits a high resistance to various antibiotics. factors like poor hygiene practices and surrounding school conditions make students particularly susceptible to bacterial infections. This study was conducted on 254 nasal samples from high school students in Tobruk to determine the nasal carriage rate of methicillin-resistant *Staphylococcus aureus* (MRSA). The study included students aged 15 to 20 years. Bacteria were isolated and identified using optimal bacteriological methods, including the examination of bacterial cultures, colony morphology, Gram staining, and biochemical tests. Methicillin-resistant strains were confirmed by using the Xpert MRSA test. Out of 254 samples, 101 contained Gram-negative bacteria, and 153 contained Gram-positive bacteria. Among the Gram-positive samples, 138 contained *Staphylococcus* spp., and 15 samples contained other Gram-positive bacterial species. Among the 138 Gram-positive isolates, 48 were identified as *Staphylococcus aureus*, representing 18.9%, of which 26 isolates were methicillin-resistant (MRSA), accounting for 54.2% of the positive samples. Male students carried MRSA (53.8%) more than female students (46.2%), with no significant gender differences. Students aged 15-17 had a higher rate of nasal carriage of methicillin-resistant *S. aureus* (58.3%) compared to those aged 18-20 (%41.7).(%38.9). The 26 MRSA isolates showed 100% resistance to Penicillin, Oxacillin, and Cefoxitin. Resistance to Tetracycline, Erythromycin, and Gentamicin ranged between 19.2% and 30.8%, while resistance to Clindamycin did not exceed 3.8%. The isolates were 100% susceptible to Trimethoprim, Moxifloxacin, Levofloxacin, Linezolid, and Ciprofloxacin.
Keywords. Nasal Carriage, Staphylococcus Aureus, MRSA, Antibiotic Resistance.

Introduction

The genus Staphylococcus belongs to Gram-positive bacteria with diameters of 0.5-1.5 µm, it is characterized as; non-motile, non-spore forming facultative anaerobes, Staphylococcus is traditionally divided in two groups based on the ability of bacteria to produce coagulase, an enzyme that makes blood to clot: coagulase-positive Staphylococci, includes the most known species; *Staphylococcus aureus* whereas coagulase-negative Staphylococci (CoNS), are common commensals of the skin [1]. *S. aureus* is a spherical-shaped and coagulase-positive bacterium. It is a frequent cause of serious health problems with high morbidity and mortality. *S. aureus* colonizes the skin and nasal mucosa, and is thus considered normal flora. The anterior nares appear as the main reservoir site for *S. aureus* replication and spread to other body sites. Approximately 25–30% of healthy individuals are nasal carriers for *S. aureus* [2,3]. *S. aureus* is recognized as a significant pathogen on a global scale and is increasingly identified as a predominant agent causing infections in individuals facing critical health conditions. The influence of S. aureus infection on human well-being has notably escalated due to its exceptional capacity to develop resistance against antimicrobial agents[4].

Due to the fact that the primary habitat of this bacterium is the moist squamous epithelium of the anterior nasal cavity, most cases of invasive *S. aureus* infection are assumed to arise from nasal carriage [5,6]. There is increasing concern over the frequency of *S. aureus*. Methicillin-resistant S. aureus emergence as a result of its remarkable antibiotic-adaptation ability [7]. The difference between methicillin-resistant *S. aureus* (MRSA) and methicillin-susceptible *S. aureus* (MSSA) is in its resistance to ß-lactam antibiotics; this is often associated with resistance to multiple other antibiotics, which limits the therapeutic options [8]. National estimates in the United States for the years 2000 to 2002 indicated the prevalence rates of S. aureus and methicillin-resistant S. aureus (MRSA) [9]. Colonization rates were 31.6% and 0.84%, respectively. It was also observed that approximately 7% or more of hospitalized patients are colonized with MRSA. While asymptomatic nasal colonization with S. aureus is prevalent, it is believed to play a significant role in the pathogenesis of most infections caused by this bacterium [10].

