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Original article

Staphylococcus aureus carriage and contamination of mobile phones among students of An-Najah National University in Palestine

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Background: Mobile phones have become integral and indispensable accessories. *Staphylococcus aureus* (*S. aureus*) nasal and oropharyngeal carriage and mobile phone contamination may represent an important source of cross, auto or nosocomial infections under certain conditions.
Objectives: This study aimed to determine the frequency, antibiotic susceptibility, and virulence of *S. aureus* isolated from the nose and oral cavity and mobile phone contamination among randomly selected students of An-Najah National University in Palestine.
Methods: Nasal, oral, and mobile swabs were collected from 300 volunteer students for the isolation of *S. aureus*. Using disc diffusion test, the susceptibilities of isolated *S. aureus* strains were determined against erythromycin, oxacillin, vancomycin and clindamycin antibiotics. In addition, clindamycin resistance induction test was conducted. Furthermore, production of virulent factors (gelatinase, protease and/or amylase) by 40 representative *S. aureus* strains isolated from different sources was determined.
Results: The frequency of *S. aureus* isolation was highest from nasal swabs (30.0%), followed by oral (17.0%) and mobile (7.3%) ones. There were several risk factors that insignificantly increase the frequency of nasal, oral, and/or mobile contamination by *S. aureus*. Most of the risk factors are related to overcrowding in closed areas, hand contact with common objects, misuse of antibiotics, and improper preparation or preservation of food. Among the 126 isolated *S. aureus*, resistance was highest against erythromycin (42.1%), followed by oxacillin (15.1%) and clindamycin (9.5%). Remarkably, inducible resistance to clindamycin was found in 30.2% and 12.5% of total and mobile isolates, respectively. The highest frequency of isolation of MRSA was from nasal swabs (17.7%), followed by mobile swabs (12.5%). Similar proportions of production of gelatinase (71.0 - 80.0%) and amylase (62.0 – 71.0%) were found in *S. aureus* isolated from different sources, but lower frequency of protease production was found in mobile isolates (43.0%) in comparison to oral (85.0%) and nasal (75.0%).
Conclusions: A considerable number of students were *S. aureus* carriers and/or their mobile phones were contaminated with *S. aureus*. Some isolates were MRSA, with inducible resistance to clindamycim and/or virulent enzyme producers.

Keywords: *Staphylococcus aureus*, carrier, mobile-phone, MRSA, inducible resistance, virulent enzymes.

Staphylococcus aureus (*S. aureus*) is one of the most common human pathogens, which can cause several diseases.[1, 2] A great deal of the virulence from this organism occurs through cross-infection, which occurs when it is spread from patient to patient in hospitals and other institutional settings. In contrast, healthy individuals have a small risk of contracting an invasive infection caused by *S. aureus*, but they can be carriers of the organism.[2] However, *S. aureus* carriers are at increased risk of developing *S. aureus* infections after invasive medical or surgical procedures, and more frequently develop *S. aureus* bacteremia when admitted to a hospital.[3]

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Mobile phones have become integral and indispensable accessories of professional and social daily life. They are increasingly becoming an important means for conversation worldwide as they are easily accessible, economical, and user friendly.[4] Mobile phones are in continuous contact with their owners, creating a surface prone to attract microbial contamination, which may cause infections in those handling the contaminated device. In the city of Nablus, many people, including workers in health institutions, use mobile phones while dealing with persons at high risk of acquiring infections (the elderly, babies, immunocompromised individuals, etc.).

The present study was carried out to determine the frequency of *S. aureus* nasal and/or oral carriage among students at An-Najah National University. In addition, the frequency of students' mobile phone contamination with *S. aureus* was evaluated. Isolated *S. aureus* susceptibility to several antibiotics and inducible resistance to clindamycin were examined. Furthermore, for representative isolates, virulence was determined by the detection of production of amylase, gelatinase, and protease enzymes.

Materials and methods

Settings

The current study was conducted at An-Najah National University in Nablus, West Bank, Palestine. The university has about 23,000 students attending different colleges, including the media, information technology (IT), science, educational science, sports, engineering, law, arts, medicine and health science, economics, and literature.

Study design

In the present cross-sectional study, the inclusion criterion was students at An-Najah National University. Teachers or other employees were excluded. Convenience sampling was carried out in collection of specimens from students. Each student was informed about the research (informed consent letter) before he/she gave their consent. The study proposal and protocol was approved by An-Najah National University Protocol for Human Subjects Research Institutional Review Board (IRB).

Sample collection

Specimens were collected during 1/11/2015 to 1/2/2016. The present study included 300 volunteer students who were conveniently selected from An-Najah National University. The number of volunteer was designed so that it can be funded by the university and can provide statistically reliable results. The students were both males and females and from different colleges. A questionnaire was completed for each student.

