Deanship of Graduate Studies

Al-Quds University

Knowledge, attitude, and practices regarding Methicillin-resistant *Staphylococcus aureus* (MRSA) infection control and nasal MRSA carriage rate among dental students of Al-Quds University

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Dedication

This thesis is dedicated to my family, especially my parents and my husband, for providing me with unconditional support as I completed my graduate education. I am forever grateful to my husband, as he helped me every step of the way. Without the unending support, encouragement and understanding, it would not have been possible to sail through this educational program. I dedicate this work to my precious sons, Wisam and Yazan. I hope they will understand one day why mommy spent so much time working on the computer, and I plan to have more time with them from now on. Also, I dedicate this to my sister and brothers, I will always be grateful for their endless love and encouragement.

Finally, I also dedicate this work to my loyal friends, I will forever appreciate their tremendous support.

Suzan M Mustafa

Declaration

I declare that this study is the result of my own work research, except where otherwise indicated. It has been submitted for Master degree and not for any higher degree to any other universities.

Name: Suzan Mohammad Jubran Mustafa

Signed: 

Date: 9.1.2023

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Abstract

Background: *Staphylococcus aureus* (*S. aureus*), a normal flora of the nasal cavity, which can cause minor to life-threatening diseases and healthcare associated infections. Methicillin-resistant strains of *S. aureus* spread are of concern in the hospital and community and are causing a great challenge for treatment options. In Palestine, there are no previous reports regarding *S.aureus* or MRSA in the dental student community. Moreover, their knowledge, attitude, and behavior toward these pathogens are not clearly known.

Aim: The purpose of this study was to assess the knowledge and attitude regarding Methicillin-resistant *S.aureus* (MRSA) and compliance to hygiene practices among dental students in Al-Quds University – Palestine. So, this study might provide an understanding of dental students' knowledge level of MRSA as they progress through a baccalaureate program, which could help to identify gaps in curriculum and areas of needed improvement. In addition, determining the nasal carriage rate of *S.aureus* and MRSA and identifying the contributing risk factors for *S.aureus* and MRSA nasal colonization.

Study methodology: The study methodology consisted of two parts; A cross-sectional (KAP-study) and an experimental lab-based study design with a sample consisting of 280 dental students, it was conducted at the faculty of dentistry of Al-Quds University. The participants were asked to answer a self-administered questionnaire that involves questions relevant to each studied risk factor, in addition to a set of questions to evaluate knowledge, attitude, and hygiene practices regarding MRSA. Swab samples were collected by the researcher from the nasal of study participants for identification of *S.aureus* and MRSA nasal prevalence and antibiotic susceptibility patterns.

Findings: 280 dental students from the clinical phase (4^{th} and 5^{th} year dental students) participated in our study**.** Most of the participants were females; 73.2% (n=205), while 26.8% (n=75) were males. 53.9% were 5^{th}-year dental students and 46.1% were 4^{th}-year dental students. The knowledge score showed a mean of 18.40 with a SD of 2.73. It, therefore, indicated that dental students had intermediate knowledge regarding MRSA. The attitude score showed a mean of 32.12 with a SD of 4.19. It, therefore, indicated that dental students

had positive attitudes towards methicillin-resistant *S. aureus.* The practice score showed a mean of 22.21 with a SD of 2.35. It, therefore, indicated that the dental student's practices regarding MRSA infection prevention are good. Moreover, the results showed a significant difference in the level of compliance to infection prevention practices, among dental students of Al-Quds university, where the differences were in favor of 4th-year dental students, but there was no statistically significant differences in the level of knowledge or attitude toward methicillin-resistant S. aureus infection control according to clinical year of study.

According to the lab identification methods carried according to the standard criteria of the Clinical Laboratory Standards Institute guidelines (CLSI), the nasal colonization of *S.aureus* among dental students of Al-Quds University was **(68/280) 24.3%**, while methicillin-resistant *S.aureus* (MRSA) nasal colonization was **(21/280) 7.5%.**The nasal MRSA carriers showed slightly higher attitude and practice scores compared with non-carriers. However, these differences were not statistically significant. A significant relationship was found between MRSA nasal carriage and visiting the hospital in the past 6 months, using antibiotics in the past 6 months, having a previous *staphylococcus* bacterial infection and having a member of the family working in healthcare.

The antibiotic susceptibility test results showed 68 isolates were *S.aureus*. 21 of them were MRSA, while 47 isolates were MSSA. All isolates of MRSA were resistant to amoxicillin (100%), followed by 28.5% resistant to amoxicillin\clavunic acid, 23.8% resistant to erythromycin, 19% were resistant to clindamycin, and 14.2% were noted resistant to gentamicin. No isolates were found resistant to vancomycin in this study.

Conclusion: The prevalence of MRSA nasal colonization among the dental student population was higher than the nasal colonization rate among the general community in Palestine, but lower than the rate among healthcare workers in hospital settings. This indicates the importance of the implementation of strategies that can help in breaking the bridge of transmission of MRSA. In addition, further education of dental students on MRSA is needed to improve MRSA infection control in the dental setting.

المعرفة والمواقف والممارسات الصحية المتعلقة ببكتيريا المكورات العنقودية الذهبية المقاومة للميثيسيلين، ومعدل الحمل الأنفي لها لدى طلبة طب الأسنان في جامعة القدس

إعداد: سوزان محمد جبران مصطفى

إشراف: الدكتور مراد إبراهيم

ملخص:

الخلفية:المكورات العنقودية الذهبية هي بكتيريا تتواجد بشكل طبيعي بالأنف، والتي يمكن أن تسبب أمراضاً تتراوح ما بين الطفيفة إلى أخرى تهدد الحياة والالتهابات المرتبطة بالرعاية الصحية.تشكل السلالات المقاومة للميثيسيلين مصدر قلق في المستشفى والمجتمع وتسبب تحديا كبيرا لخيارات العلاج. في فلسطين، لا توجد تقارير سابقة في مجتمع طلاب طب الأسنان بخصوص هذه البكتيريا . علاوة على ذلك ، فإن معرفتهم وموقفهم وسلوكهم تجاه مسببات الأمراض هذه غير معروفة بوضوح .

الهدف: الغرض من هذه الدراسة هو تقييم مدى المعرفة والمواقف والممارسات الصحية لدى طلاب وطالبات طب الأسنان فيما يتعلق ببكتيريا المكورات العنقودية الذهبية المقاومة للمضاد الحيوي الميثيسيلين ،لذلك قد توفر هذه الدراسة فهما لمدى مستوى معرفة طلاب طب الأسنان بهذه البكتيريا أثناء تقدمهم خلال برنامج دراستهم ،التي يمكن أن تساعد على تحديد الفجوات في المناهج الدراسية ومجالات التحسين اللازمة. بالإضافة إلى تحديد معدل الحمل الأنفي لهذه البكتيريا لدى طلاب وطالبات طب الأسنان وتحديد عوامل الخطر المساهمة في حمل الأنف لل MRSA.و*S.aureus*

منهجية الدراسة: تم إجراء تصميم دراسة مقطعية مع عينة مكونة من 280 طالب وطالبة طب أسنان في كلية طب الأسنان بجامعة القدس. طلب من المشاركين الإجابة على استبيان ذاتي يتضمن أسئلة ذات صلة بكل عامل خطر تمت دراسته ، بالإضافة إلى مجموعة من الأسئلة لتقييم المعرفة والمواقف وممارسات النظافة فيما يتعلق بالمكورات العنقودية الذهبية المقاومة للميثيسيلين. تم جمع مسحات أنفية من المشاركين في الدراسة لتحديد معدل الحمل الأنفي لهذه البكتيريا وأنماط الحساسية للمضادات الحيوية.

النتائج: شارك 280 طالب وطالبة طب أسنان من المرحلة السريرية (طلاب السنة الرابعة والخامسة) في دراستنا. كان معظم المشاركين من الإناث بنسبة 73.2٪ (العدد = 205)، في حين أن 26.8٪ (العدد = 75) كانوا من الذكور. 53.9٪ كانوا في السنة الدراسية الخامسة و 46.1٪ كانوا طلاب طب الأسنان في السنة الرابعة.أظهرت درجة المعرفة متوسطاً قدره 18.40 مع متوسط معياري قدره 2.73، وذلك يشيرإلى أن طلاب طب الأسنان لديهم معرفة متوسطة فيما يتعلق بالمكورات العنقودية الذهبية المقاومة للميثيسيلين. كما أظهرت درجة المواقف منوسطا قدره 32.12 مع منوسط معياري قدره 4.1 .وذلك

يشيرإلى أن طلاب طب الأسنان لديهم مواقف إيجابية . أظهرت درجة الممارسة متوسطا قدره 22.12 وذلك يشيرإلى أن ممارسات طلبة طب الأسنان فيما يتعلق بالوقاية من العدوى جيدة. كما أظهرت النتائج وجود اختلاف في مستوى الالتزام بممارسات الوقاية من العدوى، بين طلبة طب الأسنان في جامعة القدس، حيث كانت الفروق لصالح طلبة طب الأسنان في السنة الرابعة، ولكن لم تكن هناك فروق ذات دلالة إحصائية في مستوى المعرفة أو الموقف تجاه مكافحة عدوى المكورات العنقودية الذهبية المقاومة للميثيسيلين وفقا لسنة الدراسة السريرية.

وفقاً لطرق تحديد المختبر التي يتم تنفيذها وفقاً للمعايير القياسية لإرشادات معهد معايير المختبرات السريرية، تبلغ نسبة المعدل الأنفي للمكورات العنقودية الذهبية بين طلاب طب الأسنان في جامعة القدس (280/68) 24.3% ،في حين تبلغ نسبة المعدل الأنفي للمكورات العنقودية الذهبية المقاومة للميثيسيلين (280/21) 7.5 %.وقد أظهرت نسبة الحاملون للبكتيريا معدلات أعلى قليلاً من ناحية المواقف والممارسات الصحية مقارنةً بغير الحاملين.ومع ذلك، لم تكن هذه الإختلافات ذات دلالة إحصائية .

تم العثور على علاقة ذات دلالة إحصائية بين الحمل الأنفي للمكورات العنقودية الذهبية المقاومة للميثيسيلين وزيارة المستشفى في الأشهر ال 6 الماضية، واستخدام المضادات الحيوية في الأشهر ال 6 الماضية ،ووجود عدوى بكتيرية سابقة بالمكورات العنقودية ، ووجود أحد أفراد الأسرة يعمل في مجال الرعاية الصحية.

أظهرت نتائج اختبار القابلية للمضادات الحيوية أن 68 عينة كانت من المكورات العنقودية الذهبية، بحيث 21 عينة منها كانت مقاومة للميثيسيلين,في حين أن 47 عينة كانت غير مقاومة للميثيسيلين.كانت جميع العينات المقاومة للميثيسيلين أيضا مقاومة للأموكسيسيلين (100٪) ، تليها 28.5٪ مقاومة للأموكسيسيلين / الكلافونيك أسيد، و 23.8٪ مقاومة للإريثروميسين ، و 19٪ مقاومة للكليندامايسين ، و 14.2٪ كانت مقاومة للجنتاميسين. لم يتم العثور على أي عينة مقاومة للفانكومايسين في هذه الدراسة.

الخلاصة: وجد أن نسبة المعدل الأنفي للمكورات العنقودية الذهبية المقاومة للميثيسيلين ، بين طلاب طب الأسنان كانت أعلى من معدل المجتمع العام في فلسطين،لكن هذه النسبة كانت أقل من المعدل بين العاملين في مجال الرعاية الصحية في المستشفيات.وهذا يدل على أهمية تنفيذ الاستراتيجيات التي يمكن أن تساعد على كسر جسر انتقال هذه البكتيريا.بالإضافة إلى ذلك ، يوصى بتعزيز معرفة طلاب طب الأسنان بالمكورات العنقودية الذهبية المقاومة للميثيسيلين، لتحسين مكافحة العدوى بها في عيادات الأسنان.

List of abbreviations

AAUJ	American Arab University of Jenin
AST	Antibiotic susceptibility testing
CA-MRSA	Community-associated Methicillin-Resistant *S.Aureus*
CDC	Centers for Diseases Control and Prevention
CLSI	Clinical and Laboratory Standards Institute
DHCPs	Dental health care professionals
DHCWs	Dental health care workers
HA-MRSA	Hospital-acquired Methicillin-Resistant *S.Aureus*
IPC	Infection Prevention and Control
KAP	Knowledge, Attitude, and Practices
MIC	Minimal Inhibitory Concentration
MRSA	Methicillin-Resistant *Staphylococcus Aureus*
MSSA	Methicillin-Sensitive *Staphylococcus Aureus*
MSA	Mannitol Salt Agar
PPE	Personal Protective Equipment
S.aureus	Staphylococcus aureus
SD	Standard deviation
SP	Standard Precautions
SPSS	Statistic Package for Social Science

List of Contents:

List of tables

List of figures

Chapter One:

Introduction

1.1 Introduction

Staphylococcus aureus (S. aureus) is a gram-positive bacteria that can either be an opportunistic fatal pathogen or a persistent nasal human flora that colonizes 20–30% of the adult population (S. aureus carriers) (Olsen, 2013).

Colonization of *S. aureus* in the anterior nares has been determined to be a significant risk factor for causing infection by the colonizing site (Malone, 2017). There are three patterns for *S. aureus* carriers: The majority of people (60%) are intermittent carriers, 20% of the population are persistently colonized with *S. aureus* and 20% of populations never carry this organism (Ansari et al., 2016a).

Previous studies have reported that *S. aureus* can cause many different community and hospital-acquired bacterial infections (Yamakhakha, 2019). Infections caused by *S. aureus* could range from mild skin infections to serious life-threatening diseases such as endocarditis, sepsis, and osteomyelitis (Malone, 2017). One of the most prevalent pathogenic bacteria, *S. aureus* is known to cause a variety of diseases globally, and it is highly associated with high rates of morbidity and mortality and strongly connected to nosocomial infections (Efa, 2018). Nearly 119,247 *S. aureus* bloodstream infections and 19,832 fatalities as a result occurred in the US in 2017. (Centers for Diseases Control and Prevention 2017).

The continuous spreading and emerging of antimicrobial-resistant *S. aureus* isolates, particularly methicillin-resistant *S. aureus* (MRSA), is contributing to a worldwide challenge for the treatment of infectious diseases caused by these pathogens (Yılmaz et al., 2017). As a crucial component of infection management strategy for this organism, screening for and eliminating MRSA from carriers has been acknowledged and advised (Sakr et al., 2018).

In the general population, less than 2% were found to be nasal carriers of methicillin-resistant staph aureus (MRSA) at any given time (Yoo et al., 2018). Risk factors associated with

increased MRSA nasal colonization include prolonged hospitalization, antibiotic exposure, and previous *S. aureus* infection (Ansari et al., 2016b; Meza, 2018). Other risk factors also included crowding, family size, smoking, inappropriate hygiene, and contact with a domestic animal (Olsen, 2013).

A previous Mediterranean study done in 2007, reported rates of hospital-acquired MRSA to be the highest in Jordan (56%), Cyprus (55%), Egypt (52%), Malta (50%) and Algeria (45%), while in other Mediterranean countries lower rates were reported in Morocco (19%), Tunisia (18%) and Lebanon (12%) (Borg et al., 2007).

The majority of studies worldwide focused on MRSA rates in the hospital and community-acquired basis. Few studies reported the epidemiology of *S. aureus* and MRSA in the dental field. A study in Nepal (2016), found nasal carriage rates among dental students of *S. aureus* and MRSA to be 15% and 4% respectfully (Ansari et al., 2016a). Another study in India (2017), concluded the MRSA rate to be 18.5% among the dental school population (Hema et al., 2017a).

Knowledge, attitude, and practices are three important key elements in the dynamic of life, thus, the right information, positive perception, and good compliance are imperative to guide dental students in treating and serving their patient (Alharbi et al., 2019).

Although the rate of transmission of MRSA in dental settings is rarely reported, this doesn't discard the fact that it is a common source of cross-contamination, and adherence to the infection prevention standard precautions (SP) guidelines is a must (Yoo et al., 2018). As dental professionals are as capable of infecting the patient, dental healthcare workers' hands have the potential to be contaminated with a variety of pathogens, and both direct and indirect contact with them can operate as a source of infection, including the spread of germs that are multidrug resistant (Laheij et al., 2012). Additionally, earlier research has shown that dental healthcare professionals and dentistry students had significant levels of MRSA nasal colonization (Baek et al., 2016; Yoo et al., 2018).

The source of MRSA transmission in dentistry mostly because of contamination of environmental surfaces, such as dental syringes, dental chairs, light handles, etc. Due to microbial aerosols and splashes from patients (Lai, 2013). Therefore, knowledge, attitude, and

hygiene practices regarding MRSA can reflect the dental practitioners' adherence to preventive measures (Yoo et al., 2018).

For the execution of tactics that can help break the MRSA transmission bridge among high-risk groups, prevalence reports are essential (Beam et al., 2006). In Palestine, no previous studies targeted contributing risk factors among dental students, and with the emergence of MRSA bacteria worldwide, the assessment of knowledge, attitude, and hygiene standard precautions guidelines among dental Palestinian students is very important.

1.2. Study Justification

Despite the advancement in public health, sanitation, and antimicrobials, MRSA continues to spread and burden communities in the past two decades (Meza, 2018). The containment of MRSA in every healthcare facility depends heavily on the screening for MRSA nasal carriage. Additionally, identifying those who have been colonized enables effective management to stop the spread of this pathogen (Efa, 2018).

