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RESEARCH ARTICLE

THE PREVALENCE AND ASSOCIATED FACTORS OF *STAPHYLOCOCCUS AUREUS* COLONIZATION IN THE ORAL CAVITY OF ADULTS

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Abstract

Background and aims: Long-term carriers of *S. aureus* are thought to make up between 21% and 30% of the human population. The bacteria are present in the mouth mucous membrane, the lower reproductive tract of females, the nose, and the typical skin microbiota. *S. aureus* can cause a wide range of ailments, from mild skin infections like cellulitis, boils, carbuncles, folliculitis, abscesses and scalded skin syndrome. Finding the prevalence of *S. aureus* in the oral cavities of adult dental patients as well as any possible contributing factors was the aim of this study.
Methods: One hundred patients—fifty-nine with natural teeth and fifty with prosthetics who attended dental clinics run by the Sana'a University Faculty of Dentistry participated in a cross-sectional study. The buccal mucous membranes of both groups were sampled, and the swabs were cultured on both selective medium (Mannitol salt agar) and medium supplemented with 5% blood. After that, all cultured plates were incubated at 37°C with oxygen for 48 hours, after which the bacterial growth was identified using conventional techniques.
Results: Compared to female patients (41%), male patients had an oral colonization rate of *S. aureus* of 58.9%; for the younger age group (24–34 years), it was 70% with OR=3.7 (p=0.003). There was a significant link (odds ratio = 4.9) between detachable prostheses, prosthesis wearers with more than six years of experience (OR=17, p<0.001), and smokers who regularly lit up (OR=7.3, p= 0.03). Furthermore, a significant association was discovered between the practice of consistently ingesting large amounts of sugar (*OR*=5.7, p=0.01) and the growth of *S. aureus* in the oral cavity.
Conclusion Healthy persons had a high frequency of *Staphylococcus aureus* in their oral cavities, and the infection was linked to certain behaviors such as smoking, chewing Qat, using prostheses, and patients who were younger in age. Also, the study emphasizes how crucial it is to practice proper oral hygiene because *Staphylococcus aureus* can primarily cause possible systemic infections through the mouth cavity.
Keywords: Associated factors, colonization, oral cavity, prevalence, *Staphylococcus aureus*.

INTRODUCTION

Staphylococcus aureus is one of the most common *staphylococci* that can cause opportunistic infections, such as infections contracted in clinics and the general public[1,2]. *S. aureus*, a member of the human microbiome, can result in infections such as pneumonia, bloodstream infections, urinary tract infections, and infective endocarditis, which can be fatal[3-7]. Moreover, investigations have demonstrated that the predominant oral pathogens in patients receiving intensive care and senior adults receiving long-term care are *S. aureus* and gram-negative[8-10]. Patients with dermatological disorders[11], intravascular catheters[12], and diabetes[13,14] are more susceptible to infection from *S. aureus*. Patients who are

immunocompromised[15], surgical patients[16,17], and healthcare personnel[18] all have the same effect. Concerns over the existence of resistant *S. aureus* in the population have been highlighted by the growing prevalence of the infection in hospitals[3-5]. The rising incidence of multi-drug resistance strains of *S. aureus* in hospitals and the community can make treatment for *S. aureus* infections more difficult[4].

The nasal cavity has long been thought to be *S. aureus'* primary reservoir[19,20]. According to a study conducted on healthy people, 12.4% of *S. aureus* was found in the throat and 36.4% of the germs were isolated from the nasal area[21]. The same patterns were discovered in a study conducted in a hospital, where *S. aureus* was more common in the nose region than in the throat area in around half of the patients who were admitted and the medical staff[22,23,]. In a hospital setting, the percentage of patients with *S. aureus* ranged from 45% to 80%[20,24]. In addition to the nose, cutaneous, and throat regions, the oral cavity has been identified as one of the prospective reservoirs for *S. aureus*, despite the fact that the infection is believed to be transient[25]. There is a worry, though, that it might end up serving as *S. aureus* main reservoir[26]. Research conducted in various areas on the oral cavity of healthy adults and children revealed a relatively high prevalence of *S. aureus*, ranging from 4% to 36% and 33% to 64%, respectively[23].

A review on oro-facial bacterial infections illnesses found that *S. aureus* was associated with face cellulitis and a bullous form of facial infection around the lips and nose[27,28]. It also caused oral infections. Acute dentoalveolar abscess, dry mouth, denture wearers, and angular chelitis[29-33], among other oro-facial illnesses, have also been linked to *S. aureus* in the oral cavity has been linked to systemic infections and potentially fatal conditions include aspiration pneumonia, rheumatoid arthritis, and infective endocarditis[23,34-36]. When there are more colonization in oral cavity, there is a higher chance of infections, which can change oral and overall health issues. Thus, the purpose of this study was to evaluate the prevalence of *S. aureus* in adult oral cavities as well as the relationship between oral hygiene behaviors, dental prosthesis, and sociodemographic factors and *S. aureus* colonization in oral cavities.