MRSA is known to be resistant to all β-lactam antibiotics [11]. Mec A gene codes for the penicillin-binding protein PBP 2A is responsible for methicillin resistance in MRSA and coagulase-negative Staphylococci [12]. A new methicillin resistance gene, mecC, has been identified in *S. aureus* [13]. In clinical laboratories, culture and biochemical testing are the most reasonable methods for diagnosing bacterial infections [14]. Several molecular methods based on polymerase chain reaction have been introduced as alternatives to ensure accurate identification [15]. The most widely used tool for the identification and classification of bacteria, including Staphylococci, is PCR [16]. For bacterial group classification, clinical laboratories have

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used PCR amplification and gene sequencing. In addition, the use of broad-spectrum bacterial and fungal PCR directly from clinical materials is now more widely available [17]. This study was conducted to determine the nasal carriage rate of MRSA.

Methods

Site of study

This study was carried out in Eastern Libya, the city of Tobruk.

Study population

According to the statistics of Ministry of Education in Tobruk Municipality for the year 2024, the total students, whose ages ranged between 15-20 years were 5634 distributed in different schools within Tobruk city.

Inclusion criteria

The study participants were selected based on specific inclusion and exclusion criteria. To qualify for inclusion, students had to be enrolled in one of the designated schools within the study area and fall within the predetermined age range. Additionally, participants—or their guardians, in the case of minors—were required to provide informed consent, demonstrating their voluntary willingness to take part in the research. Conversely, students were excluded if they had a prior diagnosis of Methicillin-resistant Staphylococcus aureus (MRSA) infection, were currently using antibiotics, or had any chronic medical conditions or immunodeficiencies that could confound the results. Those unable or unwilling to provide informed consent were also ineligible. These criteria ensured a focused and medically relevant participant pool while minimizing potential confounding variables.

Specimen collection

Data was collected over a period of five months between January 2024 to May 2024. The research had permission from the Ministry of Education and, Tobruk Municipality before starting data collection. Samples were obtained from the anterior nares of students by using sterile dry-cotton swabs. Each swab was inserted 2-3 centimeters in the nasal cavity and rotated 4-5 times both clockwise and anticlockwise before swab withdrawal. Samples were labeled and transported in Amies transport media to the microbiology laboratory within 5-6 hours. Samples were incubated in thioglycollate broth for 24 hours, and then streaked onto a blood agar and MacConkey agar plates and incubated for an additional 24 hours at 37 ◦C, Becton Dickinson. UK (BD.UK). Over the next 24-48 hours, the colonies' growth was observed, their size, shape, color, and hemolytic activity. The growth on blood agar was identified by Gram staining, catalase test, tube coagulase test and growth on Mannitol salt agar to detect *S. aureus* and coagulase negative Staph. The Antibiotic Susceptibility Testing (AST) was performed on Mueller Hinton Agar with bacterial suspension of 0.5 MacFarland turbidity standards. The diameter of the inhibition zones for each antibiotic was measured with a ruler and interpreted according to Clinical and Laboratory Standards Institute CLSI guidelines (2024) [18].

Ethical considerations

This study on Methicillin resistance *S. aureus* in school students follow ethical standards to protect participants, ethical considerations include informed consent, voluntary participation, and confidentiality, the research protocol reviewed before data collection, risks and purpose of the study were explained to participants, adhering to ethical considerations is important for the study's integrity and trust between researchers and participants.

Identification of S. aureus

Bacteria were isolated and identified using optimal bacteriological methods, including examination of bacterial cultures, colony morphology, Gram staining, and biochemical tests. Methicillin-resistant strains were confirmed using the Xpert MRSA test (Figure 1).

Statistical analysis

Statistical analyses were done by using SPSS. Microsoft Office Excel 2019 was used for entry data. The results were expressed as percentages and proportions. The Chi-square test was performed. The Value of P≤0.05 was used as a significant level for association in comparison.

Results

High schools participated in this study: The study included students aged from 15 to 20 from public high schools in Tobruk, in which 254 students were enrolled in this study. Simple random sampling was used to choose students from each school (Table 1 and Figure 2). Of the 254 high school students included in this study, 39.8% (101/254) were male students, while 60.2% (153/254) were female students. The results showed that 76.38% (194/254) were aged between 15-17 years, and 23.62% (60/254) were aged between

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18-20 years. Whereas 20.1% (51/254) were from Um-Almominin high school, Al-Dahyh high school, Al-Amal high school, and Tlayih Al-mstqbil high school, followed by Al-Farouk high school, 19.7 % (50/254) (Table 2&3). 254 specimens were collected from nasal swabs.