A few studies in Palestine assessed the rate of *S. aureus* and MRSA nasal colonization. One was among nursing students of AAUJ in 2016 which found (9.1 %) of the students to be *S. aureus* nasal carriers and found (3.3%) isolates of MRSA (Mubaslat et al., 2016). Another investigation of the MRSA strains that cause infections in the northern part of Palestinians healthcare facilities and the general public found *S. aureus* nasal carriers to be (24%) and MRSA rate (2%) (Adwan et al., 2013).

Another study conducted for detection of *S. aureus* and MRSA isolated from healthcare personnel nares at three Gaza hospitals, found the nasal carriage rate of *S. aureus* to be (42.1%), and MRSA was (22.6%) (al Laham, 2015). A study also preformed to determine the rate of *S. aureus* and MRSA nasal carriage among healthcare workers at Al-Shifa hospital in Gaza, reported *S. aureus* to be (31%) and MRSA was reported to be (25.5%) (el Aila et al., 2017). These results highlight the high carriage rate of MRSA among the Palestinian population. This is considered a major risk factor for MRSA transmission which could lead to systemic and severe infections (Hadyeh et al., 2019).

Since dental students interact closely with patients during clinical practice, they are more prone to contract MRSA and disseminate it to patients (Hema et al., 2017a). Understanding the pathogen, its mode of transmission, risk factors, and protective measures are crucial for appropriate infection control measures (de Giusti et al., 2011).

1.3. Problem Statement

The nose is the primary colonization site of *S. aureus* (de Oliveira et al., 2021). *S. aureus* nasal colonization is a known risk factor for causing *S. aureus* infection (Efa, 2018).MRSA could be transmitted to the nose by contamination of hands and from objects where it can live for days to months. The nasal carriage of S. aureus acts as a harboring source for infections in the colonized individual, also as a source of cross-contamination for community spread (Hema et al., 2017a).

MRSA is quite found in social environments where person to person contact is frequent and crowding is prevalent (Reddy, 2010). In dental clinics, the chances of MRSA transmission is high because of the closeness between a patient's nose (where MRSA colonizes) and the oral cavity to the dental worker (Reddy, 2010). Students in general stay in close proximities, and could share materials that could be potential fomites (Yamakhakha, 2019). Any lack or gaps in knowledge and awareness in the dental setting could interfere with the adherence to standard infection precautions (Yoo et al., 2018).

Previous studies reported that students had very poor knowledge of the pathogen, and the attitude of the study participants to MRSA was inadequate (Ajani et al., 2020;De Giusti et al., 2011).Thus, assessment of the knowledge, attitudes and practice of dental students and dental health practitioners is essential for creating an appropriate dental field for MRSA infection control (Yoo et al., 2018).

There have never been any prior reports of S. aureus or MRSA in the dental student population in Palestine. Additionally, nothing is known about their awareness of, attitudes about, and conduct in relation to these infections. Therefore, this study would serve as a baseline to identify associated risk factors for nasal colonization in dental students, and the results may be helpful in developing an MRSA infection control protocol in dental health care

clinics and facilities, as well as for planning future educational programs for dental students and, if necessary, improving the current curriculum.

1.4. General Aims

Evaluating the knowledge and attitude regarding MRSA and compliance to hygiene practices among dental students in Al-Quds University – Palestine. In addition, determining the nasal carriage rate of *S. aureus* and MRSA and identifying the contributing risk factors for *S. aureus* and MRSA nasal colonization.

1.5. Study Objectives

1) Identify the prevalence of *S. aureus* and MRSA nasal carriage among 4^{th} and 5^{th} year dental students.
2) Assessment of the level of knowledge and awareness regarding MRSA.
3) Assessment of the attitude and perception toward MRSA.
4) Evaluating the dental students' compliance with infection prevention practices.
5) Determine the socio-demographic risk factors associated with *S. aureus* and MRSA nasal colonization.
6) Determine the lifestyle association with *S. aureus* and MRSA nasal carriage.
7) Relate the medical history with *S. aureus* and MRSA nasal carriage.
8) Determine the antibiotic susceptibility patterns of *S. aureus* and MRSA.

1.6. Research questions

1. What is the level of knowledge and attitude toward methicillin-resistant *S. aureus*, and the level of compliance to infection prevention practices among dental students of Al-Quds University?
2. What is the current nasal prevalence of *S. aureus* and methicillin-resistant *S. aureus* circulating among the dental student population?
3. What are the present antimicrobial susceptibility patterns of *S. aureus* strains isolated from dental students' nasals?

4. What are the risk factors associated with MRSA nasal colonization?
5. Is there an association between knowledge, attitude, infection prevention practices, and MRSA nasal prevalence?

1.7. Expected Outcome:

Determining the proportion of clinical dental students who have S. aureus and MRSA in their nasal passages. These findings point to students who are susceptible to colonization, which could aid in the development of strategies to stop the spread of bacteria. The evaluation of dental students' knowledge, attitude, and hygiene practices would give an idea about the level needed to for targeted educational programs and additional courses within the university curriculum.

Chapter Two:

Literature review

2.1 Introduction

In this chapter, an overview of previous literature about Methicillin-Resistant *Staphylococcus Aureus* (MRSA), in particular, studies related to its nasal prevalence, associated risk factors, and antimicrobial resistance patterns were reviewed. Moreover, studies related to knowledge, attitude, and practices regarding Methicillin-resistant *Staphylococcus aureus* (MRSA) infection control were addressed. Due to the lack of information concerning dental students' knowledge regarding MRSA infectious bacteria in the literature, I have reviewed the literature related to dental and other healthcare professionals' risks, perceptions, and attitudes, in addition to nursing and medical students' knowledge.

Gram-positive *Staphylococcus aureus (S. aureus)*, a frequent human pathogen of healthcare-associated and community-acquired infections that is responsible for significant morbidity and mortality, is both a normal flora species and a pathogen that affects humans (Salmonav et al, 2020). In some countries, Dental health care professionals who test positive for MRSA are sometimes prohibited from treating patients as long as they are carriers of this bacterium because they are thought to pose a danger of bacterial transmission to patients and coworkers (Volgenant et al., 2021).

2.2 The prevalence of *S. aureus* and MRSA nasal carriage in the community

Staphylococcus aureus can be detected in different body regions such as the skin, axilla, gastrointestinal tract, rectum, and vagina, the anterior nares appearing as the main reservoir (Wertheim et al., 2005).

As early as the first days of birth, nasal colonization may start (Maayan-Metzger et al., 2017). When a baby is 8 weeks old, the carriage rate is between 40 and 50 %; at 6 months, it falls to 21%. (Peacock et al., 2003).

Although each person's adult nasal microbiota is unique, *Corynebacterium*, *Propionibacterium*, and *Staphylococcus* species are reported to be the most prevalent ones (Sakr et al., 2018). In fact, it is known that the endogenous source of *S. aureus* is responsible for roughly 80% of staphylococcal infections in carriers. (Ahmadi et al., 2019).

According to the Centers for Diseases Control and Prevention (CDC), 33% of the population are *S. aureus* asymptomatic nasal carriers, and 2% of the population are MRSA nasal carriers (CDC, 2017).

These percentages are consistent with other cross-sectional studies, which found the nasal carriage rate of *S. aureus* to be in a range between 12%-30%, and the MRSA nasal carriage rate to be in a range of 2%-5% (Chong et al., 2006);Oskouie et al., 2020);Sharma et al., 2014). Moreover, a cross-sectional study done in West of Iran, found the nasal carriage rate of *S. aureus* and MRSA, to be 30.1% and 9.1% respectively (Ahmadi et al., 2019).

S. aureus nasal carriage rates in southeast Australia were 28%, which is comparable to rates from other community-based nasal carriage studies. MRSA nasal carriage rates were modest, at 0.7% (Munckhof et al., 2009). Also, the *S. aureus* nasal carriage rate was found relatively low in the community of Sao Paulo Brazil, with a percentage of 5.5%, and the MRSA nasal carriage rate was 2.3% (Bes et al., 2018).

The incidence of MRSA in the same country could vary considerably from region to region. For example, in Saudi Arabia, the rate of MRSA prevalence in the Western region was 42%, in the Central region was 32%, and in the Eastern regions was 27% (Aljeldah, 2020). See table 2.1 for previous reports on the methicillin-resistant Staphylococcus aureus nasal (MRSA) carriage rate among different target populations

2.3. Prevalence of *S. aureus* and MRSA nasal colonization among healthcare workers

Higher nasal colonization rates were found among health workers and people who cared for in-patients (Meza, 2018; Sakr et al., 2018). These results were consistent with other studies which found the *S. aureus* rates to be higher in hospital nurses (Shih et al., 2020;Parveen et al., 2020). Another study stated that the highest carriage rate of MRSA was found among HCWs from surgery wards (al Laham, 2015).

Moreover, a cross-sectional study done in Duhok, Kurdistan Region of Iraq, found very high S. *aureus* and MRSA nasal carriage rates, which were 100% and 50.4% respectively (Hussein et al., 2019).

In addition to a cross-sectional multicenter study which was conducted in the outpatient Otorhinolaryngology departments in Kyiv, Ukraine (Salmonav et al., 2020).The prevalence of nasal carriage rate of MRSA was 34.9%, which was significantly highest among doctors at 41.7% compared to other professions. *S. aureus* carriage rate was highest in Otorhinolaryngology departments among doctors 62.5%, whereas carriage among nurses was 42.9% and cleaners 38.9%.

In contrast to another study which stated a higher prevalence of *S. aureus* nasal carriage rate in laboratory technicians than nurses (Baroja et al., 2021).

2.4 Methicillin resistant staph aureus (MRSA) transmission in dental settings

MRSA can be transmitted to the nasal cavity via contaminated hands and surfaces where it has the ability to survive for months (Hema et al., 2017b).

Nasal colonization of S. aureus in the colonized individual is a source of cross-colonization for community dissemination, and acts as an endogenous reservoir for clinical infections (Reddy, 2010) . There is a higher likelihood of discovering infection at other body sites due to the high isolation rate of MRSA from the nares. Therefore, an infected or colonized patient, and an infected or colonized dentist could be a source of MRSA infection in dentistry (Hema et al., 2017b).

There have been very few reports of MRSA transmission from DHCPs to patients in dentistry settings (Kurita et al., 2006; Laheij et al., 2012) . However, the dental healthcare facility has certain important characteristics from the standpoint of infection prevention. For instance, using traditional dentistry tools like air/water syringes, dental seat buttons, dental seat armrests, light knobs, etc. can cause splashes and microbiological aerosols from patients to contaminate the dental clinics (Lai, 2013). Therefore, oral healthcare professionals must always be aware of the potential for transmitting MRSA by droplets or an airborne mode. As there has been an observed aerial spread of MRSA from individuals with MRSA carriage

(Gehano et al., 2009). Also, the frequent use of local anesthetic injections in dental hospital settings, exposes dental health workers to a considerable potential for percutaneous damage (Yoo et al., 2018).

Because of these previous characteristics and the reported MRSA prevalence in oral healthcare professionals, controlling MRSA infections is a significant general health concern in dental healthcare facilities.

2.5 Prevalence of *S. aureus* and MRSA nasal carriage among dental students and dental health practitioners

Although there is a lack of reporting of MRSA dental transmission, there is information available regarding *S. aureus* and MRSA nasal carriage among dental students and dental health practitioners.

The nasal colonization rate of *S. aureus* was 29.5% in dental students in a cross-sectional study done in Malaysia (Wong et al., 2018), while there was no MRSA colonization found neither in preclinical nor clinical dental students in the same study.

In an investigation which aimed to assess multi-resistant bacteria in undergraduate dentistry students in four dental schools in Europe, 1.5% of dental students tested positive for MRSA, with no significant difference between clinical and preclinical students (Volgenant et al., 2021).

In contrast to a cross-sectional study established in India (Hema et al., 2017b), which found a high rate of MRSA nasal colonization (18.5%) among dental students. The rate was found to be higher in postgraduate dental students (24.5%) compared to undergraduate students (12.5%).

These results were consistent with another cross-sectional study conducted in Ontario, Canada (Roberts et al., 2011), in which 21% of dental students and 8.4% of surfaces were MRSA positive.

Table 2.1: Summary of previous reports on the methicillin-resistant Staphylococcus aureus nasal (MRSA) carriage rate among different target populations

Study	Study location	Study population	MRSA nasal carriage rate % (n of positives/cases)
(Adwan et al., 2013)	Nablus, Palestine	University students	2% (8/360)
(Mubaslat et al., 2016)	Jenin, Palestine	Nursing students	3.3% (3/220)
(el Aila et al., 2017)	Gaza, Palestine	Healthcare workers	25.5% (51/200)
(al Laham, 2015)	Gaza, Palestine	Healthcare workers	22.6% (32/140)
(Baroja et al., 2021)	Quito, Ecuador	Healthcare workers	5% (25/481)
(Shih et al., 2020)	Tainan, Taiwan	Healthcare workers	6% (15/248)
(Hussein et al., 2019)	Duhok, Iraq	Healthcare workers	50.4% (55/109)
(Parveen et al., 2020)	Lahore, Pakistan	Healthcare workers	13% (6/46)
(Efa, 2018)	Jimma, Ethiopia	Medical students	8.4% (31/371)
(Ansari et al., 2016a)	Chitwan, Nepal	Medical students	4% (8/200)
(Hantoosh, 2022)	Al-Muthanna, Iraq	Intermediate school students	24% (72/300)
(Bes et al., 2018)	São Paulo, Brazil	Outpatients	2.3% (7/300)
(Alzoubi et al., 2020)	Amman, Jordan	Medical Students	2.8% (3/105)
(Hema et al., 2017)	Karnataka, India	Dental students	18% (74/400)
(Yoo et al., 2018)	Seoul, Korea	Dental health care professionals	2.9% (4/139)
(Volgenant et al., 2021)	Europe	Dental students	1.5% (13/879)
(Wong et al., 2018)	Kelantan, Malaysia	Dental students	No MRSA colonization
(Cavaco-Silva et al., 2021)	Lisbon, Portugal	Dental students	0.86% (4/464)
(Roberts et al., 2011)	Ontario, Canada	Dental students	21% (13/61)
(Camila et al., 2019a)	Central-West region of Brazil	Dental surgeons	9.7% (4/41)
(Salmonav et al., 2020)	Kyiv, Ukraine	Dental health care professionals	9.7% (5/155)

Moreover, a study found higher nasal carriage rates of MRSA among dental students who have clinical experience, with a colonization rate of 3.1% (Baek et al., 2016). Also, the MRSA nasal carriage rate was found 5.4% in a cross-sectional study at two teaching dentistry clinics in the UAE (Senok et al., 2020).

This significant relationship was consistent with a cross-sectional study conducted at a Dentistry University in the Lisbon Metropolitan Area, Portugal (Cavaco-Silva et al., 2021). A prevalence of *S. aureus* (25.2%) and MRSA (0.86%) nasal carriage rate was estimated. The relationship found between studying year and *S. aureus* carriage was found to be statistically significant, which was in the favor for 4th-year students.

Additionally, a higher prevalence of MRSA was found among dental students (4%), compared to non-dental students (1.6%) in a study established in Spain (Martínez-Ruíz et al., 2014).

Other cross-sectional studies examined the nasal carriage rate among dental health care workers. One of them found no MRSA nasal colonization in any of the 79 participants (Malone, 2017). While in a second study, the MRSA nasal carriage rate among DHC

professionals was found to be 2.9%, which was higher than that in the general population (Yoo et al., 2018).

In addition, in a cross-sectional study conducted in a Higher Education Institution (HEI) in the Central-West region of Brazil (Camila et al., 2019), nasal swabs were obtained from dental surgeon professors, 31.7% were colonized with *Staphylococcus spp.* and 9.7% were colonized with MRSA.

Moreover, in an observational study to assess the prevalence of MRSA and MSSA colonization in dental health care workers in the region of Mecklenburg, Germany (Lerche et al., 2021);MRSA was not isolated from any of the participants. While MSSA prevalence was 22.3%. MSSA isolates tended to be higher in dentists and dental assistants (23.5% and 23.6% respectively), than the prevalence among the patient reception employees (8.7%) and the laboratory (6.7%).

In addition to cross-sectional research that has been established in seven dental department settings in Kyiv, Ukraine (Salmonav et al, 2020). *S. aureus* carriage rate was highest among

dentists with a rate of 42%. On the other hand, the nasal carriage among nurses and cleaners was 29% and 20.9% respectively. They also found the MRSA carriage rate to be significantly highest among dentists (20%) compared to other HCWs. It was stated that MRSA nasal carriage rate among nurses and cleaners was 4.8% and 4.8% respectively.

2.6 Mechanism /Determinants of nasal colonization

The anterior part of the nasal cavity is lined with stratified, keratinized nonciliated squamous epithelium, while the rest of the nasal cavity, is covered with a ciliated columnar epithelium (Weidenmaier et al., 2012a). These two epithelia are considered suitable for S. aureus survival (Baur et al., 2014).

The bacteria must adhere and multiply in order to make up for the mechanical removal because epithelial cells are constantly lost and cleared from the nasal cavity. (Weidenmaier et al., 2012a). In addition, for the *S. aureus* to become a persistent colonizer, the host's immune defenses must be evaded (Olsen, 2013).

The nasal carriage of *S. aureus* is characterized with a latent immune response that is unable to remove *S. aureus* from the nose (Quinn et al., 2007). Environmental factors such as hospitalization, current smoking, and crowding. Host susceptibility factors such as serious underlying diseases, or conditions influencing the immune response. In addition to bacterial factors such as toxins, all may play important roles (Olsen, 2013).