MATERIALS AND METHODS

Sample size: The study's minimum sample size requirement was established by referring to an earlier investigation on *S. aureus* carriage in Yemen's oral cavity[6]. Therefore, a percentage of approximately 24% was selected to calculate the sample size with 11% as the minimum indicated prevalence. The sample size required was 100, with a 99% confidence interval.

Subjects and study sit:

In the dental clinics of Sana'a University in Yemen's Faculty of Dentistry and the Medical Microbiology Laboratory of the Faculty of Medicine and Health Sciences, 100 individuals (51 with dental prosthesis and 49 without) underwent bacterial tests for a year, starting in September 2022 and ending in September 2023 (time allowed for doctoral fieldwork).

Microbiological procedure

At the National Center for Public Health Laboratories (NCPHL) in Sana'a, Yemen, cultivation and identification were completed. The buccal mucosal membranes of were sampled. Selective solid media cultures were conducted in an oxygenated environment, such as mannitol agar, and enriched media contains 5% blood. For the identification and culture of bacteria, we followed standard procedures[37].

Data collection

An adapted questionnaire was used to gather data on the participants' oral hygiene habits and sociodemographic background. Questions about gender, age, ethnicity, and occupation were asked about sociodemographic background; questions about oral hygiene practices asked about the date of the last dental appointment, whether the patient wore a fixed or removable prosthesis, how often they brushed their teeth, what kind of toothpaste they used, and whether they used any additional mouthwash, charcoal mouthwash, or salt mouthwash.

Statistical Analysis:

The SPSS, version 23.0, was used to gather and analyze the data. Oral hygiene routines and sociodemographic variables were the subjects of descriptive statistics. Chi-square tests (χ^2) were used in bivariate studies to evaluate variables related to *S. aureus* presence. A *p*-value with one tail less than 0.05 was deemed statistically significant. Lastly, odds ratios (OR) were used to determine the correlations between the independent and dependent variables.

Ethical Consideration:

This study of The Faculty of Medicine and Health Sciences at Sana'a University received ethical approval for the Contract No. 217 project on August 21, 2022, from the Medical Ethics and Research Committee". Written, informed consent was obtained from selected people.

RESULTS

The study had 100 participants, 51 of whom had dental prosthesis and 49 of whom were controls; 39% of the participants were men and 61% were women. The participants' ages ranged from 34 to 65 years old, with an average age of 40.1±8.4 years. 40% of the participants were in the age range of 35 to 44. In terms of prosthesis type, 33% have fixed prosthesis, 18% have detachable prosthesis, and 49% do not have any prosthesis at all. In terms of how long prosthesis lasts, the majority of participants (62.7%) had ones that last 1-3 years. Also, 45.1% of the prosthesis is in the lower arch and 54.9% is in the upper arch of our patients (Table 1).

The relationship between *S. aureus* presence and participant profiles is displayed in Table 2. When taking into account gender, male patients had an oral colonization rate of *S. aureus* of 58.9%, which was greater than the rate of female patients by 41%. The odds ratio for male patients to acquire *S. aureus* was equivalent to 2.1, but the differences were not

statistically significant (p=0.08). When age groups were taken into account, the rate of oral colonization by *S. aureus* was 70% higher in the younger age group (24–34 years) than in the older age groups. The odds ratio for acquiring *S. aureus* in the 24-34 years group was equal to 3.7, with a 95% confidence interval of 1.4–9.2, an X^2 equal to 8, and a statistically significant result of p=0.003. When dental prosthesis type was taken into account, there was a correlation (odds ratio = 4.9, 95% CI=0.4–5.4) between contracting *S. aureus* in the oral cavity and removable prosthesis; however, this result was not statistically significant. Additionally, a correlation was seen between dental fixed prosthesis and contracting *S. aureus* in the oral cavity, with an odds ratio of 2.1 and a 95% confidence interval of 0.9 to 5.0. However, this result lacked statistical significance. Considering the position of the dental prostheses, there was an association between lower arch prostheses and *S. aureus* colonization in the oral cavity with an odds ratio equal to 4.2 with a 95% CI equal to 1.5-11.8, with X^2 equal to 8.1 and a p value equal to 0.004 while there was no association with prosthetics for the upper teeth. In terms of prosthesis duration, there was no correlation found between having a prosthesis for 1-3 years or 4-6 years, but there was an association between having one for longer than 6 years and contracting *S. aureus* in the oral cavity, with odds ratio equal to 17 and 95% CI equal to 2.1 – 136, X^2 equal to 11.7, and p value equal to < 0.001. In light of the patient's habits, a strong correlation was found between regular smoking and the oral cavity contracting *S. aureus*, with an odds ratio of 7.3, a 95% confidence interval of 1.08 to 62, an X^2 of 4.2, and a p value of 0.03. Additionally, a strong correlation was found between the regular chewing of Qat and the colonization of *S. aureus* in the oral cavity, with an odds ratio of 21 and a 95% confidence interval of 2.6 to 167, an X^2 of 14.5, and a p value of 0.0001.