Nasal, oropharyngeal, and mobile swabs were taken from each student. The oropharyngeal sampling involved pressing the tongue downward to the floor of the mouth by means of a spatula, and wiping a swab on the tonsils and the posterior wall of the oropharynx. In nasal sampling, the swab was introduced directly into the depth of one nostril until resistance was felt. Mobile sampling involved immersing the tip of the cotton-swab into sterile normal saline, then moving the cotton swab on the mobile's screen.

Isolation of S. aureus

Isolation of *S. aureus* was made similar to.[1, 5] Each swab was plated on Mannitol Salt Agar (MSA), which is a selective and differential growth medium used in the isolation of *S. aureus*. MSA plates were incubated at 37°C for 48 hr. MSA plates with little or no growth were re-incubated at 37°C for another 48 hr. Mannitol-fermenting colonies were selected from the MSA plates and sub-cultured to another nutrient plate and incubated at 37°C overnight. Bacteria that grew with a yellow color on the MSA were further examined for catalase and coagulase tests to confirm *S. aureus* was present.

Antibiotic susceptibility testing

Susceptibility of isolated *S. aureus* to erythromycin, vancomycin, oxacillin, and clindamycin was determined by the disk diffusion method according to the Clinical and Laboratory Standard Institute (CLSI).[6]

Inducible MLS_B phenotype

The double disk diffusion method (D-test) according to CLSI guidelines [7] was used to detect inducible MLS_B phenotype among isolated *S. aureus*. Antibiotic disks were obtained from OXOID (U/K).

Extracellular enzyme production

Detection of extracellular enzyme production was used to evaluate bioactivity and possible virulence of isolates. These tests were conducted for 40 representative available isolates. The enzymes included amylase, gelatinase, and protease. Applied procedures were similar to those mentioned in previous studies. [1, 8, 9]

Bacterial suspension preparation

To standardize the bacterial inoculums in enzyme production tests, a fresh bacterial inoculum was used to prepare a bacterial suspension with a turbidity equivalent to 4 McFarland standard suspension.

Amylase test

Although starch is not found in human tissue, it is abundantly found in the digestive tract as food, which is beneficial to amylase-producing bacteria. Starch medium composed of 2.0% starch in nutrient agar was used for amylase test. After bacterial inoculation, which included 15 µl of bacterial suspension, the plates were incubated at 37°C for 48 hr. Then iodine reagent (IKI) was added to detect the presence of starch. A non-dark blue zone around the inoculums indicated amylase production.

Gelatinase test

Tubes containing 12.0% gelatin nutrient broth were prepared. Each tube was inoculated with 15µl of bacterial suspension and incubated at 37°C for 48 hr. Then, tubes were placed with an uninoculated tube into a refrigerator (4°C) for 30 min (until the control solidified to gel). Liquefaction of cold gelatin indicated gelatinase activity.

Protease test

S. aureus strains were inoculated (15 µl of bacterial suspension) on 10.0% skim milk media and the plates were incubated at 37°C for 48 hr. A clear zone around the bacterial inoculums indicated protease production.

Statistical analysis

Frequencies of *S. aureus* isolation in relation to different variables were analyzed using Statistical Package for Social Sciences (SPSS) 14.0 (SPSS Inc., Chicago, IL, USA) software. Fisher's exact and Chi-square tests were used, and a $P < 0.01$ was considered statistically significant.

Results

Among the 300 examined volunteers, *S. aureus* bacterium was isolated from 90 (30.0%) nasal swabs, 51 (17.0%) oropharyngeal swabs, and 22 (7.3%) mobile phone swabs. In a total of 15 cases, *S. aureus* was isolated from both nasal and oropharyngeal swabs. In 7 cases with positive mobile phone swabs, nasal swabs were also positive, and four cases contained *S. aureus* positive mobile phone and oropharyngeal swabs.

Each sampled location was expected to be exposed to conditions that were different from the others; therefore, the results of the nasal, oropharyngeal, and mobile swabs were not expected to be the same. The results were arranged into three groups and were presented in three tables (1 to 3). Table 1 shows the frequency of isolation of *S. aureus* from different sources in relation to variables that may affect the isolation rate of *S. aureus* from the three sources. A significant ($P < 0.01$) difference was not found in any of the listed variables. Nasal carriage was highest (50.0%) among economics students. If $P < 0.05$ was considered significant, the nasal carriage of *S. aureus* among economics students (50.0%) was significantly ($P = 0.041$) higher than that of literature students (19.1%). On the other hand, the oropharyngeal carriage rate was highest (33.3%) among information technology (IT) students, while mobile phone contamination was highest (14.3%) among literature and medicine and health science students. To be mention, bias may had occurred in determining frequencies of *S. aureus* carriage or mobile phone contamination in some collages due to limited number of participating students from them. Increased frequency of nasal carriage of *S. aureus* was found in students aged ≥ 20 years, engaged students, students who did not have a cold or flu, students who did not suffer from allergy, students who had not left Palestine less than a month ago and students who used antibiotics without a doctor's prescription.