2.7 Risk factors associated with *S. aureus* and MRSA nasal colonization

Several sociodemographic factors are investigated as risk determinants for *S. aureus* nasal carriage. There was a higher rate in younger ages compared with adults, and in males compared with females (Ayepola et al., 2018; Sakr et al., 2018).For example, MRSA prevalence in males was 7.8% when compared to females (4.3%) (Baroja et al., 2021), but regarding age, older age groups showed a significantly higher rates of MRSA of 14%, in comparison to other age groups. This was compatible with another study which found MRSA prevalence to be higher among older persons on a population level (Leibler et al., 2017).

However, some investigations reported no discernible gender-based differences in S. aureus and MRSA carriage rates (al Laham, 2015). In contrast to some studies which found that most MRSA carriers were female (Shih et al., 2020).

Some studies also indicated that there is a higher risk among rural areas compared with urban areas (Ansari et al., 2016).

In addition, infant-mother couples had 80% similar strains. In 90% of these infants, the maternal nasal strain was the source of *S. aureus* (Maayan-Metzger et al., 2017).

Health-related factors are also of great concern and impact on nasal colonization with *S. aureus* bacteria. For example, previous hospitalization, surgery, antibiotic exposure, and previous staph infections are associated with higher nasal colonization rates (Munckhof et al., 2009; Ayepola et al., 2018; Sakr et al., 2018).On the contrary, antibiotics use before nasal swabbing or nasal medicaments decreased carriage rates of MRSA (Baroja et al., 2021).

In a study on homeless people in the US, current hemodialysis treatment, endocarditis and heavy drinking emerged as significant risk factors for MRSA nasal colonization (Leibler et al., 2017).

According to several studies, taking hormonal contraceptives and steroid regimens were also found to be associated with higher MRSA nasal carriage rates (Ahmadi et al., 2019; Chong et al., 2006). Other predisposing factors included obesity, smoking, and HIV infection, which also have been related to an increased nasal MRSA carriage rate (Olsen, 2013; Sakr et al., 2018; Wong et al., 2018).

In addition , *S. aureus* nasal carriage has been identified as a risk factor for the acquiring of health care associated infections among surgical patients (Bode et al., 2010), patients with liver cirrhosis and after liver transplantation , patients admitted to intensive care units and HIV positive patients ,as well as patients on hemodialysis or continuous peritoneal dialysis (Olsen,2013).In fact, previous studies have shown that *S. aureus* nasal carriers with a high bacterial count are three to six times more likely than carriers with a mild bacterial count to develop infections related to healthcare. (Tong et al., 2011).

Lifestyle factors such as living with domestic animals, playing sports, living in crowded areas, and increased family size were found to be associated with higher nasal carriage rates (Ansari et al., 2016; Efa, 2018; Olsen, 2013).

Outbreaks of Community-associated (CA-MRSA) have been detected among sport teams, and not just in the traditional hospital and nursing home settings (Nguyen et al., 2005). CA-MRSA skin infections was documented among wrestling and football athletes, although they are in a healthy condition. In such outbreaks, environmental sources, such as sharing of towels, razors, direct contact with MRSA lesions, improper care of skin trauma; and living in a crowding situation, are identified as risk factors for transmitting MRSA (Beam et al., 2006).

2.8 Antimicrobial resistance and susceptibility patterns of *S. aureus*

Methicillin-Resistant *Staphylococcus aureus* (MRSA) resistance is developed by having the mecA gene that codes for an altered penicillin-binding protein (PBP2a) site, and a reduced affinity to beta-lactam antibiotics, which causes resistance to nearly all beta-lactam antibiotics (Alzoubi et al., 2020).

Penicillin was once the medicine of choice for treating Staphylococcus aureus infections (Vysakh et al., 2013a). The majority of Staphylococcus aureus strains that are resistant to penicillin develop an enzyme called β-lactamase that hydrolyzes the antibiotic's β-lactam ring. Staphylococcus aureus developed resistance to methicillin and other β-lactamase resistant penicillins shortly after it was first used clinically in 1961 (Diederen et al., 2006). The first MRSA infection in Australia was reported in Sydney in 1965. The first instance of a community-associated MRSA infection (CA-MRSA) was documented in the United States in 1980 (Vysakh et al., 2013a).

Different processes contribute to S. aureus's resistance to antibiotics. Among these processes are restricted drug uptake, drug target alteration, enzymatic drug inactivation, and active drug efflux. Depending on the antibiotic in question, the bacteria may employ one or more of these resistance mechanisms (Yılmaz et al., 2017).

The antibiotic resistance and susceptibility patterns may vary considerably from region to region. This variability could be due to various factors such as; exposure to antibiotics, or use of different antibiotics in different countries, ongoing genetic mutation of strains, transmission of the resistance genes from one bacterium to another, the unique characteristics of each study population, and the various exclusion criteria employed by each study. (Alzoubi et al., 2020; Efa, 2018; Legese et al., 2018).

For instance, 100% of the MRSA isolates in a research done in Palestine (Adwan et al., 2013), were resistant to penicillin G and amoxicillin/clavulanic acid, 96% to erythromycin, 52% to clindamycin, and 48% to ciprofloxacin. All S. aureus strains were also susceptible to vancomycin.

In addition to another study conducted at Al Shifa hospital in Gaza strip (el Aila et al., 2017). All *S. aureus* isolates (100%) were resistant to penicillin, and the sensitivity of the MRSA isolates was as follows: 92.2% to gentamicin, 88.2% to ciprofloxacin, 88.2% to rifampicin, 86.3% to clindamycin, 86.3% to tetracycline, and 84.3% to vancomycin.

In a similar study also established in Gaza strip; vancomycin and doxycycline were effective against all S. aureus strains, but penicillin and ampicillin were almost universally ineffective (al Laham, 2015).

These results were consistent with another study in which no isolates were found resistant to vancomycin and teicoplanin, and all of the MRSA strains were resistant to penicillin G (Ansari et al., 2016). Moreover, in a study done in Taiwan, the MRSA isolates exhibited high rates of resistance to erythromycin (53%) and clindamycin (53%) and only one isolate was resistant to fusidic acid (Shih et al., 2020).

Additionally, in a study that assessed the antimicrobial resistance and underlying mechanisms in *Staphylococcus aureus* isolates (Yılmaz et al., 2017),all isolates were found to be susceptible to vancomycin, with various rates of resistance to penicillin (83.5%), amoxicillin/clavulanic acid (16.5%), oxacillin (13.4%), gentamicin (6.2%), ampicillin (77.3%) and erythromycin (63.9%) were found.

Moreover, all strains were resistant to penicillin and oxacillin in a study in Korea (Yoo et al., 2018). All strains were susceptible to clindamycin, ciprofloxacin, and erythromycin, all strains were also susceptible to fusidic acid, nitrofurantoin, rifampicin, and vancomycin.

2.9 Community-associated MRSA and Hospital-associated MRSA

Based on the patient's history, MRSA isolates are divided into community-associated and hospital-associated categories (American Society for Microbiology). According to this categorization, any infections involving a MRSA isolate that develop before 48 hours of admission, whether they affect inpatients or outpatients, would be categorized as CA-MRSA. The community-associated MRSA affects people who are normally healthy, weren't receiving continuing outpatient care or care in a hospital, and lived in the community (Vysakh et al., 2013a).

Methicillin-resistant Staphylococcus aureus connected with healthcare or hospitals is referred to as HA-MRSA. It involves any MRSA that was discovered in a patient after 48 hours of hospitalization, or from a patient who had previously undergone surgery or dialysis, or from a patient who had previously lived in a long-term care facility, or from a patient within a year of the date of the MRSA culture (Vysakh et al., 2013).

MRSA has historically been connected with patients in hospital, healthcare, or nursing home settings, but outbreaks have been discovered among previously healthy members of the community, raising awareness of MRSA that is associated with the community (CA-MRSA). CA-MRSA has been categorized as community-associated and community-acquired. However, due to the difficulty in tracing the origins of MRSA strains in the community, the Centers for Disease Control and Prevention (CDC) prefer the term "community-associated."(Beam et al., 2006b).

Methicillin-resistant S. aureus (MRSA) strains are increasingly commonplace worldwide, complicating staphylococcal infection treatment and control. MRSA strains, once exclusive to healthcare facilities and hospitals, are now a common source of infection in the general population. (David et al., 2010).

Additionally, surveillance studies have found variations between MRSA isolates that cause infections in the community and MRSA strains that cause infections in hospitalized patients

and healthcare workers (Choo, 2017). Although such demarcation of MRSA as healthcare-associated MRSA or community-associated MRSA can be confusing, the genetic makeup and characteristics of MRSA strains linked to infections in hospitals or the community clearly differ from one another. (Kateete et al., 2019).

Newer and more aggressive CA-MRSA strains with altered genomes, which first appeared in the late 1990s, are the main causes of skin and soft tissue infections in relatively healthy, young individuals who have never previously visited a hospital (Kong et al., 2016).

The majority of CA-MRSA strains are sensitive to non β-lactam antibiotics and commonly have SCCmec types IV or V (Choo, 2017). Additionally, Panton-Valentine Leukocidin (PVL) expressing genes *LukS*-PV and *LukF*-PV, which are linked to enhanced virulence, are sometimes seen in CA-MRSA but not usually. SCCmec types I, II, or III are present in HA-MRSA strains, however PVL-encoding genes are uncommon. (Kong et al., 2016). HA-MRSA are frequently resistant to non β-lactam antimicrobials, especially macrolides, aminoglycosides, lincosamides, and fluoroquinolones, and they are connected to nosocomial infections including endocarditis (Kateete et al., 2019).

In addition, there is a third group of MRSA strains called livestock-associated MRSA (LA-MRSA), which are considered a reservoir in livestock animals (Crespo-Piazuelo et al., 2021).This type of MSSA is thought to have originated in humans, lost its human-related components, including shock syndrome toxin I, exfoliative toxins, and Panton-Valentine Leukocidin (PVL)-associated phages, which are indicators of hospital-associated and community-associated MRSA, and then acquired antibiotic resistance genes, including mecA and tetM, when adapted to livestock (Anjum et al., 2019).

2.10 MRSA Nasal Decolonization

MRSA colonization can last for months to years, and the majority of individuals have no symptoms (Beam et al., 2006).

Given that the nasal strain of S. aureus and the infecting strain have the same genotype or phage type, there is a causal link between S. aureus nasal carriage and infection (Olsen, 2013),

and there is proof that eliminating S. aureus from the nares is effective in lowering the frequency of bacterial infection (Bode et al., 2010). Prevention of the carrier state may offer possible targets for the prevention of infection(Olsen, 2013), because MRSA colonization is linked to a 30% probability of contracting MRSA infection while in the hospital (Sai et al., 2015).

The main infection control strategies for halting the spread of the MRSA infection linked to healthcare settings include isolating colonized/infected patients, conducting admission-screening cultures for MRSA, employing barrier precautions, and requiring health care personnel to practice hand hygiene (Dow et al., 2010). For preventing the nosocomial spread of MRSA colonization and the accompanying risk of MRSA infection, MRSA decolonization has been proposed as a viable infection control method (Dow et al., 2010). In fact, decolonization has reduced the risks of surgical-site infections, bacteremia, infections in the intensive care unit (ICU), and recurrent skin infections (Cruz et al., 2021; Huang et al., 2019; Tang et al., 2020).While other trials reported that, there was no benefit of decolonization in patients at high risk for MRSA recurrence (Papastefan et al., 2019).

Utilizing an intranasal antibiotic or antiseptic, decolonization therapy involves the administration of antimicrobial or antiseptic agents to eliminate or decrease MRSA nasal carriage (e.g., mupirocin, povidone-iodine) (CDC, 2014). Most studies on MRSA nasal decontamination have used mupirocin, which is administered to the anterior nares 2-3 times per day for 5 days. Routine decolonization is not advised unless MRSA colonization is verified in the nares or other sites because increased use is associated with the emergence of mupirocin-resistant staphylococci (Abad et al., 2013).

2.11 Knowledge, attitude, and compliance regarding MRSA infection transmission:

One of the main reasons for this study's foundation is the clear absence of information in the literature about dentistry students' understanding of the contagious MRSA bacteria. The literature does, however, include details about the attitudes, and perspectives of medical students, nursing students, and other healthcare professionals.

Table 2.2: Summary of previous studies regarding methicillin-resistant Staphylococcus aureus (MRSA) knowledge among different target populations

Study	Study location	Study population	Study Results
(Yoo et al., 2018)	Seoul, Korea	Dental health care professionals	Acceptable KAP scores with respect to MRSA infection control
(de Giusti et al., 2011)	Rome, Italy	Medical, public health technician students, and general public	Very low awareness regarding MRSA
(Ajani et al., 2020)	Ogun State, Nigeria	Medical students	Inadequate KAP scores regarding MRSA
(Lloyd et al., 2016)	Eastern US	Nursing students	Low knowledge average
(Jayamaha et al., 2015)	Karapitiya, Seri lanka	Nursing students	Overall knowledge was not satisfactory
(Suss, 2017)	Mississippi, US	Nurses	Adequate knowledge of MRSA
(Daniel et al., 2017)	South Trinidad	Nurses	Level of knowledge on MRSA was inadequate
(Ahmed et al., 2021)	Mansoura, Egypt	Nurses	Unsatisfactory knowledge concerning MRSA

According to a cross-sectional study done among dental health care professionals in Korea (Yoo et al., 2018), there was still a need for more MRSA education, especially given how serious it is. Moreover, in two other studies, there was poor knowledge, attitude, and awareness regarding MRSA infection transmission, prevention, and perception among medical and biomedical students (Ajani et al., 2020; de Giusti et al., 2011).

Another study conducted among nursing students in Ohio, USA; revealed that knowledge regarding MRSA was inadequate (Lloyd et al., 2016). This was consistent with a study that evaluated MRSA knowledge, attitudes, and practices among nursing students enrolled at a teaching hospital in Karapitiya. In that study, the majority of students knowledge and overall understanding was not sufficient. Significantly, those with the worst general knowledge had positive attitudes (Jayamaha et al., 2015).

The majority of the dental students and faculty members in a survey conducted in Arkhangelsk-Russia, documented intermediate knowledge and good attitudes toward infection control practice in the dental setting, and the majority of the studied socio-demographic and MRSA-related factors were not correlated with participants' knowledge, compliance, and attitudes (Valkov et al., 2020.). Additionally, despite receiving instructions in infection control and clinical experience, Yeungnam dental hygiene students' awareness of infectious illnesses and methicillin-resistant Staphylococcus aureus (MRSA) was determined to be insufficient (Hun Lee et al, 2011).

In a study designed to evaluate the knowledge, attitudes, and compliance to infection prevention practices among health care workers (HCWs) in Nepal. Although the personnel had strong knowledge and a favorable attitude toward most elements of infection prevention, just half had heard of methicillin-resistant Staphylococcus aureus (MRSA) (Paudyal et al., 2008).

Moreover, in a study that aimed to assess the staff nurses' knowledge and awareness regarding MRSA infection prevention practices, the level of nurses' knowledge related to MRSA was insufficient, which was expressed into their failure to adjust to the preventative procedures, which has consequences for ongoing, continual teaching programs. (Daniel et al, 2017).

In contrast to another study conducted among nurses, which found high results of knowledge and compliance regarding MRSA (Suss, 2017). This study varied from others in the literature because 60% of the participants in it agreed or strongly agreed that they had received useful education about MRSA, which contributed to their greater understanding and higher rates of adherence.

Chapter Three:

Theoretical and conceptual framework:

3.1 Study theoretical and conceptual framework

The research design was conducted to examine potential risk factors for nasal colonization in dental students. For the pathogen, carriers act as reservoirs, facilitating its spread in the population, nasal colonization of S. aureus and MRSA has been recognized as a substantial contributor to the risk of recurring infections (Ayepola et al., 2018). Several risk variables have been linked to nasal carriage of *S. aureus*, they include age, occupation, sex, ethnicity, antibiotic misuse, prolonged hospital stay, repeated needle injections, nasal deformities, genetic make-up, hormonal status in women, immunological status, S. aureus skin infections, and nose-picking. Other risk factors include: smoking status, underlying diseases, history of recent common cold and fever, living places, crowding, and contact with living stock(Olsen, 2013; Ayepola et al., 2018; Wong et al., 2018). By identification of risk factors, measures could be created to help dentistry students implement infection control procedures in their dental units.

Furthermore, the "KAP" model, which frequently assesses the knowledge, attitude, and practices of the study population, is used in our study. It offers an educational assessment of the study subjects.

The fundamental components that make up the dynamic life system are knowledge, attitude, and practice (Alharbi et al., 2019). Moreover, the knowledge and attitudes of dentists and dental students regarding MRSA can affect a person's willingness to follow precautionary practice rules(Yoo et al., 2018). According to the centers for disease control and prevention (CDC); “Standard Precautions are the minimum infection prevention practices that apply to all patient care, regardless of suspected or confirmed infection status of the patient, in any setting where health care is delivered”. These procedures are created to safeguard dentists and stop them from infecting patients. Standard Precautions include:

1. Hand hygiene. 2. Use of personal protective equipment (e.g., gloves, masks, eyewear). 3. Respiratory hygiene/cough etiquette. 4. Sharps safety (engineering and work practice controls). 5. Safe injection practices 7. Sterile instruments and devices. 8. Clean and disinfected environmental surfaces. (Centers for Diseases Control and Prevention 2005).