Isolation frequency of Staphylococcus spp

In this study, a total of 254 samples from high school students were screened, of which 101 isolated samples were Gram-negative bacteria, and 153 samples were Gram-positive bacteria. Out of Gram Gram-positive bacteria isolated, a number of 138 samples yielded *Staphylococcus* Spp, and 15 samples were found to be other Gram-positive bacteria. Out of 138 students screened, 26 were nasal carriers of MRSA, and 22 were carrying methicillin-sensitive *S. aureus* (MSSA). A number of 69 students were carriers for (CoNS), while 14 students were carriers for (MRCoNS), and finally 7 students were carrying bacteria (*S. intermedius*) (Figure 2).

Isolation of *S. aureus*: From a total of 254 nasal swabs, the overall frequency of isolation of *S. aureus* was 18.9% (48/254), as shown in Table 4, with respect to sources of specimens, the isolation rate of *S. aureus* at nares was 18.89% (48/254). It was found that *S. aureus* carriage rate was the highest among males, 22.8% (23/101), while females represented 16.3% (25/153), which was insignificantly associated with what was observed between genders and frequency of *S. aureus* (X^2 =1.64; P>0.05). *S. aureus* nasal colonization prevalence was 37 isolates from the age group (15-17) years and 11 isolates from the age group (18-20) years. The carriage rate was higher among students aged 15-17 years, 19.2% (37/194), than 18-20 years, 18.3% (11/60) (X^2 = 0.02; P>0.05). The highest rate of isolation of *S. aureus* was observed in Al-Farouk high school, 37.5% (18/50) followed by Al-Dahyh high school, 22.9% (11/51), and Al-Amal high school 18.8% (9/51), while the lowest rate was recorded from Almstqbil high school, and Um-Almominin high school were 10.4% (5/51) for each (Tables 4&5).