Oropharyngeal *S. aureus* carriage rate clearly increased in younger students (< 20 years), males, students who were engaged, students who did not have a cold or flu, students without allergies, students who have not left Palestine (< 1 month), and students who used antibiotics without a doctor's prescription. If $P < 0.05$ was considered significant, engaged students possessed a significantly ($P = 0.023$) higher frequency of nasal carriage (57.1%) compared to students who were single.

Higher percentages of isolation of *S. aureus* from mobile phones were found in female students, students who were single, students without allergies, students who have not left Palestine (< 1 month), and students who did not use antibiotics without a doctor's prescription.

Table 1. Frequency of isolation of *S. aureus* from different sources in relation to different variables.

Variables		Number of students	*S. aureus* positive (%)		
			Nasal	Oropharyngeal	Mobile
Age	Less than 20 year	110	26 (23.6)	23 (20.9)	8 (7.3)
	20 or more	190	64 (33.7)	28 (14.7)	14 (7.4)
Sex	Male	86	26 (30.2)	16 (18.6)	5 (5.8)
	Female	214	64 (29.9)	35 (16.4)	17 (7.9)
Social status	Single	269	77 (28.6)	47 (17.5)	22 (8.2)
	Engaged	14	8 (57.1)	3 (21.4)	0 (0.0)
	Married	17	5 (29.4)	1 (5.9)	0 (0.0)
College	Economics	18	9 (50.0)	5 (27.8)	2 (11.1)
	IT	18	8 (44.4)	6 (33.3)	2 (11.1)
	Literature	21	4 (19.1)	4 (19.1)	3 (14.3)
	Medicine and Health science	35	9 (25.7)	4 (11.4)	5 (14.3)
	Media, Science, Educational science, sport, Engineering, Law, arts, Undetermined	208	16.7 - 36.0	0 - 24.0	0 - 8.7
Have cold or flu	Yes	85	23 (27.1)	10 (11.8)	6 (7.1)
	No	215	67 (31.2)	41 (19.1)	16 (7.4)
Suffering from allergy	Yes	85	27 (31.8)	16 (18.8)	5 (5.9)
	No	215	63 (29.3)	35 (16.3)	17 (7.9)
Travelling out Palestine (< 1 month)	Yes	16	4 (25.0)	1 (6.3)	0 (0.0)
	No	284	86 (30.3)	50 (17.6)	22 (7.8)
Using antibiotic by your self	Yes	76	26 (34.2)	15 (19.7)	4 (5.3)
	No	224	64 (28.6)	36 (16.1)	18 (8.0)

Figure 1 shows the variable in Table 1 in which the frequency of isolation of *S. aureus* increased. Remarkably, absence of allergy and not living Palestine < a month ago increased the frequency of isolation of *S. aureus* from the 3 sources. In addition, increase in frequency of isolation of *S. aureus* from nasal and oropharyngeal cavies were increased in economics students, IT students, engagement, absence of cold or flu, antibiotics use without a doctor's prescription.

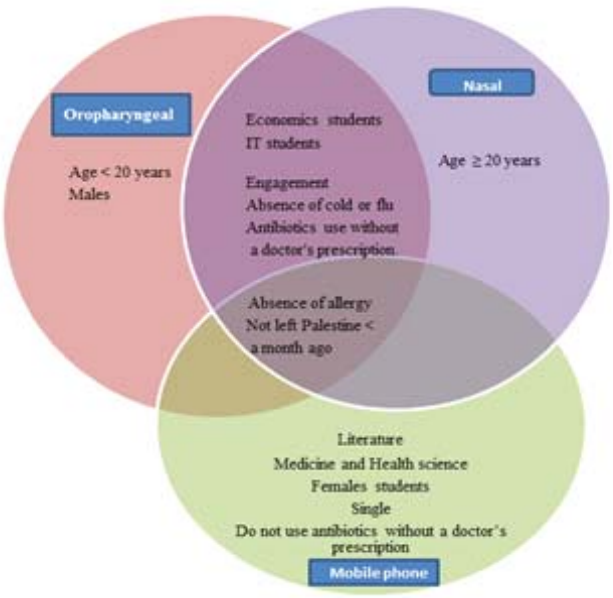

Figure 1. Increased frequency of isolation of *S. aureus* from different sources in relation to different variables.