Table 1: Sex and age distribution and others participant's profiles.

Characters	N (%)
Sex	
Male	39 (39)
Female	61 (61)
Ages	
24-34	30 (30)
35-44	40 (40)
45-54	21 (21)
≥55	9 (9)
Mean age	40.1Years
SD	8.4 Years
Mode	40 Years
Median	40 Years
Min-Max	34-65 Years
Duration of prosthesis	
1-3 years	32 (62.7)
4-6 years	6 (11.8)
< 6 years	13 (25.5)
Type of prosthesis	
No prosthesis	49 (49)
Removable	18 (18)
Fixed	33 (33)
Prosthesis sit	
Upper arch	28 (54.9)
Lower arch	23 (45.1)

Table 2: Association between presence of *S. aureus* and participant's profiles.

Characters	N (%)	*S. aureus* n=48 N (%)	*OR (95% CI)*	X^2	*p*
Sex					
Male	39 (39)	23 (58.9)	2.1 (0.9-4.6)	3.1	0.08
Female	61 (61)	25 (41)	0.4 (0.2-1)	3.1	0.08
Ages					
24-34	30 (30)	21 (70)	3.7 (1.4-9.2)	8.0	0.003
35-44	40 (40)	16 (40)	0.5 (0.2-1.3)	1.7	0.19
45-54	21 (21)	8 (38.1)	3.3 (0.8-13.1)	3.1	0.08
≥55	9 (9)	3 (33.3)	0.5 (0.1-2.1	0.8	0.35
Type of prosthesis					
No prosthesis	49 (49)	17 (34.7)	0.3 (0.15-0.77)	6.8	0.012
Removable	18 (18)	11 (61.1)	4.9 (0.4-5.4)	1.5	0.21
Fixed	33 (33)	20 (60.6)	2.1 (0.9 – 5)	3.1	0.07
Prosthesis sit					
Upper arch	28 (54.9)	11 (39.3)	0.6 (0.25-1.4)	1.2	0.27
Lower arch	23 (45.1)	17 (73.9)	4.2 (1.5-11.8)	8.1	0.004
Duration of prosthesis					
1-3 years	32 (62.7)	14 (43.8)	0.3 (0.1-0.8)	6.2	0.012
4-6 years	6 (11.8)	5 (83.3)	2.7 (0.3-2.4)	0.8	0.34
< 6 years	13 (25.5)	12 (92.3)	17 (2.1-136)	11.7	<0.001
Habits					
Smoking	7 (7)	6 (85.7)	7.3 (1.08-62)	4.2	0.03
Qat chewing	15 (15)	14 (93.3)	21 (2.6-167)	14.5	0.0001
High sugar intake	11 (11)	9 (81.8)	5.7 (1.2-28)	5.7	0.01
Oral hygiene					
Regular Tooth Bruch	39 (39)	9 (23.1)	0.16 (0.06-0.2)	15.9	<0.001
Regular Mouth wash	24 (24)	9 (37.5)	0.5 (0.22-1.4)	1.4	0.23
Regular salt mouth wash	14 (14)	6 (42.9)	0.6 (0.2-1.9)	0.71	0.34
Charcoal mouth wash	11 (11)	3 (27.3)	0.36 (0.09-1.4)	2.1	0.14
Regular Dental visit	38 (38)	16 (42.1)	0.68 (0.3-1.5)	0.8	0.35

Additionally, a strong correlation was observed between a habit of regularly consuming large amounts of sugar and the colonization of *S. aureus* in the oral cavity, with an odds ratio of 5.7, a 95% confidence interval of 1.2 to 28, an X^2 of 5.7, and a *p* value of 0.01.