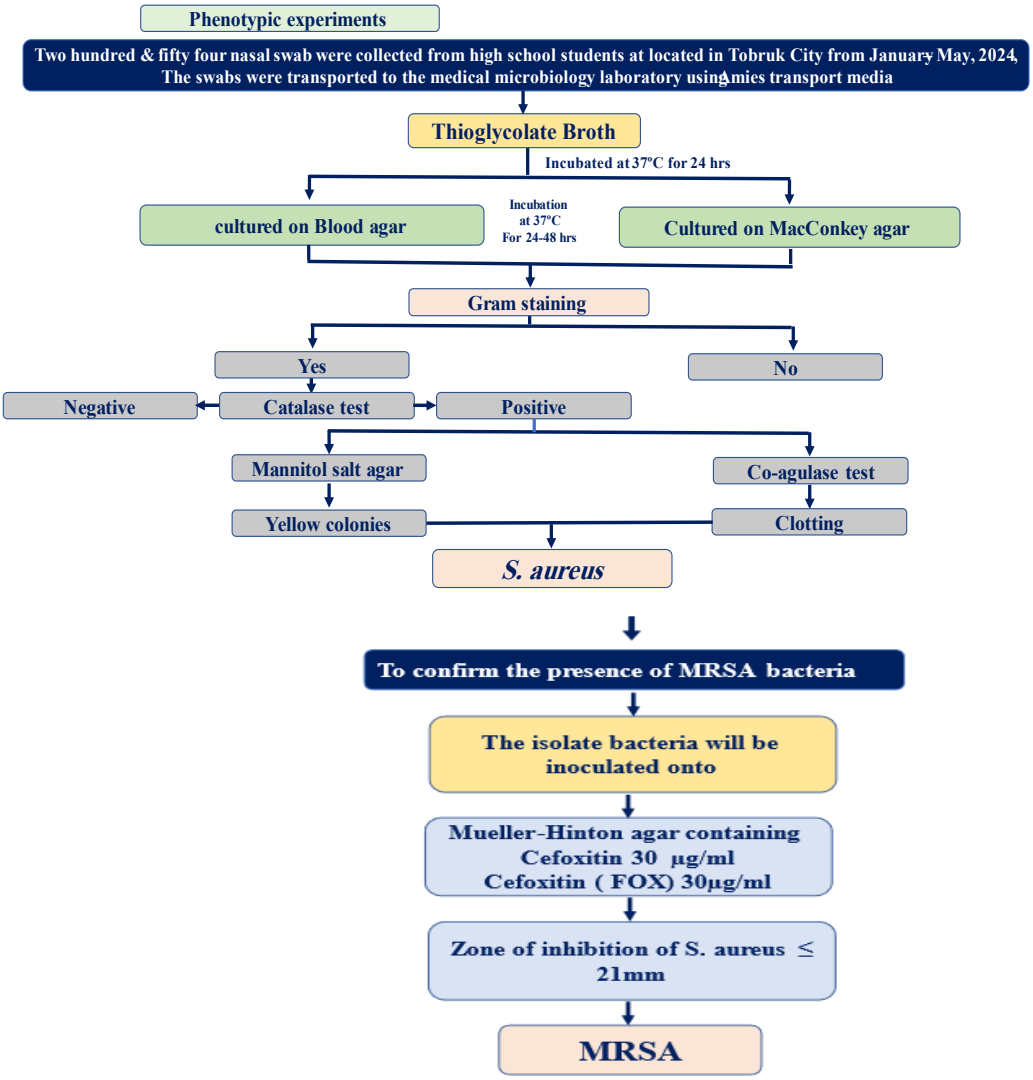

Figure 1. Flow chart explaining the experimental work

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Prevalence of Methicillin-Resistant S. aureus (MRSA)

The results showed that out of the 48 *S. aureus* isolates, 54.2% (26/48) were found to be resistant to Cefoxitin (FOX). It was also shown that MRSA carriage rate was higher among males (53.8%, 14/26) than females (46.2%, 12/26) (Table 6), with no significant association between gender and carriage rate (X^2 = 0.80; P>0.05). However, the students aged from 15-17 years showed MRSA nasal carriage rate of 58.3% (21/36), which was higher than students aged from 18-20 years (41.7%, 5/12) (X^2 = 1.01; P>0.05) (Table 7). Of the five high schools, the rate of MRSA isolation was the highest among Al-Farouk high school students (72.2%, 13/18), followed by Al-Dahyh high school students (63.6%, 7/11), Um-Almominin high school students (60%, 3/5), and Al-Amal high school students (22.2%, 2/9), while Tlayih Almstqbil high school students recorded the lowest rate (20%, 1/5) (Table 7).

Antibiotic susceptibility profile

A total of 26 MRSA isolates were interpreted according to the guidelines of CLSI [18]. The isolates showed a varying resistance to the twelve antibiotics, where the highest resistance recorded against Penicillin, Oxacillin, and Cefoxitin at a rate of 100% for each, in comparison with the resistance to other antibiotics such as Tetracycline (30.8%), Erythromycin (26.90%), and Gentamycin (19.20%), while Clindamycin was at a rate of (3.8%) of resistance. On the other hand, a high susceptibility to Trimethoprim, Moxifloxacin, Levofloxacin, Linezolid, and ciprofloxacin at a rate of 100% for each was observed (Figure 3).

The detection of MRSA using the Xpert MRSA assay: In addition, further investigation was utilized to detect the presence of MRSA, using the Xpert MRSA assay. Seven of the twenty-six samples of MRSA that were randomly selected from various high school students who took part in this study were sent to Egypt for the Xpert MRSA assay in order to further validate our findings on the prevalence of MRSA isolated from high school students in Tobruk city. It was interestingly found that all selected samples were tested and categorized as true positive for MRSA infection.