Table 2 shows *S. aureus* isolation percentages of oropharyngeal, nasal, and mobile phone swabs in relation to variables that are expected to affect the rate of oropharyngeal carriage. Oropharyngeal carriage of *S. aureus* among students increased without significance in students who drink water from public sources, students who use unchlorinated water, students who drink out of a can without an absorbent, students who buy ice-cream from hawkers, students who buy uncovered food, students who do not use miswaks, students who eat fast food, students who do not own a pet, students who drink uncooked eggs, students who eat uncooked liver, students who drink fresh juice, students who eat shatta (food prepared by drying and cutting chili peppers into very small pieces), and students who do not eat honey. Nasal carriage of *S. aureus* among students increased insignificantly in students who drink water from public sources, students who drink out of a can without an absorbent, students who buy ice-cream from hawkers, students who do not use miswaks, students who eat fast food, students who do own a pet, students who drink uncooked eggs, students who drink fresh juice, students who eat shatta, and students who do not eat honey. Mobile phone contaminated with *S. aureus* among students increased without significance in students who use unchlorinated water, students who buy ice-cream from hawkers, students who buy cotton candy, students who buy uncovered food, students who do not use miswaks, students who eat uncooked liver, students who drink uncooked eggs, students who drink fresh juice, and students who do not eat honey.

Table 2. Frequency of isolation of *S. aureus* from different sources in relation to variables that may affect oropharyngeal carriage.

Variables		Number of students	*S. aureus* positive (%)		
			Nasal	Oropharyngeal	Mobile
Drinking from public water sources	Yes	227	71 (31.3)	40 (17.6)	15 (6.6)
	No	73	19 (26.0)	11 (15.1)	7 (9.6)
Chlorine in water chlorinated-water	Yes	79	27 (34.2)	9 (11.4)	5 (6.3)
	No	204	57 (27.9)	36 (17.7)	16 (7.8)
	Don't know	17	6 (35.3)	6 (35.3)	1 (5.9)
Drinking out of can without absorber	Yes	167	56 (33.5)	29 (17.4)	7 (4.2)
	No	133	34 (25.6)	22 (16.5)	15 (11.3)
Letting others drink from own can	Yes	147	34 (23.1)	20 (13.6)	8 (5.4)
	No	153	56 (36.6)	31 (20.3)	14 (9.2)
Buying icecream from hawkers	Yes	92	27 (29.3)	20 (21.7)	9 (9.8)
	No	208	36 (17.3)	31 (14.9)	13 (6.3)
Buying cotton candy	Yes	136	36 (26.5)	21(15.4)	12 (8.8)
	No	164	54 (32.9)	30 (18.3)	10 (6.1)
Buying uncovered food	Yes	158	45 (28.5)	28 (17.7)	12 (7.6)
	No	142	45 (31.7)	23 (16.2)	10 (7.0)
Using Miswak*	Yes	28	8 (28.6)	2 (7.1)	2 (7.1)
	No	272	82 (30.1)	49 (18.1)	20 (7.4)
Eating homemade food or fast food	Homemade	68	20 (29.4)	10 (14.7)	5 (7.4)
	Both	217	65 (30.0)	38 (17.5)	17 (7.8)
	Fast	15	5 (33.3)	3 (20.0)	0 (0.0)
Having animals in your home	Yes	91	32 (35.2)	13 (14.3)	7 (7.7)
	No	209	58 (27.8)	38 (18.2)	16 (7.7)
Drinking un cooked egg	Yes	6	3 (50.0)	3 (50.0)	1 (16.7)
	No	294	87 (29.6)	48 (16.3)	21 (7.1)
Eating un cooked liver	Yes	12	3 (25.0)	3 (25.0)	1 (8.3)
	No	288	87 (30.2)	48 (16.7)	21 (7.3)
Drinking fresh juice	Yes	208	66 (31.7)	38 (18.3)	16 (7.7)
	No	92	24(26.1)	13(14.1)	6 (6.5)
Eating shatta*	Yes	205	63 (30.7)	37 (18.1)	15 (7.3)
	No	95	27 (28.4)	14 (14.7)	7 (7.4)
Eating honey	Yes	155	45 (29.0)	24 (15.5)	10 (6.5)
	No	145	45 (31.0)	27 (18.6)	12 (8.3)

*Miswak, a plant (stem part) used for cleaning of teeth
**shatta, food prepared by drying and cutting chili pepper into very small pieces.

Common causes of increase of *S. aureus* isolation from the 3 studied sources are shown in Figure 2, which included: buying ice-cream from hawkers, miswaks is not used, drinking uncooked eggs, drinking fresh juice and not eating honey.

As shown in Table 3, higher percentages of *S. aureus* nasal carriage were found among students attending ≥ 3 labs /week, students who did not attend gym for sports, students with several roommates, and students who did not have air conditioning in their room. Higher percentages of *S. aureus* oropharyngeal carriage were found among students attending 1 or more than 3 labs /week and students who attend gym for sports. Higher frequencies of *S. aureus* mobile phone contamination were found among students attending gym for sports, students with several roommates, and students who have air conditioning constantly in their room.