- The conceptual framework for this study (Figure 3.1):
    1. Nasal carriage prevalence (*S. aureus*, MRSA) and antibiotic susceptibility patterns.
    2. Socio-demographic characteristics (Gender, clinical year, demographic area, family profession, and family size).
    3. Social& lifestyle characteristics (Pets, sports, and smoking).
    4. Medical history (Previous hospitalization, surgery, antibiotic usage, underlying medical condition, and previous *S. aureus* infection).
    5. Knowledge and awareness regarding MRSA.
    6. Attitude and perception toward MRSA.
    7. Compliance with infection prevention practices.

3.2 Study dependent variables

Nasal carriage or colonization: This is bacterial adherence to nasal epithelial cells. The front portion of the nasal cavity appears to be where S. aureus colonizes most frequently. (Weidenmaier et al., 2012).

Antibiotic susceptibility: A laboratory test called antibiotic susceptibility testing (AST) is used to determine which antimicrobial regimen will work best for a certain patient. (Bayot et al., 2021).

Susceptible: “The "susceptible" category implies that isolates are inhibited by the usually achievable concentrations of an antimicrobial agent when the recommended dosage is used for the site of infection.” (CLSI definition)

Resistant: “The "resistant" category implies that isolates are not inhibited by the usually achievable concentrations of the agent with normal dosage schedules, and/or that demonstrate zone diameters that fall in the range where specific microbial resistance mechanisms.” (CLSI definition)

These variables' significance is expressed in that, the proper choice of the antimicrobial drugs depends on having knowledge of MRSA prevalence and current antimicrobial susceptibility trends (Legese et al., 2018).

Knowledge, attitude, and practices (KAP)

Knowledge: In the medical vocabulary, knowledge, familiarity, awareness, or comprehension are terms that are acquired via study or experience (American Heritage Dictionary, 2011). It is the basic criteria that allow the differentiation between right and wrong (Alharbi et al., 2019).

Attitudes: This is the personal or mental view of dental students on methicillin-resistant *staphylococcus* bacteria, as the adoption of preventive measures can be affected by one's attitudes and understanding about MRSA infection management (Yoo et al., 2018).

Practice: This means the customary, habitual, or expected procedure or way of doing something. These procedures are made to safeguard dental professionals and stop them from contaminating patients (Centers for Diseases Control and Prevention 2005).

For effective infection control, it is critical to assess the knowledge, attitudes, and practical skills of dental practitioners. As not taking the advised precautions, such as standard precautions (SPs), may contribute to the transmission of MRSA (Yoo et al., 2018).

Operationally, the knowledge, attitudes and practices regarding methicillin-resistant *Staphylococcus aureus* (MRSA) , are individually measured by a set of questions in the self-administered questionnaire in this study, as it is explained in the methodology chapter.

3.3 Study independent variables

A. Sociodemographic factors:

Gender: This refers to male and female dental student participants in the study. As some studies found a higher nasal colonization rate in males compared with females (Ayepola et al., 2018; Sakr et al., 2018), this can be explained by increased body hair, and due to variations in hygiene habits. Males are less compliant, which may predispose them to higher colonization and infection rates (Humphreys et al., 2015).

Clinical year: This refers to the educational year of dental students. It will be categorized into two groups: fourth year and fifth year. This may give an expectation that higher risks will be associated with an increased level of training experience as they are exposed to a greater number of patients (Hema et al., 2017).

Demographic area: This refers to the place of residence. It will be categorized into rural and urban. Some studies indicated that there is a higher risk among rural areas compared with urban areas (Ansari et al., 2016). This might be a result of MRSA spreading from cattle to people. (Hantoosh, 2022).

Family size: This refers to the number of family members of each participant. It will be categorized into two groups: Up to four, and more than four. A crowding living situation may indicate increased nasal carriage risk (Olsen, 2013).

The profession of the family: This refers to the current profession of each student's family. It will be categorized into healthcare and other professions. As higher nasal colonization rates were found among health workers (Meza, 2018; Sakr et al., 2018).

B. Lifestyle Factors:

Participation in sports: This refers to participation in sports and physical activity such as running, swimming, cycling, and working out in the gym, etc., which were found to be associated with higher nasal carriage rates (Ansari et al., 2016; Olsen, 2013).

Contact with pets: This refers to contact with animals, including pets and livestock, as there is a risk to humans who come into direct contact with animals acquiring MRSA (Crespo-Piazuelo et al., 2021).

Smoking: This refers to the smoking status of the participant. If he/she is a smoker or not. Although there is still debate on the impact of smoking on MRSA colonization, according to certain research, smokers are more likely than non-smokers to become colonized with MRSA, due to increased MRSA hydrophobicity by smoking, therefore increasing MRSA adherence and invasion (Choi et al., 2019).

C. Medical History:

Hospital visits in the past 6 months: This refers to if the participant has entered the hospital in the past six months. Because this variable may be influenced by the fact that there are other patients in the hospital who have MRSA colonization or infection, which are significant risk factors. (Humphreys et al., 2015).

Surgery in the past 6 months: This refers to if the participant has undergone any kind of surgery in the past six months, because this variable may influence the nasal colonization rate, due to the hospital environment, which may contain various microorganisms.

Antibiotics in the last 6 months: This refers to if the participant was under antibiotic treatment in the last 6 months. As antibiotic use may influence and cause antibiotic resistance especially the misuse and overuse of antibiotics (Munckhof et al., 2009).

Previous *staphylococcus* bacterial infection: This refers to whether the participant had a history of *staphylococcus* bacterial infection. Staph infections could range from mild skin infections to serious life-threatening infections (Malone, 2017).

Previous hospitalization, surgery, antibiotic exposure, and previous *staphylococcus* infections are health-related factors of great concern and impact on nasal colonization with *S. aureus* bacteria, in which they were found associated with higher nasal colonization rates (Munckhof et al., 2009; Ayepola et al., 2018; Sakr et al., 2018).

Medical condition: This refers to the medical status of the participants and whether there is an underlying medical condition. Because a higher incidence of MRSA was found among people with medical conditions such as HIV, discharge with long-term central venous access or a long-term indwelling urine catheter, as well as hemodialysis (Aljeldah, 2020; Beam et al., 2006).

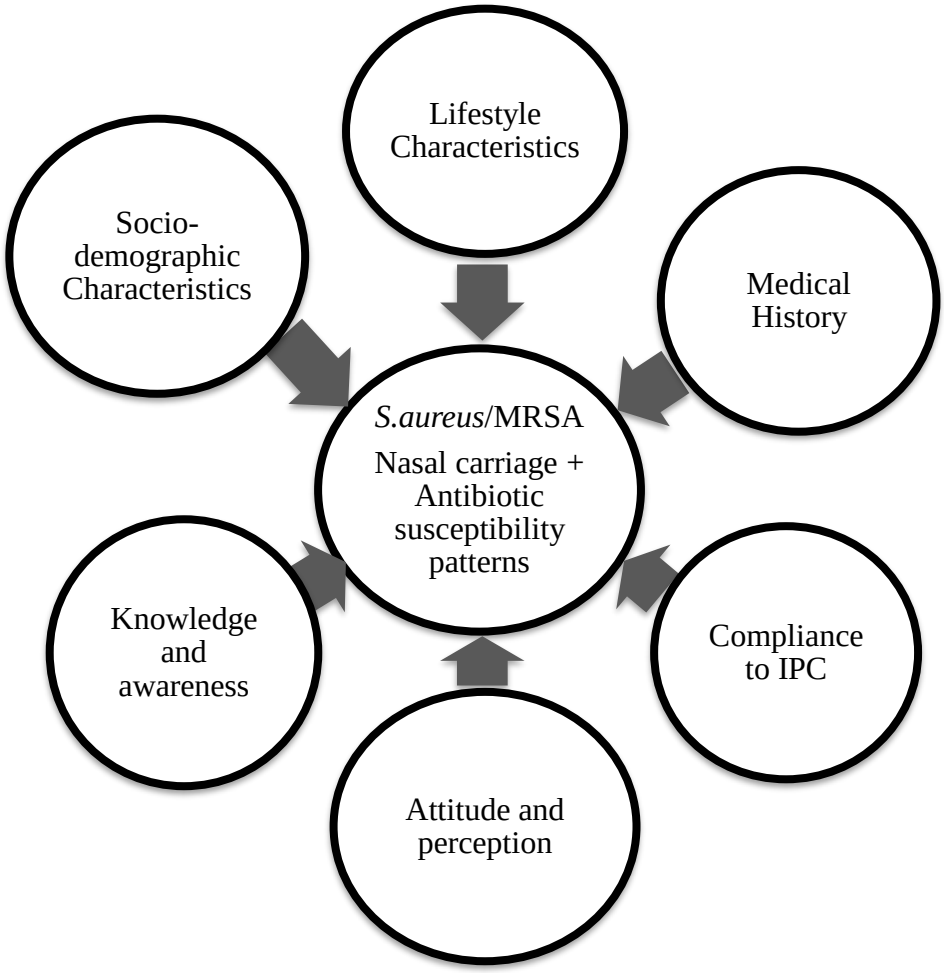


Figure 1. Study conceptual framework

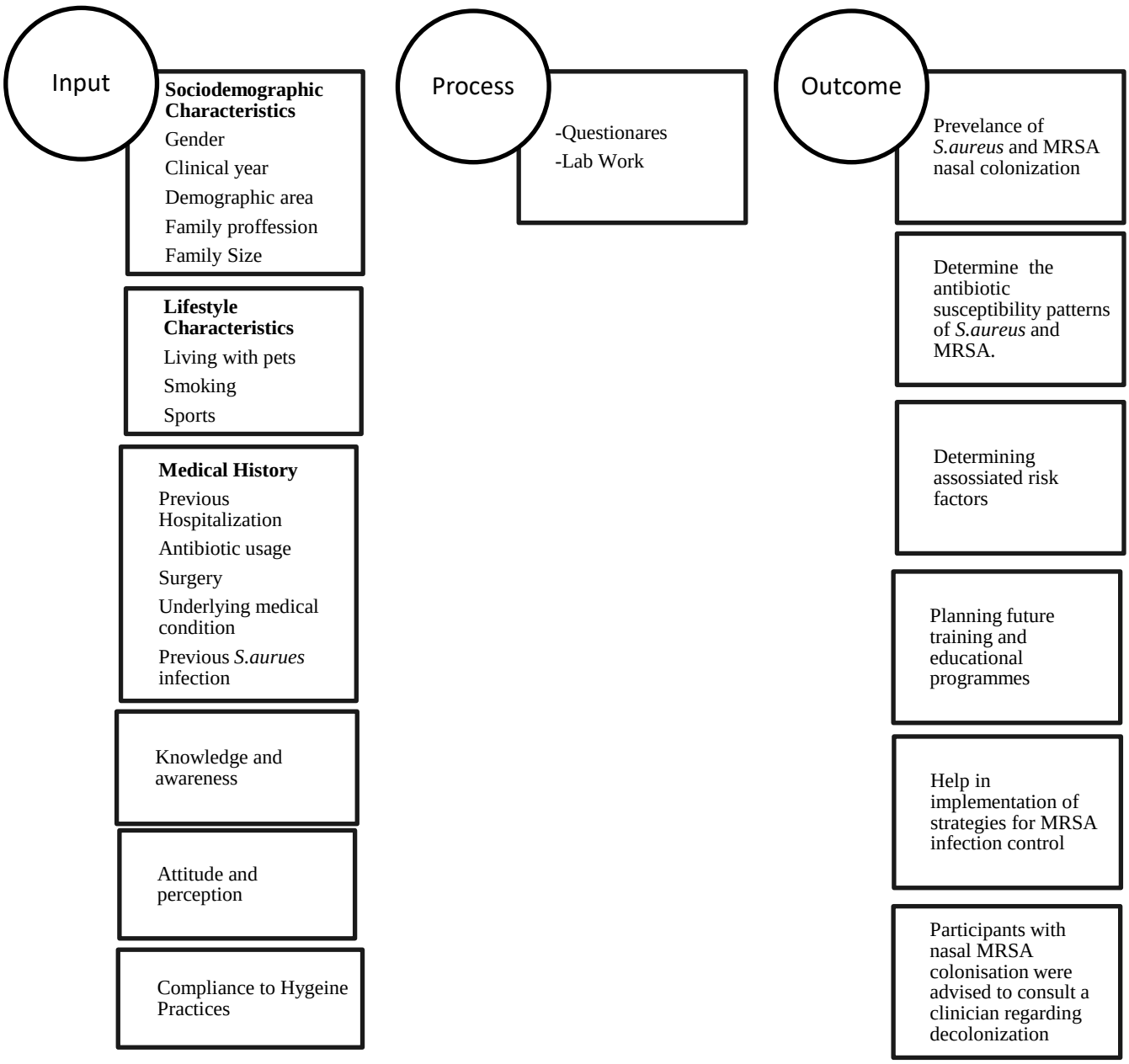


Figure 2. Study theoretical framework

Chapter Four:

Methodology

4.1 Introduction

This chapter summarizes and draws the methodology, which is used to evaluate the knowledge and attitude regarding MRSA and compliance to hygiene practices among dental students in Al-Quds University – Palestine. In addition, describing the methods used for determining the nasal carriage rate of *S. aureus* and MRSA, and describes the methods used for identifying the risk factors for *S. aureus* and MRSA nasal colonization. The design of the study is cross sectional study and a lab based study, which employs a self-administered questionnaire as a tool to collect data, in addition to collecting nasal swabs from the study sample. The chapter also discusses the data gathering process, study population, study design, sample criteria, and statistical techniques that were employed to handle the findings.

4.2 Study Setting

The study was conducted at Al-Quds University; the faculty of dentistry. Since the faculty's establishment in 2000 to establish dental medicine education in Palestine, almost 1,000 students have received a Bachelor's Degree in Dental Surgery (BDS). The clinical dental teaching school (al-abraj) is located in Abu-dis, it provides clinical training in several departments, such as orthodontics, pedodontics, endodontics, prosthodontics, periodontology, and dental surgery, for third, fourth, and fifth-year dental students.

4.3 Sample Frame

The subjects of the study are fourth and fifth-year dental students.

4.4 Study Design:

Cross-sectional study + Experimental (lab-based study)

Quantitative: Prevalence of *S. aureus* nasal carriage. Knowledge, attitude, and practices regarding MRSA infection control.

4.5 Sampling Method

Most fourth and fifth-year dental students were approached and asked to participate in the study. (Full sample population)

4.6 Inclusion-Exclusion Criteria

Inclusion criteria: University fourth and fifth-year dental students who consented to give permission for involvement and provided nasal swabs.

Exclusion criteria:

Students who are on antibiotics were excluded.

Students who consent to participate but didn't provide a nasal swab.

4.7 Study Tools

4.7.1 Laboratory data process:

4.7.1.1 Nasal swab collection:

As in earlier investigations (Yoo et al., 2018), swab samples were obtained by inserting a sterile nasal swab (Transystem ™ sterile transport swab) into each anterior nostril to a depth of about 1.5 cm and rotating it five times. The swabs were then labeled with a code number, time, and date. The collected swabs were delivered right away to the Al-Quds University Microbiology lab. See (figure 5) for the explanation of the experimental work.

4.7.1.2 Culturing and isolation of *S. aureus:*

Nasal swabs were cultured using Mannitol Salt Agar (MSA), which is a selective media for the isolation of *S. aureus*. *Staphylococcus* species can grow in MSA media because of the high salt concentration, while many other organisms cannot (Meza, 2018). The nasal swabs were immediately used to streak for isolation on the MSA media, which was incubated at 37°C for 24-48 hours (Sharma et al., 2014). By fermenting the mannitol, *S. aureus* creates yellow colonies, which are the first sign of the bacteria. (Meza, 2018).

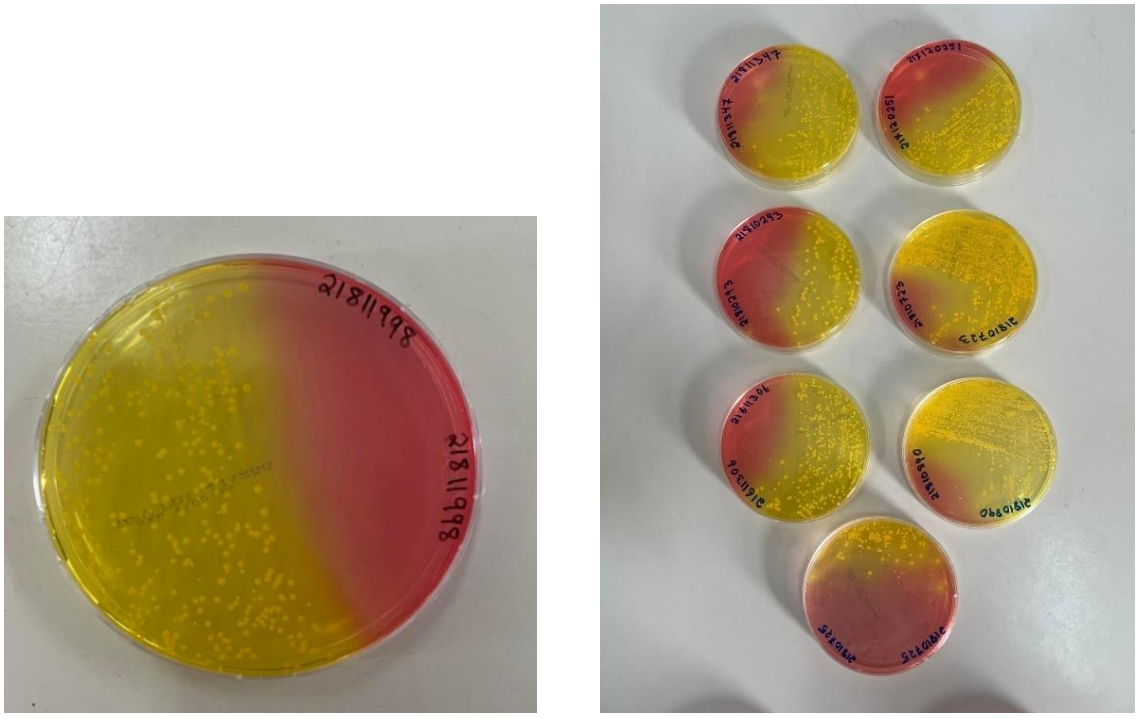


Figure 3: Yellow colonies of *S. aureus* on mannitol salt agar.