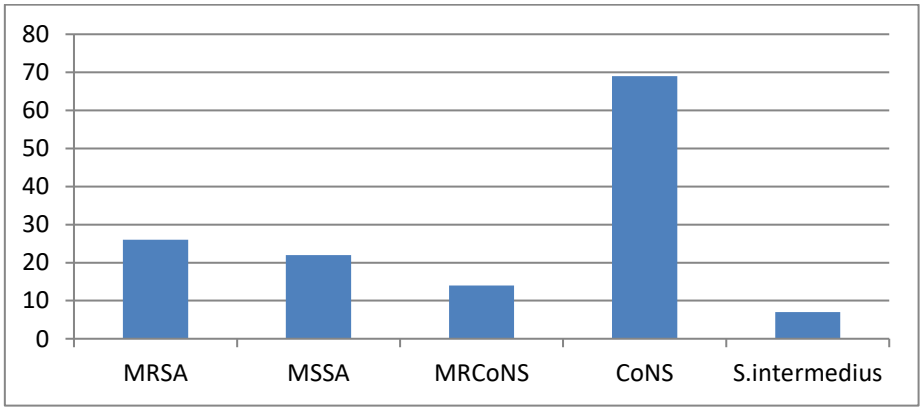

Figure 2. Staphylococcus spp. isolated from the high school students

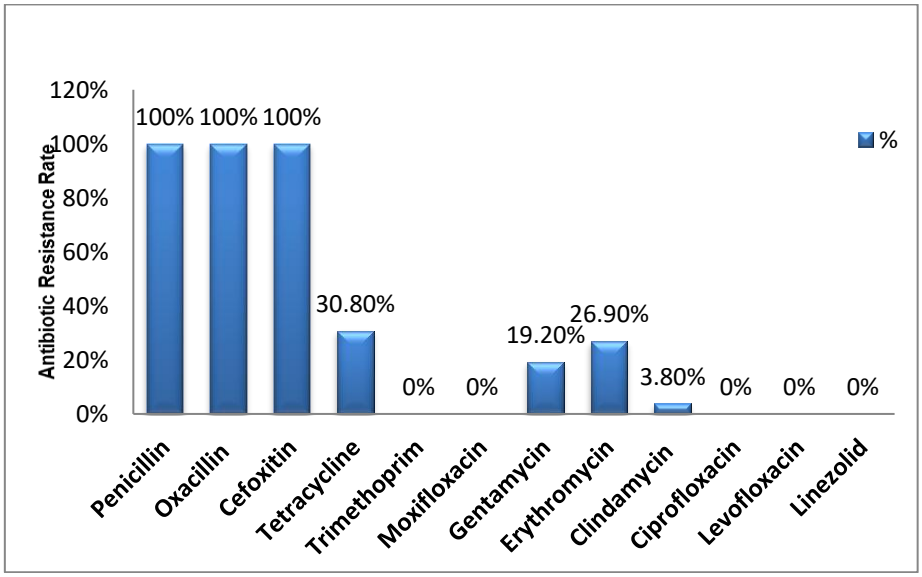

Figure 3. Antibiotic Susceptibility profile of 26 MRSA isolates 12 antibiotics of different classes.

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Table 1. Five high schools participated in this study from Tobruk City

School	First	Second	Third	Total
Al-Farouk	432	234	131	797
Tlayih Almstqbil	231	128	52	411
Um-Almominin	306	367	232	905
Al-Dahyh	275	99	219	593
Al-Amal	180	176	123	479
Total	1424	1004	757	3185

Table 2: Age distribution of high school students participated in the study.

Schools	Age of students (years) (N=254)					
	15-17		18-20		Total	
	N	%	N	%	N	%
Al-Farouk	42	16.53	8	3.15	50	19.72
Tlayih Almstqbil	38	14.96	13	5.12	51	20.07
Um-Almominin	45	17.72	6	2.36	51	20.07
Al-Dahyh	34	13.39	17	6.69	51	20.07
Al-Amal	35	13.78	16	6.30	51	20.07
Total	194	76.38	60	23.62	254	100

N= total number of students who participated in the study.

Table 3: Gender distribution of high school students who participated in the study

Schools	Gender of students (years) (N=254)					
	Male		Female		Total	
	N	%	N	%	N	%
Al-Farouk	50	19.72	0	0	50	19.72
Tlayih Almstqbil	51	20.07	0	0	51	20.07
Um-Almominin	0	0	51	20.07	51	20.07
Al-Dahyh	0	0	51	20.07	51	20.07
Al-Amal	0	0	51	20.07	51	20.07
Total	101	39.79	153	60.21	254	100

N= total number of students who participated in the study.

Table 4: Frequency of S. aureus from the noses of students according to gender.

Schools	**Source of specimen**	**No. (%) of isolate**			
		Gender			
		Specimens No. (Male + Female)	Male N(%)	Female N(%)	Total N(%)
Al-Farouk	Nasal	50 (50+0)	18 (37.5)	0(0)	18 (37.5)
Tlayih Almstqbil	Nasal	51 (51+0)	5 (10.4)	0(0)	5 (10.4)
Um-Almominin	Nasal	51 (0+51)	0(0)	5 (10.4)	5 (10.4)
Al-Dahyh	Nasal	51 (0+51)	0(0)	11 (22.9)	11 (22.9)
Al-Amal	Nasal	51 (0+51)	0(0)	9 (18.75)	9 (18.8)
Total		254 (101+153)	23 (22.8)	25(16.3)	48 (18.9)
(X^2 =1.64; P>0.05)					

N= total number of isolated S. aureus

Table 5: Frequency of S. aureus noses among students according to age.