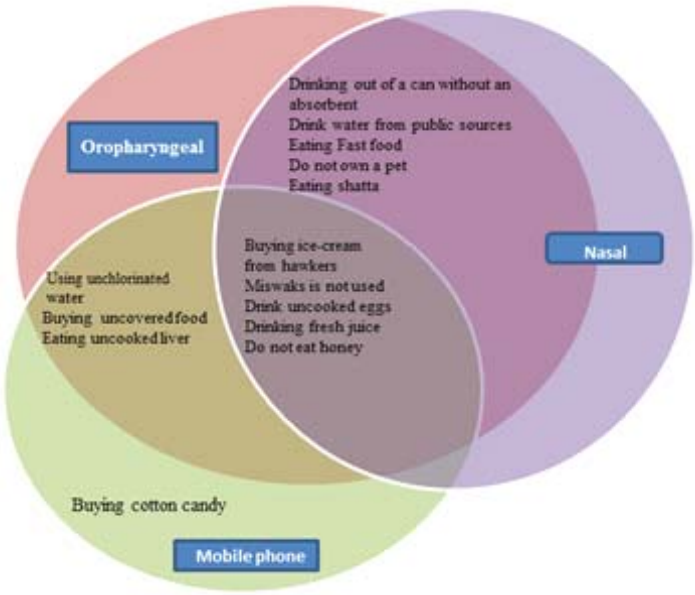

Figure 2. Increased frequency of isolation of *S. aureus* from different sources in relation to variables that may affect oropharyngeal carriage.

Table 3. Frequency of isolation of *S. aureus* from different sources in relation to variables that may affect nasal carriage.

Variables		Number of students	*S. aureus* positive (%)		
			Nasal	Oropharyngeal	Mobile
Attending scientific labs / week	Non	195	57 (29.2)	31 (15.9)	16 (8.2)
	1 lab	63	16 (25.4)	12 (19.1)	6 (9.5)
	≥ 3 labs	42	17 (40.5)	8 (19.1)	0 (0.0)
Going to gym	Yes	43	12 (27.9)	9 (20.9)	5 (11.6)
	No	257	78 (30.4)	42 (16.3)	17 (6.6)
No. of persons sharing student's Room	0	81	23 (28.4)	17 (21.0)	5 (6.1)
	1	114	34 (29.8)	16 (14.0)	8 (7.0)
	≥ 2	105	33 (31.4)	18 (11.4)	9 (8.6)
Sitting in air conditioned room	No	119	89 (33.7)	46 (17.4)	20 (7.6)
	Constantly	141	35 (24.8)	24 (17.0)	12 (8.5)
	Few times	40	11 (27.5)	8 (20.0)	2 (5.0)

Figure 3 shows the increase of frequency of isolation of *S. aureus* from different sources in relation to variables that may affect nasal carriage. Only presence of several roommates caused increase isolation of *S. aureus* from nasal cavity and mobile phone.

Table 4 and Figure 4 show the comparison of resistance to different antibiotics by *S. aureus* isolated from different sources. Among the 126 isolated *S. aureus*, 19 (15.1%) were oxacillin resistant, 53 (42.1%) were erythromycin resistant, 12 (9.5%) were clindamycin resistant and 0 (0.0%) were vancomycin resistant. Remarkably, 38 (30.2%) isolates possessed inducible resistance to clindamycin. The highest frequency of isolation of MRSA was found in nasal swabs (17.7%), followed by mobile swabs (12.5%). Erythromycin resistance and inducible clindamycin resistance were also the highest in nasal swabs, followed by oral and mobile swabs. If $P < 0.05$ was considered significant, the frequency of resistance to erythromycin among *S. aureus* isolated from the nasal cavity (52.9%) was significantly higher ($P = 0.024$) than oral (31.0%) and mobile (25.0%; $P = 0.044$). In addition, frequency of inducible resistance to clindamycin among nasal isolates (39.7%) was significantly ($P = 0.45$) higher than that of mobile (12.5%) and oral (21.4%; $P = 0.047$).

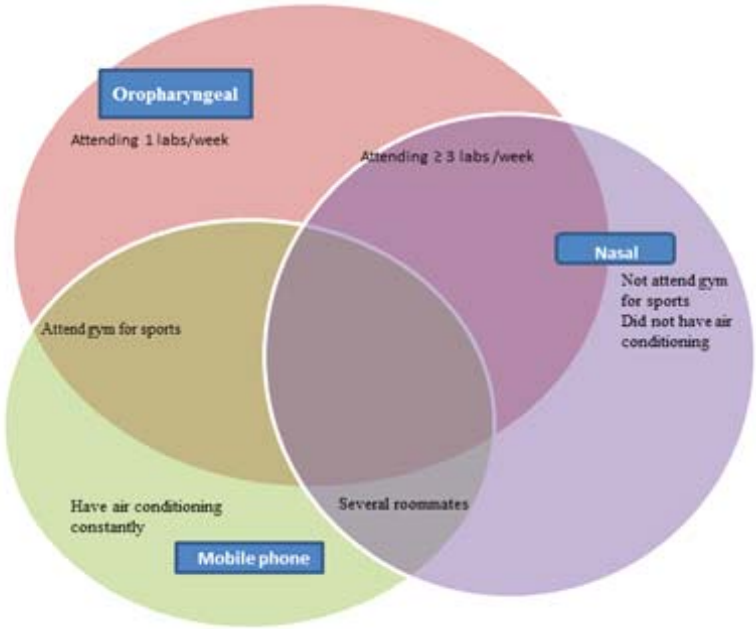

Figure 3. Increase frequency of isolation of *S. aureus* from different sources in relation to variables that may affect nasal carriage.