Further identification was carried out with catalase and coagulase tests (Ayepola et al., 2018). The catalase test is a qualitative method demonstrating the presence of the catalase enzyme, in the bacterial species analyzed, aiming at distinguishing between catalase-positive *Staphylococcus* and catalase-negative *Streptococcus* (Moraes et al., 2021). Coagulase is an extracellular enzyme synthesized by some species of *Staphylococcus*, so the coagulase test allows the recognition of species of the genus *Staphylococcus spp*., in which the presence of coagulation indicates a positive result (Moraes et al., 2021). The most accurate approach for identifying Staphylococcus aureus is coagulase testing. (Kateete et al., 2019).

4.7.1.3 Identification of MRSA:

S. aureus isolates were tested for susceptibility using the disk diffusion method in accordance with the recommendations of the Clinical Laboratory Standards Institute (CLSI). After inoculating isolates of the 0.5 McFarland standard suspension on a Mueller Hinton agar plate, a cefoxitin disk was added. Cefoxitin resistance was viewed as being equal to methicillin resistance (Ayepola et al., 2018). For 18 to 24 hours, plates were incubated at 37ºC , and inhibitory zone diameters (mm) were determined. (Efa, 2018; Ayepola et al., 2018).

The CLSI recommendations state that S. aureus, is sensitive if the diameter is ≥ 22 mm, and resistant if the diameter is ≤ 21 mm, these are the interpretative criteria for cefoxitin. And this test was validated in a wide surveillance program (Pottumarthy et al., 2005). Cefoxitin testing is very accurate and clearly distinguishes methicillin-resistant strains of *S. aureus* from methicillin-susceptible strains (Fernandes et al., 2005). Especially that cefoxitin is a more potent inducer of mecA expression than other agents (Elshabrawy et al., 2017).

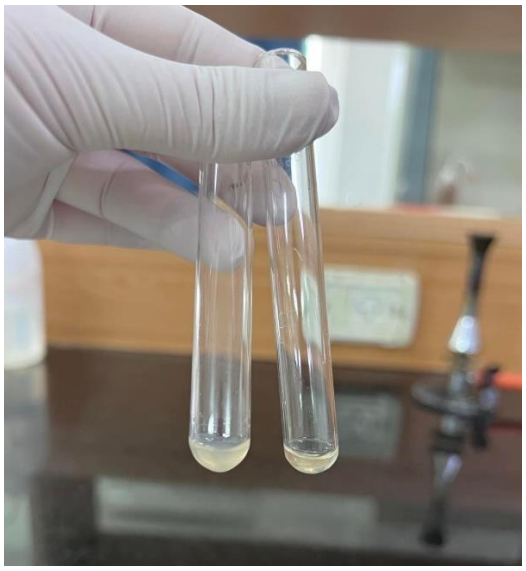
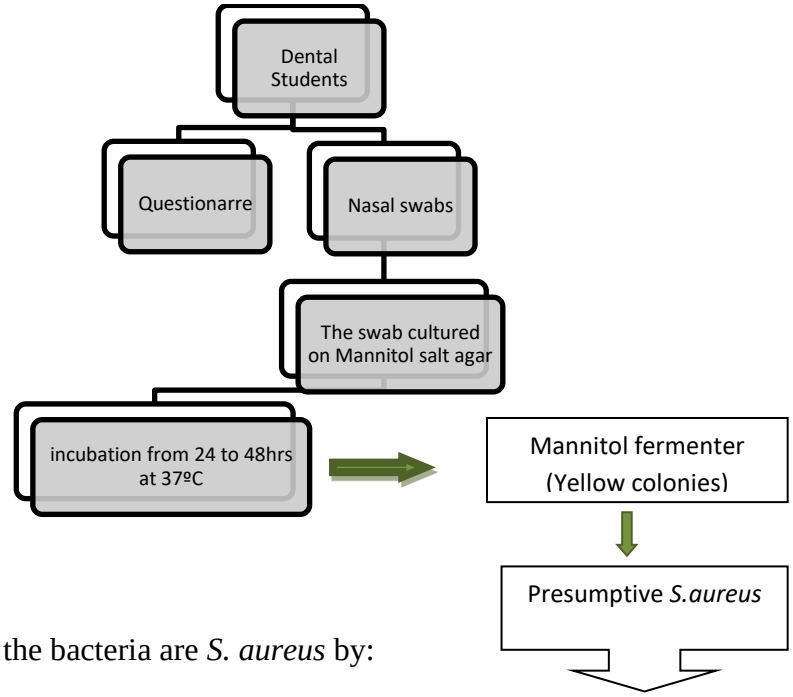
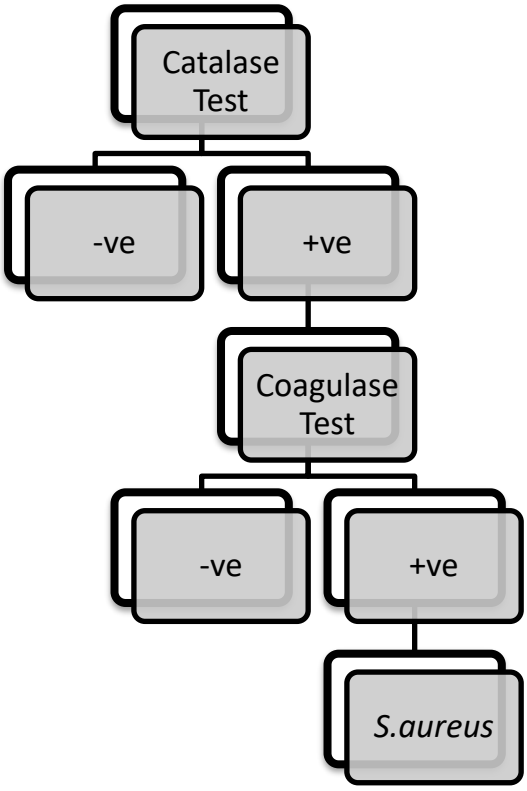
a.  b. 

Figure 4: a. Coagulase Test: The tube on the left demonstrates a positive coagulase result (The presence of clotting), while the tube on the right demonstrates a negative result. b. Catalase Test: The tube demonstrates a positive catalase result (The presence of bubbles).

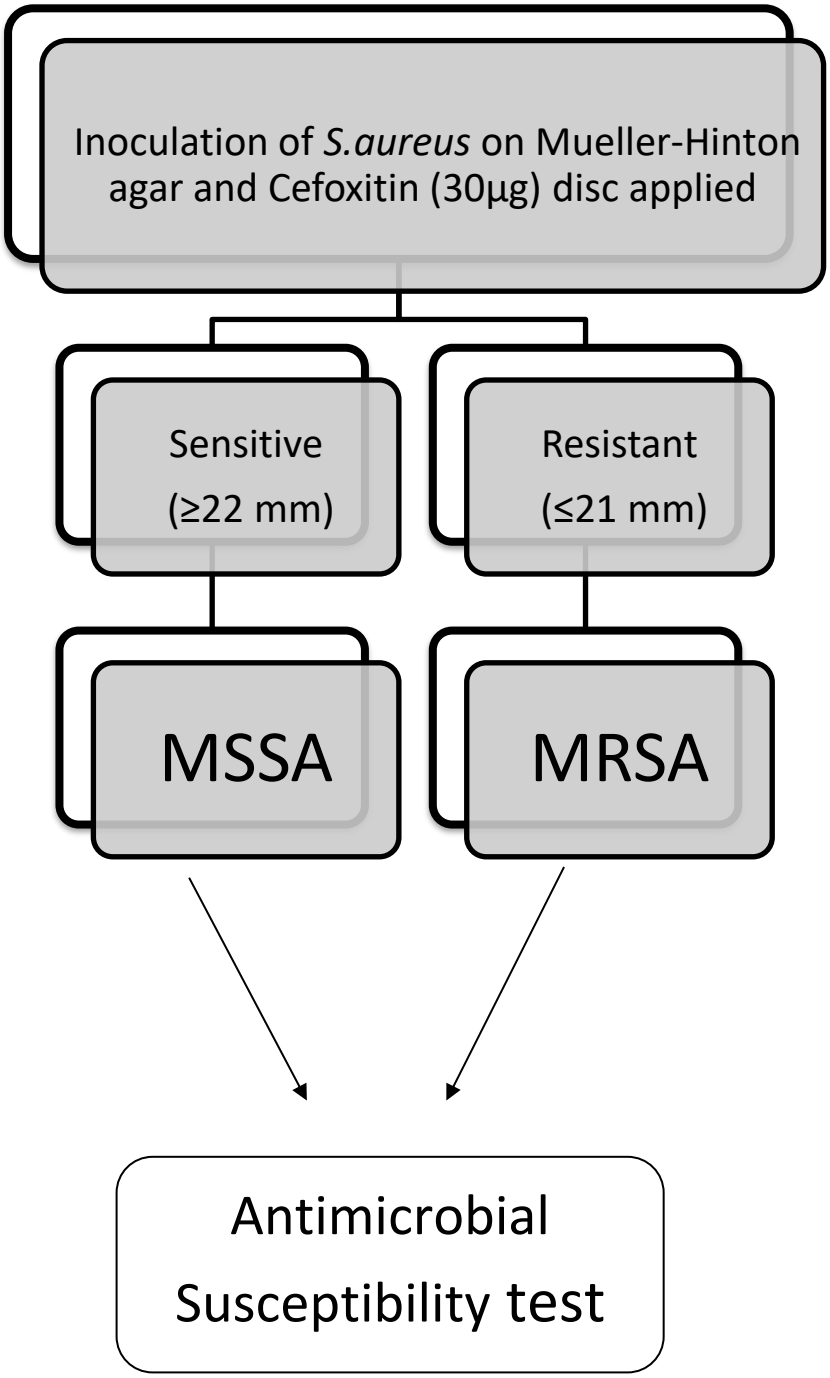
Figure 5: Flow chart of the experimental work



Verify that the bacteria are *S. aureus* by:



To distinguish MRSA from MSSA:



*MRSA – Methicillin Resistant Staph Aureus

*MSSA - Methicillin Susceptible Staph Aureus

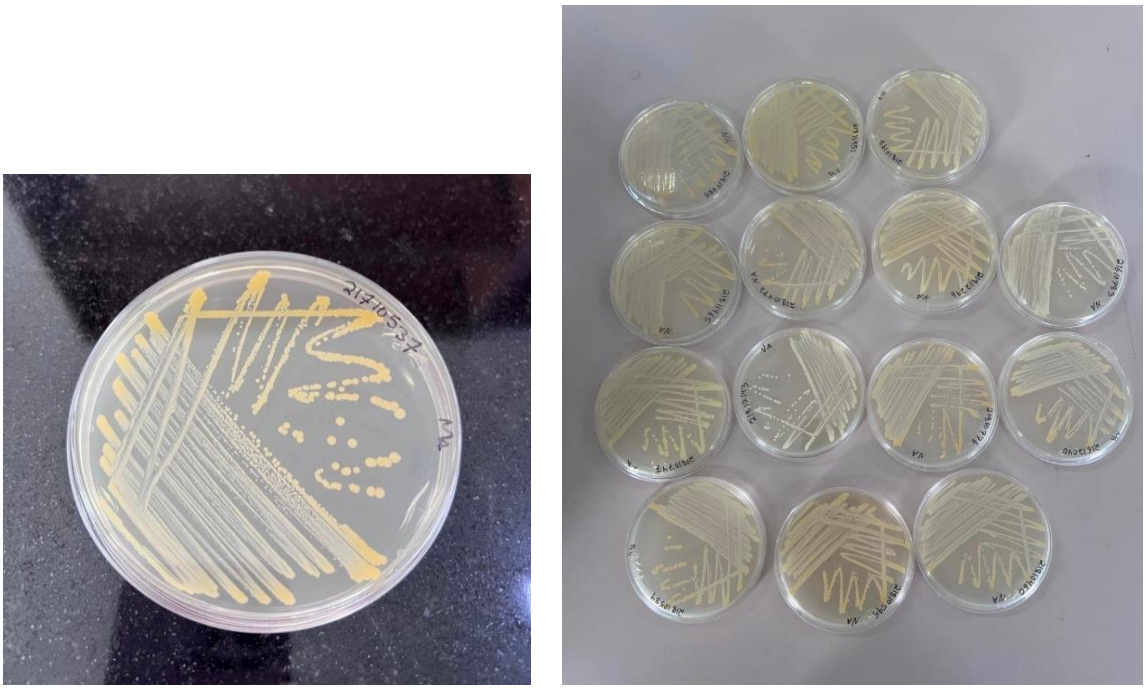


Figure 6: Growing *S. aureus* bacteria on nutrient agar in order to do 0.5 McFarland standard suspension isolates.

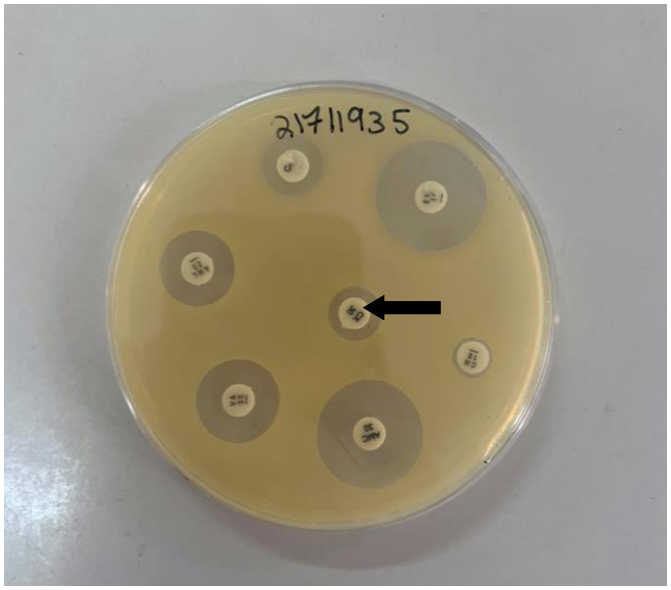


Figure 7: MRSA Identification: The photo shows a cefoxitin-resistant *S. aureus* by the disc diffusion method on Mueller-Hinton agar.

4.7.1.4 Susceptibility testing:

Antimicrobial susceptibility patterns of *S. aureus* and MRSA were assessed against several antibiotics (cefoxitin (30µg), amoxicillin (10µg), amoxicillin\clavunic acid (30µg), gentamicin (10µg), vancomycin (30µg), clindamycin (2µg), and erythromycin (15µg) (HiMedia Laboratories)). Resistance or susceptibility to each agent was determined according to the minimal inhibitory concentration (MIC) (Legese et al., 2018). Manual placement of antibiotic discs on Mueller-Hinton agar medium followed by an 18-hour incubation period at 37 °C resulted in the measurement of the zones of inhibition. Based on the CLSI criteria, the results were interpreted.

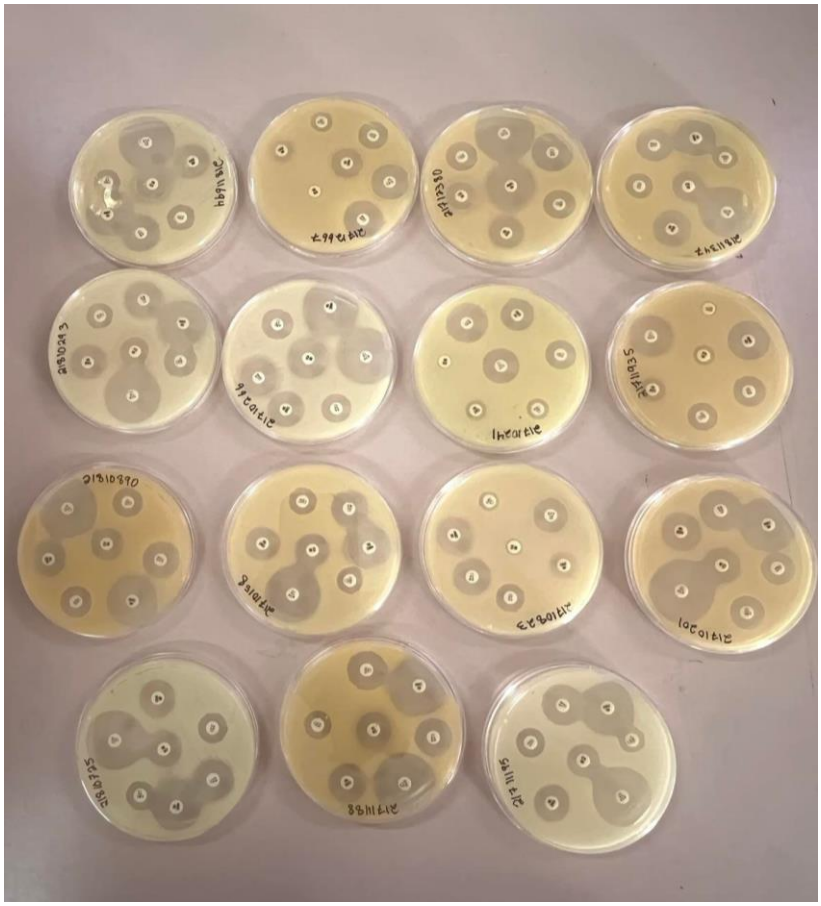


Figure 8: Various antibiotic susceptibility patterns of *S. aureus* bacteria against several antibiotics on the Mueller-Hinton agar.