DISCUSSION

Due to its potential to have potentially fatal effects, *S. aureus* carriage may be dangerous. Ignoring the possible risks associated with the oral carriage as one, the majority of reports have concentrated on the nasal carriage the same as the primary *S. aureus* reservoirs. The results of this investigation demonstrated a considerable frequency of *S. aureus* in the oral cavity of healthy people, with 48% of them exhibiting signs of colonization, suggesting that the oral cavity is another possible human reservoir for *S. aureus*. These results, which show a somewhat similar percentage of 46%, are in line with those of a previous study carried out in Japan on the oral cavities of healthy persons[38]. In Yemen, a nasal swab revealed a high (45%) frequency of *S. aureus*[20]. This suggests that, among healthy individuals, *S. aureus* is more common in the oral cavity than in the nasal area, and that, under the right circumstances, the bacteria can colonize and pose a major threat to health. According to a number of investigations, *S. aureus* has been regularly separated from the oral cavity of specific groups of people, including elderly[40], stroke patients[41], rheumatoid arthritis patients[26], terminally ill adults[39], and unwell youngsters[39]. The prevalence of *S. aureus* was frequently higher in them than in their well-being-matched peers, regardless of the region of colonization[24]. It has also been shown that the harbor of *S. aureus* in a hospital context is higher than in a community setting[42]. About 48% of the individuals had a high detection rate of *S. aureus* in their oral cavities, which raises major concerns. Persistent Methicillin-Resistant *S. aureus* (MRSA) may be able to produce nosocomial infections in the oral cavity due to the presence of *S. aureus*[3,43]; this is according to a study done on healthy youngsters. Thus, oral colonization by possible respiratory pathogens, including *S. aureus*, may have an impact on the onset and course of systemic infections, particularly in high-risk people[44].

In the current study, when taking into account gender, male patients had an oral colonization rate of *S. aureus* of 58.9%, which was greater than the rate of female patients by 41%. The odds ratio for male patients to acquire *S. aureus* was equivalent to 2.1. This finding is different from a study on oral cavity carriage in Malaysia, where an equal rate of colonization in the oral cavity was observed[23]. Additionally, when age groups were considered, the younger age group (24–34 years old) had a 70% higher rate of oral colonization by *S. aureus* than the older age groups. In this age group, the odds ratio for acquiring *S. aureus* was equal to 3.7, with a 95% confidence interval of 1.4–9.2, and an X^2 equal to 8 (p=0.003). This result was at odds with research on oral and nasal carriage conducted in Malaysia, which found no evidence of a significant correlation between age, gender, or ethnicity and the prevalence of *S. aureus* in the oral and nasal sites[23,45]. There was an association (odds ratio=4.9, 95% CI= 0.4–5.4) between contracting *S. aureus* in the oral cavity and removable prosthesis in this study when dental prosthesis type was taken into consideration; however, this result was not statistically significant. Furthermore, an association with an odds ratio of 2.1 and a 95% confidence interval of 0.9 to 5.0 was seen between contracting *S. aureus* in the oral cavity and dental fixed prosthesis. This result is consistent with a prior report that found that using dental prostheses increased the amount of pathogens in the oral cavity and that *S. aureus* was consistently present at all assessment stages (one, six, and more than 12 months)[46-48]. Respiratory pathogen reservoirs have also been speculated to exist in prosthetics[49,50]. Therefore, among healthy individuals, maintaining good dental hygiene and taking proper care of prosthetics are crucial. Regression analysis results indicated that the presence of *S. aureus* in the oral cavity is related to using a dental prosthesis. This suggests that maintaining good oral hygiene in relation to dental prosthesis is essential[51,52].

Limitations of the study

Even though this study was population-based, it had certain limitations. Initially, as no clinical examination was carried out, a direct correlation between the oral hygiene habits and the prevalence of *S. aureus* could not be established. Therefore, more research is needed to ascertain the precise connections between healthy people' oral hygiene practices and their oral carriage of *S. aureus*. Despite the fact that the prevalence of oral carriage of *S. aureus* might differ among populations, across regions, and according to various measurement techniques.

CONCLUSIONS

The high frequency of antibiotic-resistant *S. aureus* strains in the community and the potential for serious community-related illnesses are the main concerns connected with the high prevalence of *S. aureus* in the oral cavity among healthy adults. Moreover, it can raise the community's risk of contracting MRSA infections. By identifying the oral condition that has *S. aureus* colonization, therapies that target the high-risk population may be able to lower their chance of developing oral or systemic infections later on.

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AUTHOR'S CONTRIBUTIONS

Al-Sanabani NF: writing original draft, methodology, investigation. **Al-Shamahy HA:** formal analysis, data curation, conceptualization. **Nagi IAA:** writing, review. **Howilah AA:** editing, methodology. **AL-Haddad KA:** formal analysis, data curation. **Madar EM:** conceptualization. **Al-Ghaffari KM:** literature

survey. All the authors reviewed the results and approved the final version of the manuscript.

DATA AVILIABILITY

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

CONFLICT OF INTEREST

None to declare.

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