Table 4. Susceptibility of isolated *S. aureus* to different antibiotics.

Source of isolates	No. of examined isolates	Number of resistant isolates (%)				
		Oxacillin (*MRSA)	Vancomycin	Erythromycin	Clindamycin	No. of isolates (%) clindamycin inducible resistance
Nasal	68	12 (17.7)	0 (0.0)	36 (52.9)	5 (7.4)	27 (39.7)
Oral	42	5 (11.9)	0 (0.0)	13 (31.0)	6 (14.3)	9 (21.4)
Mobile	16	2 (12.5)	0 (0.0)	4 (25.0)	1 (6.3)	2 (12.5)
Nasal or/ and oral	110	17 (15.5)	0 (0.0)	49 (44.6)	11 (10.0)	36 (32.7)
Nasal, oral or/ and mobile	126	19 (15.1)	0 (0.0)	53 (42.1)	12 (9.5)	38 (30.2)

*methicillin resistant *S. aureus*

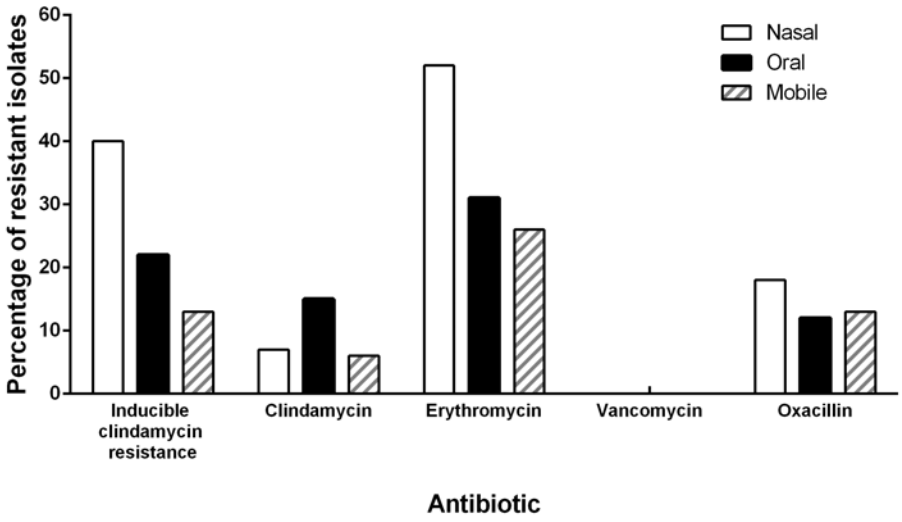

Figure 4. Percentages of antibiotics' resistance of *S. aureus* isolated from different sources.
Erythromycin resistance of *S.aureus* from nasal cavity vs oral, $P = 0.024$; Erythromycin resistance of *S.aureus* from nasal cavity vs mobile, $P = 0.044$. Inducible resistance of *S.aureus* to clindamycin among nasal isolates vs mobile, $P = 0.45$; Inducible resistance of *S.aureus* to clindamycin among nasal isolates vs oral: $P = 0.047$

Table 5. Production of extracellular enzymes by representative strains isolated from different sources.

Protease test %	Amylase test %	Gelatinase test %	Examined number	Origin of isolate
11 (85.0)	8 (62.0)	10 (77.0)	13	Oral
15 (75.0)	14 (70.0)	16 (80.0)	20	Nasal
3 (43.0)	5 (71.0)	5 (71.0)	7	Mobile

Clindamycin resistance was highest among oral swabs, followed by nasal and mobile swabs. None of the 126 *S. aureus* were vancomycin resistant.

Close percentages of gelatinase and amylase production was found in *S. aureus* isolated from different sources (Table 5). On the other hand, lower frequency of protease production was found in mobile isolates (43.0%) compared to oral (85.0%) and nasal (75.0%).

Discussion

This research was carried out to highlight the risk factors of contracting *S. aureus* from the environment, as well as the important role mobile phones play as a vehicle in spreading infections, including challenging strains (methicillin resistant *S. aureus* [MRSA] and inducible clindamycin resistant).