4.7.2 Study Questionnaire:

A self–administered questionnaire was distributed among dental students. The questionnaire involved questions related to each studied risk factor of the conceptual framework (socio-demographic, lifestyle, and medical history). It also contained a set of questions to evaluate knowledge; attitude and hygiene practices regarding MRSA infection transmission. There were 37 items in this survey form, which could be finished in 10 to 15 minutes. The final questionnaire had four parts:

- Part 1. Socio-demographic, lifestyle, and medical history section: There are 13 questions relevant to the studied risk characteristics, which include socio-demographic questions (gender, clinical year, demographic area, family profession, and family size). In addition to lifestyle-related questions (living with pets, smoking, and sports). And medical history questions (previous hospitalization, antibiotic usage, surgery, underlying medical condition, and previous *S. aureus* infection).

- Part 2. This section evaluates the knowledge of dental students regarding methicillin-resistant *Staphylococcus aureus* (MRSA). There are 8 questions in this part. They were asked whether standard precautions by wearing gloves and personal protective equipment can prevent infection, if MRSA is most often spread via health care practitioners' hands, if the source of MRSA infection is the hospital and community, and if MRSA (Methicillin-Resistant Staph aureus) is resistant to Methicillin and several other B-lactam antibiotics, also if MRSA is a Gram-positive coccus, if MRSA can survive on surfaces for days, and if it is possible that staphylococcus bacteria develop resistance to antibiotics causing skin infections that can't be cured? And if asymptomatic carriers can be a source of infection. The participants were instructed to answer by using (X) or (√) for the option that best suited their response to each topic. The responses were given on a 3-point Likert scale: (3) True, (2) Not sure and (1) False. With a maximum score of 24 points and minimum score of 8 points, for every participant in the knowledge section.

- Part 3. Attitudes towards MRSA infection control: There are 8 questions in this section that examine dental students' attitudes. Which involved the following: Do you agree

that there is a need for infection control education? Are you willing to take additional educational courses to increase your knowledge regarding MRSA? Are you willing to participate in an infection control education program? Do you see yourself as accountable for patient MRSA prevention? And if they agree that gloves and good hand hygiene can prevent the spread of MRSA, also if unnecessary antibiotic prescriptions by dentists can cause MRSA, and if MRSA is considered a serious problem globally. In addition to, while working, you could become infected with MRSA. Responses were given on a 5-point Likert scale: (5) strongly agree, (4) agree, (3) not sure, (2) disagree, and (1) strongly disagree. With a maximum score of 40 points and minimum score of 8 points, for every participant in the attitude section.

- Part 4. Compliance with infection prevention and control practices: There are 6 questions in this section to evaluate dental students' practices. There were asked if they always use gloves when contacting a patient's mucosa, if they wash their hands after coming into contact with the patient's blood or saliva, and when there's a chance that a patient's saliva or blood can spatter, do they wear a mask? Also, if they perform hand hygiene before touching a patient. And before and after wearing gloves. Responses were given on a 4-point Likert scale: (4) very often, (3) often, (2) less often, and (1) never. With maximum score of 24 points and minimum score of 6 points, for every participant in the compliance section.

4.8 Questionnaire validation

As mentioned in the previous section, the study questionnaire involved four sets of questions;((Socio-demographic, lifestyle, and medical history section), knowledge, attitude, and compliance to infection prevention practices). The second set of questions regarding MRSA knowledge was borrowed from the assessment tools of several studies (Ajani et al., 2020; de Giusti et al., 2011; Yoo et al., 2018). The third set of questions is a MRSA attitude assessment tool from Yoo et al., 2018. The fourth set of questions are questions for infection prevention

and control compliance assessment, also borrowed from Yoo et al., 2018, but some modifications were done to be relevant to our study.

A pilot study was conducted by the studies that first employed these tools to validate the questionnaire. However, due to the modifications done, further validation was established.

Cognitive validation was done by presenting the research tool to the supervisor and a panel of arbitrators who are specialized in this field, the validity of the instrument was confirmed. As they were asked to express their opinions, and the questionnaire was completed, based on these notes.

In addition, to check the reliability of the tool, 10 randomly chosen people from the sample population took the survey as a pilot. To assess the internal consistency of the survey questions, Cronbach's alpha was utilized. The coefficient of stability for the domains and the total score are displayed in the following table (4.1).

Table 4.1: Cronbach alpha reliability measure (10 questionnaires)

Dimensions	Number of questions	Cronbach alpha
Knowledge	8	0.754
Attitude	8	0.772
Practice	6	0.840
Total	22	**0.874**

It has been found that all of the investigated dimensions have a high level of reliability. This indicated that the survey was trustworthy and is regarded as a dependable tool for assessing knowledge, attitude, and practices.

4.9 Lab work quality and reliability

All lab identification methods are based on the standard reliable criteria of the Clinical Laboratory Standards Institute guidelines (CLSI), and according to standard protocols in the microbiology laboratory as applied in previous literature (Efa, 2018; Moraes et al., 2021; Yamakhakha, 2019).

The strict adherence to accepted microbiological practices was followed to reduce cross-contamination to a minimum.

4.10 Data & sample collection

The data was collected from fourth and fifth-year (280) dental students in Al-Quds University dental training school. After getting their approval by signing the informed consent form, they were asked to answer the self-administered questionnaire.

Afterward, swab samples were collected by the researcher herself after being well trained , from the nasal of study participants, taken with sterile swabs in a transport medium, which had a code number, time, and date written on them. The collected swabs were delivered right away to the Microbiology laboratory of Al-Quds University.

4.11 Statistical Analysis

Statistical analysis of the data was performed using the statistical package for social sciences IBM SPSS version 20. Specifically, the software was used to calculate the proportions of MRSA from the total isolates of S. aureus. The Chi-square was used to see whether there is a significant association between nasal carriage and various factors captured in the questionnaire.

For the KAP results, the total score of every participant was calculated, followed by calculation of the total mean (n=280 student) for every KAP dimension. Poor knowledge was defined as a total score of less than 33.3th percentile (corresponding to $\leq$ 13.33 mean score), intermediate knowledge in case of values between 33.3th and 66.6th percentiles (corresponding to a mean between 13.34-18.67), and good knowledge implying values above 66.6th percentile (corresponding to $\geq$ 18.68 mean).

For the attitudes section, poor attitude was defined as a total score of less than 33.3th percentile (corresponding to ≤ 18.66 mean score), intermediate attitudes in case of values between 33.3th and 66.6th percentiles (corresponding to a mean between 18.67-29.33), and good attitude implying values above 66.6th percentile (corresponding to ≥ 29.34 mean).

For the compliance to infection prevention section, poor compliance was defined as a total score of less than 33.3th percentile (corresponding to ≤ 12.00 mean score), intermediate compliance in case of values between 33.3th and 66.6th percentiles (corresponding to a mean between 12.01-18.00), and good attitude implying values above 66.6th percentile (corresponding to ≥ 18.01 mean).

The t-test was used to compare the means of knowledge, attitudes, and compliance according to clinical year of study, and for testing the relationship between knowledge, attitudes, practice, and MRSA nasal prevalence. A value of $P< 0.05$ was considered statistically significant.

The proper means and standard deviations were used to express continuous variables. All categorical variables were given frequencies and percentages.

4.12 Ethical Consideration

The Al-Quds University School of Public Health Research Committee received the study proposal for review and approval. The faculty of dentistry at Al-Quds University also gave its authorization to carry out the study. Prior to participating, all dental student participants were required to sign a consent form and were given information about the study's purpose and goals.

The participants were informed that the data gathered will be treated in strict confidence, and the laboratory examination results will be kept private and no one else will have access them. Participants with positive MRSA results were informed privately, and advised to consult a clinician regarding decolonization.

Chapter Five:

Results:

5.1 Study Approach

In this study, the descriptive analytical approach is used. This strategy aids in understanding the current condition and future planning. It enables the researcher to look into dentistry students' understanding of and attitudes toward Methicillin-resistant *S. aureus* (MRSA) and adherence to hygiene practices, which may assist uncover curriculum gaps and areas that require improvement. Additionally, identifying risk factors for nasal colonization among dentistry students and the results may be helpful in developing a program for MRSA infection management in dental clinics and facilities.

5.2 Study Results

An understanding of the risk factors for carriage of MRSA is crucial for understanding the potential for invasive infections and transmission of diseases cause by this pathogen, so our first section of the questionnaire involved questions related to each studied risk factor of the conceptual framework (socio-demographic, lifestyle, and medical history). The distribution of the study sample according to these studied variables are represented in table 5.1.

According to table 5.1, most of the participants were females;73.2% (n=205), while 26.8% (n=75) were males.53.9% were 5^{th}-year dental students and 46.1% were 4^{th}-year dental students. The majority (87.9%) had more than 4 family members, while 12.1% had only up to 4 family members. 40% (n=112) of dental students had a family member who worked in healthcare.70% didn’t have any contact with pets, while 30% did. 38.2% (n=107) participates in sports, but 61.8% (n=173) didn’t. The majority; 77.9% (n=218) were non-smokers.

Moreover, 177 (63.2%) students answered that they have heard of Methicillin-Resistant *Staph aureus* (MRSA), while 103 (36.8%) students answered that they had not. The majority

(155/177) knew about MRSA from lectures, while the others knew about it from social media (6.4%) or group discussions (1.4%).

Table 5.1: The research sample's distribution in relation to the research components

Variables	Levels	N	%
Gender	Male	75	26.8
	Female	205	73.2
Clinical year	4th-year dental student	129	46.1
	5th-year dental student	151	53.9
Place of residence	Rural	138	49.3
	Urban	142	50.7
Number of family members	Up to 4	34	12.1
	More than 4	246	87.9
Profession of family	Healthcare	112	40.0
	Other	168	60.0
Participate in sports	Yes	107	38.2
	No	173	61.8
Contact with pets	Yes	84	30.0
	No	196	70.0
Smoking	Yes	62	22.1
	No	218	77.9
Have you visited the hospital in the past 6 months	Yes	48	17.1
	No	232	82.9
Had surgery in the past 6 months	Yes	12	4.3
	No	268	95.7
Used antibiotics in	Yes	131	46.8

Variables	Levels		N	%
the last 6 months	No		149	53.2
Had a previous *staphylococcus* bacterial infection	Yes		36	12.9
	No		244	87.1
Have an underlying medical condition	Yes		10	3.6
	No		270	96.4
If yes, what is it	Bicuspid aortic valve (congenital)		1	10
	Colon inflammation		1	10
	Crohn's Disease, Eczema		1	10
	Diabetes/insulin		1	10
	Familial Mediterranean fever (FMF)		1	10
	Migraine		1	10
	Mitral valve prolapse		1	10
	Polycystic ovary syndrome (PCOs)		1	10
	Ulcerative colitis		1	10
	VD3 + VB12 deficiency		1	10
Have you heard of Methicillin-Resistant *Staph aureus* (MRSA)	Yes		177	63.2
	No		103	36.8
	If Yes	Lecture	155	55.4
		Group discussion	4	1.4
		Internet/social media	18	6.4

For the KAP dimension results, as explained in the methodology section, the total score of every participant was calculated, followed by calculation of the total mean (n=280 student) for every KAP dimension.

In order to understand the study results, we can use the key in the following table (5.2): (Explained in the statistical analysis section)

Table 5.2: Key of the Likert scale

Scale	Means range for Knowledge	Means range for attitude	Means range for practices
Low	13.33 and below	18.66 and below	12.00 and below
Medium	13.34-18.67	18.67-29.33	12.01-18.00
High	18.68 and above	29.34 and above	18.01 and above

The results related to the research question of what is the level of knowledge and attitude toward methicillin-resistant *S. aureus*, and the level of compliance to infection prevention practices among dental students of Al-Quds University. Means were calculated according to the 3 KAP dimensions as shown in table (5.3).

The knowledge score showed a mean of 18.40 with a SD of 2.73. It, therefore, indicated that dental students had intermediate knowledge regarding MRSA. The attitude score showed a mean of 32.12 with a SD of 4.19. It, therefore, indicated that dental students had positive attitudes towards methicillin-resistant *S. aureus.* The practice score showed a mean of 22.21 with a SD of 2.35. It, therefore, indicated that the dental student's practices regarding MRSA infection prevention are good.

Table 5.3: Means of KAP dimensions regarding MRSA.

Themes	Number of questions	Maximum/Minimum score points for each section	Mean	SD	Level
Knowledge	8	24/8	**18.40**	2.73	Intermediate
Attitude	8	40/8	**32.12**	4.19	High
Practice	6	24/6	**22.21**	2.35	High

5.2.1 Level of dental students' knowledge regarding methicillin-resistant *S. aureus* (MRSA):

Table 5.4 presents numbers and percentages of the knowledge responses of participants about MRSA. According to the results in table 5.4: 70.7% of dental students answered correctly that standard precautions by wearing gloves and personal protective equipment can prevent infection. Moreover, 64.2% of dental students answered correctly that the source of MRSA infection could be the hospital or the community. Furthermore, 58.5% answered correctly the fact that MRSA is a Gram-positive coccus, while 18.2% gave a negative answer to it.

In addition, 42.1% of students were not sure if *staphylococcus* bacteria could develop resistance to antibiotics causing skin infections that can't be cured. 36.4% of students answered correctly that asymptomatic carriers could be a source of infection, while 21.4% answered it incorrectly, and 42.1% were not sure about it.

Table 5.4: The knowledge responses regarding methicillin-resistant *S. aureus*, among dental students of Al-Quds University

	Sentence	True (Correct answer)	Not sure	False
	Standard Precaution by wearing gloves and personal protective equipment can prevent infection	198 (70.7%)	52 (18.5%)	24 (8.57%)
	MRSA is typically disseminated through the hands of medical professionals	185 (66%)	70 (25%)	25 (8.9%)
	The source of MRSA infection is the Hospital and Community	180 (64.2%)	74 (26.4%)	26 (9.2%)
	MRSA (Methicillin-Resistant Staph aureus) is resistant to Methicillin and several other B-lactam antibiotics	157 (56%)	90 (32.1%)	33 (11.7%)
	MRSA is a Gram-positive coccus	164 (58.5%)	65 (23.2%)	51 (18.2%)
	MRSA can survive on surfaces for days	132 (47.1%)	104 (37.1%)	44 (15.7%)
	Is it possible that staphylococcus bacteria develop resistance to antibiotics causing skin infections that can't be cured?	121 (43.2%)	118 (42.1%)	41 (14.6%)
	Asymptomatic carriers can be a source of infection	102 (36.4%)	118 (42.1%)	60 (21.4%)
Average Knowledge score N=280		**18.40**		

5.2.2 Level of dental students' attitude regarding methicillin-resistant *S. aureus* (MRSA)

Table 5.5 presents numbers and percentages of the attitude responses of participants towards MRSA. According to table 5.5: The majority of dental students (88.9%) agreed that there is a need for infection control education, and 80.7 % of students agreed on willing to take additional educational courses to increase their knowledge regarding MRSA. Furthermore, 86.1% of students agreed on the fact that they are responsible for MRSA prevention among patients, and 61.8 % of students agreed that unnecessary antibiotic prescriptions by dentists

could cause MRSA. 24.6 % of students disagreed with MRSA being considered a serious problem globally. In addition, 34.6 % of the students were not sure if they were exposed to MRSA infection while working.

Table 5.5: The attitude responses toward methicillin-resistant *S. aureus*, among dental students of Al-Quds University

	Sentence	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
	Do you agree that there is a need for infection control education?	165 (58.9%)	84 (30%)	24 (8.6%)	2 (0.7%)	5 (1.8%)
	Are you willing to take additional educational courses to increase your knowledge regarding MRSA?	131 (46.8%)	95(33.9%)	47 (16.8%)	3 (1.1%)	4 (1.4%)
	Are you willing to participate in an infection control education program?	123 (43.9%)	103 (36.8%)	50 (17.9%)	0	4 (1.4%)
	Do you see yourself as accountable for patient MRSA prevention?	99 (35.4%)	142 (50.7%)	32 (11.4%)	4 (1.4%)	3 (1.1%)
	Gloves and good hand hygiene can prevent the spread of MRSA	86 (30.7%)	117 (41.8%)	67 (23.9%)	4 (1.4%)	6 (2.1%)
	Unnecessary antibiotic prescriptions by dentists can cause MRSA	91 (32.5%)	82 (29.3%)	91 (32.5%)	8 (2.9%)	8 (2.9%)
	MRSA is considered a serious problem globally	73 (26.1%)	106 (37.9%)	85 (30.4%)	10 (3.6%)	6 (21%)
	While working, you could become infected with MRSA.	42 (15%)	92 (32.9%)	97 (34.6%)	35 (12.5%)	14 (5%)
	Average attitude score N= 280	**32.12**				

5.2.3 Level of dental students' compliance with infection prevention practices

Table 5.6 presents numbers and percentages of the practice responses of participants for infection prevention. From table 5.6, the findings showed a high score of practice feedback according to students' answers. The majority of dental students (98.9%) answered that they always use gloves when contacting a patient's mucosa. 98.9 % also answered that they wash their hands after coming into contact with the patient's blood or saliva. Moreover, 96.8% of dental students answered that they wear a mask when there is a possibility of a patient's saliva or blood splashing. The majority (96.8%) also performed hand hygiene after touching a patient, and 88.6 % performed hand hygiene before touching a patient.