Schools	**Source of specimens**	**N (%) of isolates**			
		Age (years)			
		Specimens No. (15-17 + 18-20)	15-17 N(%)	18-20 N(%)	Total N(%)
Al-Farouk	Nasal	50 (42+8)	18(42.9)	0(0)	18(42.9)
TlayihAlmstqbil	Nasal	51(38+13)	4 (10.5)	1(7.7)	5(10.4)
Um-Almominin	Nasal	51 (45+6)	4(8.9)	1(16.7)	5 (10.4)
Al-Dahyh	Nasal	51 (34+17)	6(17.6)	5(29.4)	11 (22.9)
Al-Amal	Nasal	51 (35+16)	5(14.3)	4(25)	9 (18.75)
Total		254 (194+60)	37(19.2)	11(18.3)	48 (18.9)
(X^2 = 0.02; P>0.05)					

N= total number of isolated S. aureus

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Table 6: Prevalence of nasal carriage of MRSA among high school students according to gender.

Schools	Source of specimens	No. (%) of isolate			
		Gender			
		Specimens No. (Male + Female)	Male N(%)	Female N(%)	Total N(%)
Al-Farouk	Nasal	18 (18+0)	13 (72.2)	0(0)	13(72.2)
Tlayih-Almstqbil	Nasal	5 (5+0)	1(20)	0(0)	1(20)
Um-Almominin	Nasal	5 (0+5)	0(0)	3(60)	3(60)
Al-Dahyh	Nasal	11 (0+11)	0(0)	7(63.6)	7(63.6)
Al-Amal	Nasal	9 (0+9)	0(0)	2(22.2)	2(22.2)
Total		48 (23+25)	14(60.9)	12(48)	26(54.2)
(X^2 = 0.80; P>0.05)					

N= total number of isolated MRSA

Table 7: Prevalence of nasal carriage of MRSA among high school students according to age.

Schools	Source of specimens	No. (%) of isolate			
		Age (years)			
		Specimens No. (15-17 +18-20)	15-17 N(%)	18-20 N(%)	Total N(%)
Al-Farouk	Nasal	18(18+0)	13(72.2)	0(0)	13(72.2)
TlayihAlmstqbil	Nasal	5(4+1)	0(0)	1(100)	1(20)
Um-Almominin	Nasal	5(4+1)	3(75)	0(0)	3(60)
Al-Dahyh	Nasal	11(6+5)	3(50)	4(80)	7(63.6)
Al-Amal	Nasal	9(4+5)	2(50)	0(0)	2(22.2)
Total		48 (36+12)	21(58.3)	5(41.7)	26(54.2)
(X^2 = 1.01; P>0.05)					

N= total number of isolated MRSA

Discussion

Nasal carriage of S. aureus is approximately 20–30% of healthy individuals, with high permanent colonization among children [19,20]. The emergence of MRSA, which causes infections, has become a worrying problem in the clinical field because MRSA strains are resistant to many antibiotics, particularly β-lactam classes[21]. Nasal carriage of S. aureus has been demonstrated to be a significant risk for nosocomial and community-acquired infection in a variety of populations [22], and MRSA has become an important issue in public health, mostly due to community-associated MRSA (CA-MRSA) [23]. This study was conducted to determine the nasal carriage of S. aureus and MRSA prevalence among high school students in Tobruk city, Libya.

The overall nasal carriage of S. aureus in this study population was 19% (48/254), from nasal swabs. In a related study, Salem et al. 2019 in Libya also reported an isolation rate of 20% (48/240) from nasal swabs of primary school children [24]. Our findings were also similar to those reported from other countries [25,26,27]. However, the nasal carriage rate of *S. aureus* in this study tends to be lower than that reported from Nigeria (56.3%), India (46.67%), United States (39.6%), Netherlands (36%), Nepal (31%), and Iraq (17.75%)[28,29,25,30,31,32]. On the other hand, the prevalence of *S. aureus* among schoolchildren in our study was found to be higher than other reports from China (5.1%), and Serbia (2.59%) [33,34]. Variation in the S. aureus nasal carriage from one country to another might be attributed to differences in geographical distribution, sampling, culturing, and diagnostic techniques used by the researchers. Gender distribution in this study was 60.21% females and 39.79% males.