The assumption is that most invasive *S. aureus* infections arise from nasal carriage. [10] The danger of *S. aureus* carriage is not limited to the carrier only, but *S. aureus* can be spread easily to others by sneezing caused by other pathogens (e.g. viruses). In the present study, *S. aureus* bacterium was isolated from 30.0% nasal swabs, while 17.7% of isolates were MRSA. In a study carried out in Brazil[11], the percentage of nasal carriage of *S. aureus* among university students was 40.8%, and 5.8% of isolates were methicillin-resistant.

In a study carried out in the UK, [12] *S. aureus* oral carriage was reported in 18.0% of the tested cases, while 10.0% were MRSA. This was in accordance with the present study's findings on oropharyngeal carriage (17.0%) and MRSA (11.9%).

In the present study, *S. aureus* was isolated from 22 (7.3%) mobile swabs. Among the isolated strains, 12.5% were MRSA and 12.5% possessed inducible clindamycin-resistant phenotypes. Both phenotypes presented a big challenge to the treatment. In a study carried out at King Abdulaziz University in Saudi Arabia, out of 105 cell phones screened, 17 (16.2%) cell phones were found to harbor *S. aureus*. [13] In Ghana, a total of 100 mobile phones of students at the University of Cape Coast were sampled. All sampled mobile phones were contaminated with varied

numbers of bacteria, including *S. aureus* (4.0%), *Bacillus cereus* (23.0%), *Proteus mirabilis* (19.0%), *Klebsiella pneumoniae* (10.0%), *Streptococcus pneumoniae* (10.0%), *Escherichia coli* (8.0%), *Pseudomonas aeruginosa* (4.0%), *Salmonella spp* (3.0%), and *Shigella spp* (2.0%). In addition, all the isolated bacteria were resistant to ampicillin, cloxacillin, and cefuroxime. [14]

In the present study, nasal carriage of *S. aureus* was highest (50.0%) among economics students, followed by IT students. This high level of carriage may be attributed to the architecture of the collage and the crowded conditions among students. On the other hand, contact with keyboards from computers may contribute to the higher oropharyngeal carriage of *S. aureus* among IT students, where they showed the highest oropharyngeal carriage (33.3%). Interestingly, while the economic students possessed the highest frequency of *S. aureus* nasal carriage they also possessed relatively increased frequency of isolation of *S. aureus* from oropharyngeal cavies. On the other hand, IT students were with the highest frequency of *S. aurues* oropharyngeal carriage and also possessed increased level of nasal carriage with this bacterium. This may indicate the spread of the bacterium between nasal and oropharyngeal cavies by body secretion. Similarly, *S. aureus* carriage in nasal and oropharyngeal cavies were increased in engagement cases, absence of cold or flu, and antibiotics use without a doctor's prescription. Furthermore, absence of allergy and not leaving Palestine < a month ago increased the frequency of isolation of *S. aureus* from the nasal, oropharyngeal and mobile phone.

Students in medicine and health science collage may be at higher risk of acquiring infection from hospital or laboratory work. This group of student did not show the highest rates of *S. aureus* carriage and mobile phone contamination was similar to literature student. This may reflect the strict regulation of infection control applied in the hospitals and laboratories. In addition, students always work under supervision of medical professionals. The rate of mobile phone contamination of students in medicine and health science was similar to that of literature student and therefore, was not considered a unique property to medicine and health science collage. The frequency of isolation of *S. aureus* from the nose was found to be higher in students aged ≥ 20 years, which can be attributed to the increased risk of acquisition of *S. aureus* with age. The *S. aureus* nasal carriage rate was also higher in students who were engaged, which can be attributed to physical contact. The use of antibiotics without a doctor's prescription showed higher rates of nasal and oral *S. aureus* carriage. The use of antibiotics can kill normal flora in the nose and throat region, creating selective pressure for persistence of more resistant strains of *S. aurues*; the bacterium is known to secrete a number of extracellular enzymes, as well as bacterial accumulation, which may contribute to allergies. This may explain the higher frequencies of nasal and oropharyngeal carriages of *S. aurues* in students with allergies. Lower rates of nasal and oropharyngeal carriage of *S. aureus* in students with a cold or flu may be a sequence of a decrease in concentration of *S. aureus* due to an increase in secretion within respiratory tract due to coughing or sneezing caused by a cold or flu.

Students who travelled out of Palestine (< 1 month) possessed lower isolation rates of *S. aureus* from the nose, throat and mobile phones compared to those who did not travel (Table 1). This may reflect the endemic nature of *S. aureus* in the city of Nablus. In addition, An-Najah National University may contribute to increased rates of *S. aureus* due to close contact between students as a result of limited space and overcrowding.

Students who were single possessed higher percentages of contamination of mobile phones (8.2%) compared to students who were engaged or married (both were 0.0%). This may be attributed to the less frequent use of mobile phones by students who were engaged or married and the higher rates of mobile social media use found in students who are single.