While 2.5% of dental students answered that they never perform hand hygiene before and after wearing gloves.

Table 5.6: The responses for the level of compliance with infection prevention practices, among dental students of Al-Quds University

	Sentence	Very often	Often	Less often	Never
	Do you always use gloves when contacting a patient's mucosa?	250 (89.3%)	27 (9.6%)	1 (0.4%)	2 (0.7%)
	Do you wash your hands after coming into contact with the patient's blood or saliva?	238 (85%)	39 (13.9%)	3 (1.1%)	0
	When there's a chance that a patient's saliva or blood can spatter, do you wear a mask?	240 (85.7%)	31 (11.1%)	7 (2.5%)	2 (0.7%)
	Do you perform hand hygiene after touching a patient?	227 (81.1%)	44 (15.7%)	8 (2.9%)	1 (0.4%)
	Do you perform hand hygiene before touching a patient?	180 (64.3%)	68 (24.3%)	27 (9.6%)	5 (1.8%)
6	Do you perform hand hygiene before and after wearing gloves?	155 (55.4%)	87(31.1%)	31 (11.1%)	7 (2.5%)
Average compliance score N=280		**22.12**			

5.2.4 KAP score comparison between 4th year and 5th year dental students:

The results showed a significant difference in the level of compliance to infection prevention practices, among dental students of Al-Quds university, where the differences were in favor of 4th-year dental students.

On the other hand, there was no statistically significant differences in the level of knowledge or attitude toward methicillin-resistant S. aureus infection control, among 4th year and 5th year dental students of Al-Quds university. This is represented in table 5.7.

Table 5.7: The level of knowledge of, attitude toward MRSA, and practices among dental students according to clinical year.

Fields	Clinical year	N	Mean	Std. Deviation	Value of "t"	Sig
Knowledge	4th-year	129	18.3396	2.79498	1.920	0.056
	5th-year	151	18.5495	2.66714		
Attitude	4th-year	129	32.4186	4.52026	1.084	0.279
	5th-year	151	31.8742	3.88554		
Practices	4th-year	129	22.5194	2.08079	2.070	0.039
	5th-year	151	21.9470	2.54503		

5.2.5 The nasal colonization prevalence of *S. aureus* and methicillin-resistant *S. aureus* (MRSA) circulating among the dental students of Al-Quds University

Lab identification methods were carried according to the standard criteria of the Clinical Laboratory Standards Institute guidelines (CLSI). After identification of *S. aureus* as explained in figure 5, the isolated *S. aureus* were inoculated onto Mueller-Hinton agar & cefoxitin (30µg) disc was applied. Resistance to cefoxitin was considered equivalent to resistance to methicillin. According to the CLSI guidelines, the interpretive criteria for cefoxitin is *S. aureus*, sensitive ≥22 mm, and resistant ≤21 mm.

As noted in table 5.8, the nasal colonization of *S. aureus* among dental students of Al-Quds University is **24.3% (68/280)**, while methicillin-resistant *S. aureus* (MRSA) nasal colonization is **7.5% (21/280)**.

Table 5.8: Nasal prevalence of *S. aureus* and methicillin-resistant *S. aureus* (MRSA) among dental students of Al-Quds University

Variables	Carriers	N	%
S. aureus	Yes	68	24.3
	No	212	75.7
MRSA	Yes	21	7.5
	No	259	92.5

5.2.6 The relationship between nasal MRSA carriage and questionnaire results (KAP):

The relationship between knowledge, attitudes, practice, and MRSA nasal prevalence was tested by using the t-test. According to table 5.9, the nasal MRSA carriers showed slightly higher attitude and practice scores compared with non-carriers. However, these differences were not statistically significant.

Table 5.9: Knowledge, attitude and practices among dental students of Al-Quds University according to the current MRSA nasal prevalence.

Fields	MRSA	N	Mean	Std. Deviation	Value of "t"	Sig
Knowledge	**No**	259	18.3838	2.76179	0.118	0.906
	Yes	21	18.4571	2.51567		
Attitude	**No**	259	32.0463	4.20568	1.103	0.271
	Yes	21	33.0952	3.97372		
Practices	**No**	259	22.1853	2.38625	0.633	0.528
	Yes	21	22.5238	1.96517		

*. By using T-test.

5.2.7 The relationship between sociodemographic, lifestyle, medical characteristics, and *S. aureus* nasal carriage:

The chi-square test was used to investigate the association between the study variables and the *S. aureus* nasal carriage. Results showed a significant relationship between S. aureus nasal carriage and visiting the hospital in the past 6 months, using antibiotics in the past 6 months, and having a previous *staphylococcus* bacterial infection.This is demonstrated in the following table (5.10):

Table 5.10: The association between the study variables and the *S. aureus* nasal carriage

Variables	N	%	S. aureus		Chi	P-value
Gender			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Male	75	26.8	(62, 82.7)	(13, 17.3)	2.693	0.117
Female	205	73.2	(150, 73.2)	(55, 26.8)		
Clinical year			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
4th-year dental student	129	46.1	(98, 76)	(31, 24)	0.008	0.999
5th-year dental student	151	53.9	(114, 75.5)	(37, 24.5)		
Place of residence			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Rural	138	49.3	(99, 71.7)	(39, 28.3)	2.338	0.163
Urban	142	50.7	(113, 79.6)	(29, 20.4)		
Number of family members			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Up to 4	34	12.1	(26, 76.5)	(8, 23.5)	0.012	0.913
More than 4	246	87.9	(186, 75.6)	(60, 24.4)		
Profession of family			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Healthcare	112	40.0	(79, 70.5)	(33, 29.5)	2.722	0.118
Other	168	60.0	(133, 79.2)	(35, 20.8)		
Participate in sports			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**

Variables	N	%	S. aureus		Chi	P-value
Yes	107	38.2	(76, 71)	(31, 29)	2.068	0.155
No	173	61.8	(136, 78.6)	(37, 21.4)		
Do you have contact with pets			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	84	30.0	(61, 72.6)	(23, 27.4)	0.625	0.449
No	196	70.0	(151, 77)	(45, 23)		
Smoking			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	62	22.1	(46, 74.2)	(16, 25.8)	0.100	0.740
No	218	77.9	(166, 76.1)	(52, 23.9)		
Have you visited the hospital in the past 6 months			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	48	17.1	(29, 60.4)	(19, 39.6)	7.373	0.009
No	232	82.9	(183, 78.9)	(49, 21.1)		
Had surgery in the past 6 months			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	12	4.3	(6, 50)	(6, 50)	4.508	0.077
No	268	95.7	(206, 76.9)	(62, 23.1)		
Used antibiotics in the last 6 months			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	131	46.8	(88, 67.2)	(43, 32.8)	9.761	0.002
No	149	53.2	(124, 83.2)	(25, 16.8)		
Have you ever had a previous *staphylococcus* bacterial infection			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	36	12.9	(22, 61.1)	(14, 38.9)	4.791	0.037
No	244	87.1	(190, 77.9)	(54, 22.1)		
Do you have an underlying medical condition			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	10	3.6	(7, 70)	(3, 30)	0.184	0.709
No	270	96.4	(205, 75.9)	(65, 24.1)		

*. By using Chi square test.

5.2.8 The relationship between sociodemographic, lifestyle, medical characteristics, and MRSA nasal carriage:

The chi-square test was used to investigate the association between the study variables and the MRSA nasal carriage. Results showed a significant relationship between MRSA nasal carriage and visiting the hospital in the past 6 months, and using antibiotics in the past 6 months. Moreover, there was a significant relationship between MRSA nasal carriage and having a previous *staphylococcus* bacterial infection.

In addition, there is a significant relationship between MRSA nasal carriage, and dental students who have a member of the family working in healthcare.This is demonstrated in the following table (5.11):

Table 5.11: The association between the study variables and the MRSA nasal carriage

Variables	N	%	MRSA		Chi	P-value
Gender			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Male	75	26.8	(72, 96)	(3, 4)	1.809	0.210
Female	205	73.2	(187, 91.2)	(18, 8.8)		
Clinical year			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
4th-year dental student	129	46.1	(122, 94.6)	(7, 5.4)	1.483	0.261
5th-year dental student	151	53.9	(137, 90.7)	(14, 9.3)		
Place of residence			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Rural	138	49.3	(126, 91.3)	(12, 8.7)	0.561	0.502
Urban	142	50.7	(133, 93.7)	(9, 6.3)		
Number of family members			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Up to 4	34	12.1	(31, 91.2)	(3, 8.8)	0.098	0.728
More than 4	246	87.9	(228, 92.7)	(18, 7.3)		
Profession of family			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Healthcare	112	40.0	(100, 89.3)	(12, 10.7)	2.780	0.008
Other	168	60.0	(159, 94.6)	(9, 5.4)		
Participate in sports			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	107	38.2	(98, 91.6)	(9, 8.4)	0.207	0.648

No	173	61.8	(161, 93.1)	(12, 6.9)		
Do you have contact with pets			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	84	30.0	(78, 92.9)	(6, 7.1)	0.022	0.999
No	196	70 %	(181, 92.3)	(15, 7.7)		
Smoking			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	62	22.1 %	(58, 93.5)	(4, 6.5)	0.126	0.899
No	218	77.9 %	(201, 92.2)	(17, 7.8)		
Have you visited the hospital in the past 6 months			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	48	17.1	(43, 89.6)	(5, 10.4)	0.710	0.035
No	232	82.9	(216, 93.1)	(16, 6.9)		
Had surgery in the past 6 months			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	12	4.3	(11, 91.7)	(1, 8.3)	0.013	0.999
No	268	95.7	(248, 92.5)	(20, 7.5)		
Used antibiotics in the last 6 months			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	131	46.8	(115, 87.8)	(16, 12.2)	7.884	0.006
No	149	53.2	(144, 96.6)	(5. 3.4)		
Have you ever had a previous *staphylococcus* bacterial infection			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	36	12.9	(27, 75)	(9, 25)	0.041	0.043
No	244	87.1	(226, 92.6)	(18, 7.4)		
Do you have an underlying medical condition			**No (N, %)**	**Yes (N, %)**	**Chi**	**P-value**
Yes	10	3.6	(9, 90)	(1, 10)	0.093	0.547
No	270	96.4	(250, 92.6)	(20, 7.4)		

*. By using Chi square test.

5.2.9 Antimicrobial susceptibility results

S. aureus and MRSA isolates were tested for susceptibility using the disk diffusion method in accordance with the recommendations of the Clinical Laboratory Standards Institute (CLSI, 2011) to the following antibiotics: cefoxitin, amoxicillin, amoxicillin\clavunic acid, gentamicin, vancomycin, clindamycin, and erythromycin. Resistance or susceptibility to each agent was interpreted according to the CLSI guidelines. See table 5.12 for results:

Table 5.12: Antibiotic resistance results of MRSA and MSSA isolates

Antibiotics	MRSA (21)	MSSA (47)
Cefoxitin	21 (100%)	0
Amoxicillin	21 (100%)	45 (95.7%)
Amoxicillin\Clavunic acid	6 (28.5%)	2 (4.2%)
Gentamicin	3 (14.2%)	0
Clindamycin	4 (19%)	0
Erythromycin	5 (23.8%)	0
Vancomycin	0	0

As shown in table 5.12: Among 21 tested MRSA isolates, resistance to amoxicillin was most common (100%), followed by resistance to amoxicillin\clavunic acid (28.5%). Five isolates (23.8%) were found resistant to erythromycin, four isolates (19%) were resistant to clindamycin, and three isolates (14.2%) were noted resistant to gentamicin. And despite the recent emergence of vancomycin resistant staphylococcus bacteria (VRSA), fortunately none of the MRSA isolates were resistant to vancomycin.

With regards to the methicillin-susceptible S. aureus (MSSA), 95.7% were found resistant to amoxicillin, and two isolates (4.2%) were found resistant to amoxicillin\clavunic acid. While all MSSA isolates were susceptible to gentamicin, clindamycin, and erythromycin. No isolates were found resistant to vancomycin in this study.

Chapter Six:

Discussion:

6.1 Discussion

Our objectives in this study are evaluating the knowledge and attitude regarding MRSA and compliance to hygiene practices among dental students in Al-Quds University – Palestine. In addition to determining the nasal carriage rate of *S. aureus* and MRSA and identifying the contributing risk factors for *S. aureus* and MRSA nasal colonization. As a result, this chapter presents the research's findings and links them to related literature reviews. A conclusion and recommendations based on the findings of the study conclude this chapter.

6.1.1 Knowledge of dental students regarding methicillin-resistant S. aureus (MRSA):

The knowledge of 280 dental students about methicillin-resistant *S. aureus* (MRSA) was assessed in this study. The overall knowledge score showed a mean of 18.40 with a SD of 2.73, which indicated that dental students had intermediate knowledge regarding MRSA. In addition, 177 (63.2%) students answered that they have heard of Methicillin-Resistant *Staph aureus* (MRSA), while 103 (36.8%) students answered that they had not. It can be inferred that continual updates for dental students regarding antimicrobial resistant organisms' education is needed.

The majority of students answered correctly that standard precautions by wearing gloves and personal protective equipment could prevent infection (70.7%). While many students were not sure about the fact that 'MRSA can live on a surface for days' (37.1%), which is a point of concern, because this kind of information is essential towards preventing the spread of MRSA infection. Moreover, many of the participants 21.4% disagreed with the sentence "Asymptomatic carriers could be a source of infection". It can be predicted that students need more education in this area.

Our findings in knowledge scores were compatible with a previous study conducted among dental health care professionals in Korea (Yoo et al., 2018), which there was further need for education on MRSA, especially regarding its seriousness. Another study

conducted among nursing students in Ohio, USA; revealed that knowledge regarding MRSA was inadequate (Lloyd et al., 2016). Our result was not compatible with a study designed to evaluate the knowledge, attitudes, and compliance to infection prevention practices among health care workers (HCWs) in Nepal, where the staff had good knowledge (Paudyal et al., 2008). This could be explained that health care workers such as nurses, doctors, surgeons, etc., have more experience which is reflected to better knowledge.

6.1.2 The attitude of dental students toward MRSA infection control:

In this study, the attitude dimension had a mean score of 32.12 and a standard deviation of 4.1. Therefore, it suggested that dentistry students had an optimistic attitude. Table 5.6 shows that many students felt that infection control education is necessary. The majority also agreed on willing to take additional educational courses to increase their knowledge regarding MRSA. These statements have positive attitudes.

On the other hand some students (12.5%) disagreed with the statement, 'You are exposed to MRSA infection while working'.Also, a small percentage of dental students (5.8%) disagreed with the fact that 'Unnecessary antibiotic prescriptions by dentists can cause MRSA'. They must understand that using antibiotics improperly leads to the development of antibiotic resistance, hence the problem with this mindset needs to be corrected. Also, 30.4% of the participants tended to reply, of not being sure if MRSA is considered a serious problem globally. This kind of misperception, can contribute to failure of proper infection control.

According to the literature review, there is a descriptive study on health care workers in Nepal (Paudyal et al., 2008), in which they found a positive attitude toward most aspects of MRSA infection control, which is similar to our findings. On the other hand, in a cross-sectional study done in 2011 among medical students (de Giusti et al., 2011), their findings indicated poor attitude, and perception regarding MRSA infection transmission.

6.1.3 Compliance to infection prevention practices among dental students:

Although the MRSA capability of cross-infection in dental practice has been rarely reported, one can't deny the significance of the dental setting in regards of infection transmission (Yoo et al., 2018). As there is a risk of infection transmission due to contamination by aerosols and splashes from various dental equipment such as; turbine handpieces, ultrasonic scalers and air-water syringes (Valkov et al., 2020). So failure to adhere to basic infection control routines, would increase infection risk significantly.

For the practice dimension, the practice score showed a mean of 22.21 with a SD of 2.35. It, therefore, indicated that the dental student's practices regarding MRSA infection prevention are good. As shown in table 5.7 the majority (89.3%) of dental students answered that they always use gloves when touching a patient's mucosa. The majority of participants also agreed with the item "wash your hands after coming into contact with the patient's blood or saliva" (85%). While 2.5% answered that they never perform hand hygiene before and after wearing gloves.

One of the best methods to stop the spread of MRSA is by good hand hygiene, thus every healthcare professional should wash their hands thoroughly before and after coming in contact with someone who has the infection. Since germs can only be disseminated once with contaminated hands, even washing your hands "many often" after contacting patients may not be sufficient. Although the percentage is small, 1.8 % of the dental students stated that they never perform hand hygiene before touching a patient, and 2.5% said the same for before and after wearing gloves. Every healthcare worker, should know that hand hygiene is essential to prevent the spread of infection.

In a survey done in Arkhangelsk, North-West Russia (Valkov et al., 2020), most of the dental students and dental faculty members reported good compliance with infection control routines in dental practice, which is compatible with our study. While the results of a research conducted in 2017 that evaluated the staff nurses' MRSA infection control methods revealed that infection prevention protocols had not been adjusted, which has implications for ongoing continuous teaching programs. (Daniel, 2017).