Though the higher proportions of males, 22.8% (23/101) of the subjects, were found to be the carriers of S. aureus than females, 16.3% (25/153). Similarly, Salem et al. 2019 reported a higher prevalence 22.1% (27/122) of *S. aureus* colonization in male children than female children, 17.8% (21/118) [24]. According to Reta et al. 2015, a higher prevalence of S. aureus colonization in male children 46.4% (71/153) than in female children was reported 35.4% (52/147) [35]. Students included in this study aged from fifteen to seventeen years old. 19.2% (37/194) of *S. aureus* nasal carriage was at age group from 15-17 years old, while S. aureus nasal carriage among age group 18-20 years was 18,3% (11/60). In the study conducted in 2008 in school children of Pokhara city in western Nepal, *S. aureus* nasal carriage in age group 6-10 years was 32.5% (29/89), however, in age group ranged from 11-15 years the nasal carriage by S. aureus was 27.3% (15/55) [25].

The highest isolation rate of *S. aureus,* 37.5% (18/50) was found from the nares of Al-Farouk high school male students, followed by Al-Dahyh high school female students, 22.9% (11/51), and Al-Amal high school female students, 18.8% (9/51), then male students at Tlayih Almstqbil high school and Um-Almominin high school female students at 10.4% (5/51) for both. MRSA was detected using a Cefoxitin (30µg) disc, which has high efficiency to detect MRSA and was performed by the standard disc diffusion method according to CLSI-2024 recommendations [36]. All *S. aureus* isolates showed 100% resistance to Penicillin. Similarly,

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MRSA isolates showed 100% resistance to Penicillin, Oxacillin, and Cefoxitin. In agreement with this observation, the previous studies also reported 100% resistance of S. aureus isolated from healthcare workers of Jimma University Specialized Hospital [37,38].

Likewise, Uwaezuoke and Aririatu reported high resistance of *S. aureus* strains to Penicillin (95.8%) of isolated from clinical sources in Owerri, Nigeria [39]. The absolute resistance of MRSA isolates to these antibiotics indicates the dissemination and dominance of HA-MRSA in the community, hence CA-MRSA strains, capable of resisting only β-lactam antibiotics as a result of carriage of the genetic element SCCmec type IV. SCCmec type IV is one of the shorter SCCmec variations, less likely to carry multidrug resistance [40]. The prevalence of MRSA among S. aureus isolates was 54.2% (26/48) of nares. A report from Ujjain, India, in 2013 showed that the prevalence of MRSA among preschools was 29% (102/351) [41]. Prevalence of MRSA among primary school children according to study in Southwest Ethiopia was 23.1% (39/169) [42]. In another study conducted in 2014 by Suliman et al, at Omdurman City, Sudan, the prevalence of MRSA was reported to be 16.3% (7/43) [43]. These variable results in the prevalence of MRSA were reflections of the local endemic city, sanitary standards, environmental conditions, timing, and seasonal differences in the design of the work and personal hygiene. The current study showed that MRSA nasal carriage was higher among males than females, 53.8% (14/26) VS 46.2% (12/26). Similarly, Salem et al. in Gharyan city West of Libya, reported higher prevalence of MRSA in male children than female children, 22.1% (27/122) VS 17.8% (21/118), respectively [24]. Reta et al. reported a higher prevalence of MRSA in male children than female children, 16.9% (12/71) VS 9.6% (5/52) [35].

In this study, 58.3% (21/36) of MRSA strains were isolated from age group ranged from 15-17 years old, however 41.7% (5/12) were isolated from students aged from 18-20 years old, these differences may due to number of students aged from 18-20 in this study which was less than the students aged 15-17 who represented the highest isolation rate of S. aureus. In 2014, a researcher from Jordan suggested that, higher prevalence of MRSA was detected among children aged 9-12 years old than among age group 6-9 years old [44]. This study showed that 72.2% (13/18) of MRSA nasal carriage was among Al-Farouk high school students, while MRSA nasal carriage was closely converged among Al-Dahyh high school students and Um-Almominin high school students 63.6% (7/11) and 60% (3/5), respectively. To a lesser incidence, Al-Amal high school students, and Tlayih Almstqbil high school students recorded nasal carriage rates were 22.2% (2/9) and 20% (1/5), respectively. Although the percentage of students carrying MRSA at Tlayih Al mstqbil high School for males was much lower than the percentage at Al Farouk high School for males, the results showed that males were more likely to carry MRSA than females, the number of male students included in this study was less than that of female students (101/254) (153/254) respectively.