Oropharyngeal carriage of *S. aureus* among students was insignificantly increased in students who drink or eat from sources that have a higher possibility of contamination (i.e. water from public sources, unchlorinated water, drinking out of a can without an absorbent, buying ice-cream from hawkers, buying uncovered food, and eating fast food). Eating uncooked food such as uncooked eggs, uncooked liver, fresh juice, or *shatta*, also increased the rate of oropharyngeal carriage of *S. aureus*. Shatta food is unique in our region. It is prepared by drying and cutting chili pepper into very small pieces then some water is added to it. It is not heated and may contain preservative so it can remain contaminated with some bacteria. It used as appetizer (personal

communications). In our study, frequency of nasal and oropharyngeal carriage of *S. aureus* was slightly increased in students eating shatta. The rate of oropharyngeal carriage of *S. aureus* decreased among students who eat honey and used miswaks. This can be attributed to their antimicrobial properties. [15, 16] Thus using miswaks is recommend to increase the health of teeth and oral cavities as it decrease the frequency of normal flora that is responsible for dental problems.

Common causes of increase of *S. aureus* nasal and oropharyngeal carriage as well as mobile phone contamination included buying ice-cream from hawkers, *miswaks* is not used, drinking uncooked eggs, drinking fresh juice and not eating honey.

Higher rates of *S. aureus* nasal carriage were found among students attending ≥ 3 labs per week and students who had several roommates. Since both involve several people in confined spaces, an increased risk of contamination exists as *S. aureus* can be contracted through respiration, vacuolization or/and sneezing caused by viruses or other causes.

Increase isolation of *S. aureus* from nasal cavity and mobile phone was only associated with presence of several roommates.

Although *S. aureus* bacterium was not isolated from patients, there were considerable percentages of strains of MRSA, which were isolated from nasal or/and oral swabs (15.5%) and from mobile phone swabs (12.5%). Furthermore, percentages of inducible resistance to clindamycin detected in *S. aureus* isolated from nasal or/and oral and mobile swabs were 32.7% and 12.5%, respectively. These resistance phenotypes represent a threat to the carriers and their contacts, especially if carriers are exposed to illness or associated with patients. Hospitalized patients (some who are immunocompromised) remain in hospitals for long periods of time and use their mobile phones for entertainment. Such use may represent a higher risk of contracting resistant *S. aureus* strains.

In the present study, determination of extracellular enzyme secretion by a number of isolated strains was carried out to evaluate virulence of isolated strains. Such enzymes can cause destruction of the host tissues. *S. aureus* isolated from oral and nasal cavities, as well as from mobile phone screens appeared to be virulent strains since most of them produce gelatinase, protease, and amylase (starch is present only as food in intestine, and may increase the nutrient support for the amylase producing strains). The isolation of extracellular enzyme producing strains from mobile phone screens may reflect the presence of biologically active bacteria and the formation of a biofilm on phone screens. In a previous study [9] carried out in India, it was observed that 100.0% clinical *S. aureus* strains isolated from burns and wounds showed positive results in gelatin hydolysis, where 50.0% of isolates were positive in the starch hydrolysis test and 35.0% were positive in the protein hydrolysis test. The differences in the rate of enzyme production may be attributed to the origin of isolate collection and some differences in applied procedures.

Although, *S. aureus* virulent resistant strains may represent a minor danger to healthy individuals, they represent a fatal challenge to individuals who undergo major medical procedures or take medication (i.e. surgery, cortisol therapy, etc.), as well as to the surrounding people with insufficient immunity (i.e. the elderly, cancer patients, etc.).

Hospitalized persons do not realize that their mobile phones carry life-threatening microbes. Thus, medical staff with different educational degrees should be informed about the role mobile phones play in spreading bacterial infections, as well as the importance of disinfecting the mobile phones of staff and patients using tissue paper containing 70.0% alcohol. Another important application of this study is examination of nasal, or oropharyngeal carriage of *S. aureus* in patients that will undergo major medical procedures as surgery and disinfection of their mobile phones. These precautions should be also made for persons who accompany patients.

At the level of health minister, the food preparation services must be checked continuously to detect possible source of food contamination. The university must carry out periodical examination of contamination of equipment that serve students as conditioners, computers and water sources.

Limitations of this study included the limited number of students especially when they were distributed on large number of variables like colleges. This hindered detection of strong relationships. Another limitation of this study is the lack of typing methods of *S. aureus* strains. That may make the relationship of strains isolated from different individuals or sites clearer.

Conclusion

A considerable number of students at An-Najah University owned contaminated mobile phones and/or were carriers of the *S. aureus* bacteria in nasal, or/and oral cavities. Some of the isolated bacteria were MRSA and possessed inducible clindamycin resistance, and/or produced tissue degrading enzyme(s). There are several risk factors the can increase the frequency of nasal, oral, and/or mobile phone contamination by *S. aureus*. We recommend continuous monitoring of *S. aureus* carriage and mobile phone contamination for workers in hospital settings as well as patients and their companying.

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Conflict of interest

There is no conflict of interest to declare.

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