6.1.4 KAP score according to clinical year:

According to our study results, there was a significant difference in the level of compliance to infection prevention practices, among dental students of Al-Quds university, where the differences were in favor of 4th-year dental students. This was the opposite of what is expected since 5th year students should be more experienced.

On the other hand, there was no statistically significant differences in the level of knowledge or attitude toward methicillin-resistant S. aureus infection control, among 4th year and 5th year dental students of Al-Quds university. The absence of significant difference in knowledge might be explained by the proximity between the two years on the level of education.

6.1.5 Nasal colonization prevalence of S. aureus and methicillin-resistant S. aureus (MRSA):

In dentistry, MRSA carriage rates vary greatly between nations (0-21%) (Baek et al., 2016; de Oliveira et al., 2021; Martínez-Ruíz et al., 2014; Roberts et al., 2011). This could be explained by variations in antibiotic use by nation, differences in application of infection control practices, or may be due to the use of different techniques and different interpretation guidelines (Salmonav et al., 2020; Volgenant et al., 2021).

In our study, regarding the nasal colonization prevalence among dental students (280 students) of Al-Quds University, the nasal colonization of *S. aureus* was found to be **24.3%**, while methicillin-resistant *S. aureus* (MRSA) nasal colonization was **7.5%.** These percentages are consistent with a cross-sectional study done in Duhok, Kurdistan Region of Iraq, which found the *S. aureus* and MRSA nasal carriage rates to be 22.3% and 4.3% respectively. In addition, the *S. aureus* percentage was very close to a previous study conducted in Nablus-Palestine among university students, which stated the *S. aureus* colonization rate to be 24% (Adwan et al., 2013).But in our study, the MRSA colonization rate was higher (7.5%) than the Nablus study among general university students, which was 2%. Our results were also higher than a previous study conducted among nursing students at the American Arab University of Jenin (AAUJ), in which the *S. aureus* and MRSA nasal colonization rates were 9% and 3.3% respectively (Mubaslat et al., 2016).

While in another two studies conducted in Gaza (al Laham, 2015; el Aila et al., 2017), the MRSA carriage rate was found much higher (22.6% and 25.5%). This could be due to being conducted among health care workers in the hospital setting, which has a high risk of MRSA transmission.

Moreover, according to the Centers for Diseases Control and Prevention (CDC), 33% of the population are *S. aureus* asymptomatic nasal carriers, which is compatible with our results, while the MRSA nasal carriers were found to be 2% of the population, which is lower than the finding in this study. The higher MRSA nasal carriage in this study, illustrates the need for further practice and commitment to infection control measures, like hand hygiene and proper wearing of personal protective equipment while taking care of patients in the dental clinic, to prevent cross contamination.

6.1.6 The relationship between nasal MRSA carriage and questionnaire results (KAP):

Regarding the correlation between nasal MRSA carriage and questionnaire findings (KAP), it can be hypothesized that nasal MRSA carriers exhibit worse knowledge, attitude, or practice scores than non-carriers due to their ignorance of infection prevention. In contrast to non-carriers, nasal MRSA carriers in this study demonstrated somewhat higher attitude and practice ratings. However, these variations lacked statistical significance. These findings are in line with a study conducted in Korea in 2018 which found no connection between nasal MRSA carriage and questionnaire outcomes. (KAP) (Yoo et al., 2018).

6.1.7 The association between *S. aureus*, methicillin-resistant *S. aureus* (MRSA) carriage rates and study variables:

According to study results, the investigation of the association between the study variables and the *S.aurues* nasal carriage showed a significant relationship between S.aureus nasal carriage and using antibiotics or visiting a hospital within the previous six months, and having a previous *staphylococcus* bacterial infection, which is compatible with previous studies(Munckhof et al., 2009; Ayepola et al., 2018; Sakr et al., 2018) .

Moreover, the investigation of the association between the study variables and the MRSA nasal carriage, showed a significant relationship between MRSA nasal carriage and using antibiotics or visiting a hospital within the previous six months,, having a previous

staphylococcus bacterial infection and having a member of the family working in healthcare, this is because healthcare professionals that work at the intersection of the hospital and the community could be a source of MRSA cross-contamination between the two settings (Oskouie et al., 2020).

Other research revealed that men were more likely than women to carry MRSA (Oskouie et al., 2020; Ahmadi et al., 2019). While in our study, nonsignificant results showed higher rates of MRSA nasal carriage among females. Also, higher MRSA nasal carriage rates were found among fifth year students, students who live in rural areas, and students who participate in sports, but these results were also nonsignificant.

6.1.8 Antibiotic susceptibility results:

In relation to the antibiotic susceptibility results, all MRSA isolates were found resistant to amoxicillin (100%). The widespread use of amoxicillin in the region's gram-positive bacterial illness treatment regimen may be to blame for the high prevalence of resistance that has been documented. In addition to people having ready access to a lot of antibiotics without physicians' prescriptions. Moreover, 28.5% were found resistant to amoxicillin\clavunic acid, 23.8% were found resistant to erythromycin, four isolates (19%) were resistant to clindamycin, and three isolates (14.2%) were found to be gentamicin resistant. Vancomycin resistance was not discovered in any of the isolates.

The differences in antibiotic resistance and susceptibility patterns may vary according to each study population, and the variability in various factors such as; quantity of antibiotic use, or the use of different antibiotics in different countries, continuous genetic mutations among strains or the spread of resistance genes from one bacterium to another (Alzoubi et al., 2020; Efa, 2018; Legese et al., 2018).

Our findings were in line with a study carried out in Palestine in 2013, which discovered that all MRSA isolates were penicillin-resistant and all strains of S. aureus were vancomycin-sensitive. While the resistant rates to amoxicillin/clavulanic acid, erythromycin, and clindamycin were higher than our study (Adwan et al., 2013).

6.2 Limitations

1. The study examines dental students' knowledge, attitudes, and practices, rather than real testing of their knowledge and attitudes, or by directly observing their preventive practices, because it is a descriptive, not an observational study.

2. The students in the sample were all educated at the same university. The sample chosen might not be a true reflection of the total population of dentistry students.

3. Lack of previous studies of dental students' knowledge regarding MRSA. The study's reliability is impacted by this. More research on this subject can improve comparability, which will boost the credibility of the results.

4. Only the nasal cavity was swabbed, so there is a chance that MSSA or MRSA, which may colonize in other colonization sites, such as the skin, perineum or pharynx, maybe missed. Therefore, the actual prevalence of MSSA or MRSA may be higher.

5. Also, sampling was done only once, making it impossible to differentiate between intermittent and persistent carriers.

6. The MRSA nasal colonization was not identified if it is due to community or hospital-acquired strains.

7. Decolonization and follow-up could not be done.

8. No bacterial isolate was used a control during identification of bacteria, so false-positives and false negatives might be a possibility.

9. The bidirectionality of the data because of the cross-sectional study design.

6.3 Conclusion

Most of the dentistry students at Al-Quds University reported intermediate knowledge of, good compliance with, and positive attitudes towards, infection control routines regarding MRSA in dental practice. The prevalence of MRSA nasal colonization among the dental student population was higher than the rate among the general community in Palestine (2% MRSA rate (Adwan et al., 2013)), but lower than the rate among healthcare workers in hospital settings. This indicates the importance of the implementation of strategies that can help in breaking the bridge of transmission of MRSA. In addition, it is recommended to enhance dental students' knowledge of MRSA, and increase their awareness regarding antibiotic resistance.

6.4 Recommendations

- Broaden students understanding of MRSA. By putting more emphasis on this knowledge in the dentistry school curriculum.
- Instruct Palestinian universities to integrate infection control courses in their academic curriculum, along with periodic training of dental students on infection prevention.
- Increase awareness of the concept of antimicrobial stewardship, and how the misuse and overuse of antibiotics contributes to antibiotic resistance.
- Further studies among Palestinian dental students would also be interesting to compare the knowledge of MRSA, compliance with and attitudes towards, infection control routines in different Palestinian dental universities.
- More research is required to determine how dentists and dental students contribute to the spread of MRSA in the dental setting and its transmission to patients.
- Further research should be done across the nation to determine the risk variables that contribute to S. aureus and MRSA colonization, especially in university settings.

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Appendices

Appendix 1: Information sheet and consent form

Al-Quds University

School of Public Health

Dear Dental Student,

I am a Master's degree student at Al-Quds University doing a Master of Infectious diseases prevention and control (MID). I am conducting research on the knowledge, attitude, and practices regarding Methicillin-resistant *Staphylococcus aureus* (MRSA) infection control and nasal MRSA carriage rate among dental students of Al-Quds University.

This letter is meant to inform you of the specifics of the study and how you can participate. You must sign the **CONSENT FORM** that will be given to you if you voluntarily decide to take part in this study. Please make sure you have read all the information provided before signing.

Thank you

The principal investigator is Dr. Suzan Mustafa, a master student at the School of Public Health at Al-Quds University.

The title of the study is as below:

Knowledge, attitude, and practices regarding Methicillin-resistant *Staphylococcus aureus* (MRSA) infection control and nasal MRSA carriage rate among dental students of Al-Quds University

Study purpose

The purpose of this research is to evaluate the knowledge and attitude regarding MRSA and compliance to hygiene practices among dental students in Al-Quds University. In addition, determining the nasal carriage rate of *S. aureus* and MRSA and identifying the contributing risk factors for *S. aureus* and MRSA nasal colonization. In Palestine, there are no previous reports regarding *S. aureus* or MRSA in the dental student community. Moreover, their knowledge, attitude, and behavior toward these pathogens are not known.

Procedure

You will be asked to fill a questionnaire to assess the level of knowledge and attitude toward methicillin-resistant *S. aureus,* and the level of compliance to infection prevention practices and answer several questions regarding factors that increase the likelihood of S. aureus colonization, and then give a nasal swab sample that will be taken from the nares. Swab samples will be taken in accordance with a defined protocol. And examined in the Microbiology laboratory of Al-Quds University.

Risk and Discomfort

There will be absolutely no risk or injury during the collection of swab samples. However, you are encouraged to gently rub the outside of your nostrils after the operation is complete if you experience any discomfort during the swabbing in order to reduce it.

Benefits

If you take part in this study, you might directly benefit from knowing your carriage status, having the test results used for you, and getting treated if you test positive for MRSA depending on the doctor's judgment. Additionally, your involvement will assist us in identifying the nasal carriage of methicillin-resistant Staphylococcus aureus among dentistry students at Al-Quds University.

Results will be made accessible, along with suggestions for potential tactics to stop the spread of MRSA infections.

Additionally, knowing how well-versed dentistry students are in MRSA as they move through bachelor programs may help to spot curricular gaps and areas that require improvement.

Incentives

No rewards will be given to you for participating in this study.

Confidentiality:

The data gathered for this study will be treated in strict confidence. Using a coding method, the laboratory examination results will be kept private and no one else will have access to them. Only you and the medical professionals will be informed if the laboratory test results are positive for MRSA.

Right to decline or reject

Although you are entirely free to decline to take part in this study or to stop taking part at any moment, the success of our goal depends greatly on your input. I kindly ask for your cooperation to participate in this study because there is no danger to you other than a small amount of time commitment.

OPTIONS FOR CONSENT AND SIGNATURE:

I have read the information sheet and am aware of all the requirements, so I now agree to fully engage in the study.

Participant code.....Signature .....Date.....

Name (data collector) .....Signature .....Date.....

Thank you for your cooperation!

Appendix 2: Study questionnaire

<u>Section 1</u>: Sociodemographic questions

Please select the answer you find most appropriate:

1. **Gender** Male Female
2. **Year of study** 4th-year dental student 5th-year dental student
3. **Place of residence** (الريف أو قرية) Rural (المدينة) Urban
4. **Number of family members** Up to 4 More than 4
5. **Does any of your family members work in Healthcare** Yes No
6. **Do you participate in sports (رياضة)** Yes No
7. **Do you have contact with pets (طيور أو حيوانات أليفة)** Yes No
8. **Smoking** Yes No
9. **Have you visited the hospital in the past 6 months?** Yes No
10. **Had surgery in the past 6 months** Yes No
11. **Used antibiotics in the last 6 months** Yes No
12. **Have you ever had a previous *staphylococcus* bacterial infection?** Yes No
13. **Do you have an underlying medical condition?** Yes No

If yes, what is it? ……

<u>Section 2:</u> Questions regarding Methicillin-Resistant Staphylococcus Aureus (MRSA) knowledge: Please choose the answer you find most appropriate:

14. Have you heard of Methicillin-Resistant *Staph aureus* (MRSA):

- Yes
- No

15. If yes, how did you know about it?

- Lecture
- Group discussion
- Radio/television
- Internet/Social media

	Knowledge	True	Not sure	False
16.	MRSA is a Gram-positive coccus			
17.	MRSA (Methicillin-Resistant *Staph aureus*) is resistant to Methicillin and several other B-lactam antibiotics			
18.	The source of MRSA infection is the Hospital and Community			
19.	Asymptomatic carriers can be a source of infection			
20.	Standard Precaution by wearing gloves and personal protective equipment can prevent infection			
21.	MRSA can survive on surfaces for days			
22.	MRSA is typically disseminated through the hands of medical professionals			
23.	Is it possible that *staphylococcus* bacteria develop resistance to antibiotics causing skin infections that can't be cured?			

Section 3: Questions regarding attitudes towards MRSA infection control. What is your attitude regarding the following statements?

	Attitude	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
24.	Do you see yourself as accountable for patient MRSA prevention?					
25.	Do you agree that there is a need for infection control education?					
26.	Are you willing to participate in an infection control education program?					
27.	While working, you could become infected with MRSA.					
28.	Gloves and good hand hygiene can prevent the spread of MRSA					
29.	MRSA is considered a serious problem globally					
30.	Unnecessary antibiotic prescription by dentists can cause MRSA					
31.	Are you willing to take additional educational courses to increase your knowledge regarding MRSA?					

Section 4: Questions regarding compliance with infection prevention and control practices. What is your compliance regarding the following statements?

	Practice	Very often	Often	Less often	Never
32.	Do you always use gloves when contacting a patient's mucosa?				
33.	Do you wash your hands after coming into contact with the patient's blood or saliva?				
34.	When there's a chance that a patient's saliva or blood can spatter, do you wear a mask?				
35.	Do you perform hand hygiene after touching a patient?				
36.	Do you perform hand hygiene before touching a patient?				
37.	Do you perform hand hygiene before and after wearing gloves?				

Appendix 3: School of Public Health Ethical approval letter

Al-Quds University
Jerusalem
School of Public Health

جامعة القدس
القدس
كلية الصحة العامة

التاريخ : 2022/2/6

عزيزتي الطالبة سوزان مصطفى المحترمة
برنامج ماجستير: الوقاية وضبط الامراض المعدية

الموضوع: موافقة لجنة اخلاقيات البحث العلمي

قامت اللجنة الفرعية لأخلاقيات البحث التابعة لكلية الصحة العامة بمراجعة مشروع الرسالة

بعنوان:

" Knowledge, attitude, and practices regarding Methicillin-resistant Staphylococcus aureus (MRSA) infection control and nasal MRSA carriage rate among dental students of Al-Quds University"

المقدم من (مشرف الرسالة/ د. مراد ابراهيم).

يعتبر مشروعك مستوفيًا لمتطلبات أخلاقيات البحث في جامعة القدس.

نتمنى لكم كل التوفيق في تسيير المشروع.

رئيسة لجنة اخلاقيات البحث
د. نهى الشريف

كلية الصحة العامة
Faculty of Public Health

نسخة/ أعضاء لجنة البحث
نسخة/ الملف

Jerusalem Branch/Telefax 02 2799234

Figure 9: School of Public Health Ethical approval

Appendix 4: Faculty of dentistry approval letter

بسم الله الرحمن الرحيم

Al-Quds University
Jerusalem
School of Public Health

جامعة القدس
القدس
كلية الصحة العامة

التاريخ: 2022/2/20

حضرة الدكتور محمد أبو يونس المحترم
عميد كلية طب الأسنان/جامعة القدس

الموضوع: تسهيل مهمة الطالبة سوزان مصطفى

تحية طيبة وبعد،،،

تقوم الطالبة سوزان مصطفى ماجستير ضبط الأمراض المعدية/كلية الصحة العامة/جامعة القدس بإجراء بحث الرسالة باشراف الدكتور مراد ابراهيم بعنوان:

Knowledge, attitude, and practices regarding Methicillin-resistant Staphylococcus *aureus* (MRSA) infection control and nasal MRSA carriage rate among dental students of Al-Quds University

وتهدف الدراسة إلى تقييم مدى معرفة طلاب وطالبات طب الأسنان ومواقفهم وممارساتهم حول هذه البكتيريا المقاومة للمضاد الحيوي الميثيسيلين , وتحديد نسبة وجود هذه البكتيريا في الأنف,وهي بحاجة إلى تعبئة إستمارة الدراسة وأخذ مسحات من الأنف من طلاب وطالبات طب الأسنان في جامعة القدس. نرجو من حضرتكم السماح لها بتوزيع استبانة الدراسة وأخذ المسحات الأنفية من العينة المطلوبة.علماً بأن الدراسة ستكون لأغراض البحث العلمي فقط.

شاكرين لكم حسن تعاونكم ،،،

د. حازم إغا
عميد كلية الصحة العامة

نسخة: الملف

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Figure 10: Faculty of dentistry approval

Appendix 5: List of names & specialties of referees:

1- Dr. Ibrahim Abbasi – Al-Quds University
2- Dr. Elham Khateeb – Al-Quds University