Because males were more affected by MRSA, this could be explained by several reasons, including levels of some vitamins such as vitamin D, as well as elevated smoking habits among males [45]. Among the other reasons that may increase the incidence of MRSA among males is the difference in some habits among them, for example, the level of sanitation and hand hygiene, in general, males are more exposed to dirty surroundings than females that may that causes mingling between males, another expected reason could be the practice of some sports [46]. Also, among the possible reasons that may increase the rate of MRSA among males are some habits such as going to public places such as football and sports halls and barber shops, and sharing shaving tools and sports clothing [47].

There are many ways of transmitting bacterial infection among the members of society, including exchanging or borrowing personal items of infected persons [48]. In the sense of the results, more than half of the students showed different behavioral attitudes, which might be the main causes of bacterial transmission, such as the exchange and borrowing of sports clothes among them, because some schools lack educational health programs that teach students some healthy behaviors [49]. It is not surprising that schools suffer from a shortage of water; students do not find water and soap for washing hands most of the time, in addition to the lack of safe drinking water [50,51]. Among the most important causes of bacterial infection is the poor or neglectful treatment of wounds. Even superficial wounds need direct cleaning and disinfection, as open wounds are susceptible to bacterial infection [52]. The issue goes beyond poor sanitation and school environment, as some schools lack first aid materials [53], and even if they are available, it has been found that educational personnel are not trained or lack primary medical information and have not been engaged in training courses on how to conduct first aid.

The high rate of MRSA isolation and their resistance to antibiotics (100% resistance to Penicillin, Oxacillin, and Cefoxitin), and variable resistance profiles toward the other antibiotics show that these antibacterial agents would be unreliable. Trimethoprim, Moxifloxacin, Levofloxacin, Linezolid, and Ciprofloxacin seem to be the antimicrobial agents that showed 100% effect against *S. aureus* in the study. Hence, Trimethoprim, Moxifloxacin, Levofloxacin, Linezolid, and ciprofloxacin may be used as the drug of choice for treating MDR-MRSA infections. However, frequent monitoring of these antibiotic susceptibilities and routine testing should be carried out. Use of Trimethoprim, Moxifloxacin, Levofloxacin, Linezolid, and ciprofloxacin should be limited to preserve their value. It should be administered only in those cases where there is a clear need. Although all isolates were found to be sensitive to Trimethoprim, Moxifloxacin, Levofloxacin, Linezolid, and ciprofloxacin, Screening and MIC determination should be performed to detect emerging resistance early and monitor treatment response. Regular surveillance of nosocomial infections, including monitoring of

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MRSA and MSSA antibiograms and establishing defined antibiotic policies, may be useful in reducing the incidence of MRSA. Therefore, this study forms an opening to facilitate epidemiological studies. However, in addition to antibiotic combinations for the treatment of MRSA, new treatment options using other antibiotics are gradually emerging. However, these all have their disadvantages, such as drug delivery and resistance. That is why this approach has not been successfully applied in practice. Moreover, the use of new antibiotics leads to different resistance mechanisms, and new resistance characteristics may appear. Therefore, the rational use of antibiotics in appropriate combinations is the only promising alternative for infections caused by MRSA-like bacteria. However, developed nations are working on making effective MRSA treatment strategies, including novel drugs or vaccines, gene therapy, bacteriophage engineering, and so on by utilizing the latest tools and techniques. The researcher's study recommends detecting novel resistance mechanisms, such as mecC or uncommon phenotypes, such as borderline-resistant Oxacillin resistance. In general, the present study revealed high CA-MRSA both among high school students in the city of Tobruk, calling for appropriate surveillance for drug resistance patterns of microbial isolates for commonly used antibiotics not only within the health institutions, but also the community at large.

Conflict of interest. Nil

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