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MRSA carriage rate among dental healthcare personnel: a multicentric cross-sectional study

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ABSTRACT

Methicillin-resistant Staphylococcus aureus (MRSA) represents a significant global healthcare challenge, yet its prevalence among dental personnel remains poorly understood. ***Objective:*** *The aim of this study was to determine the carriage rate and related risk factors of MRSA among Colombian oral healthcare providers.* ***Materials and Method:*** *A multicenter descriptive cross-sectional study was conducted. Nasal swabs were obtained from 457 randomly selected healthcare professionals from dental services across eight cities in Colombia, using proportional stratified sampling and snowball sampling in 29% of the cases. Inclusion criteria were being a full-time worker in a dentistry setting, and being healthy with no upper respiratory tract infection, fever, or use of antimicrobial therapy in the previous three months. Gram staining, catalase and coagulase tests were used to identify S. aureus colonies. The methicillin-resistant phenotype was detected using the Kirby-Bauer disc method. The virulence factor encoding genes mecA and Panton Valentine Leukocidine (PVL) were detected by polymerase chain reaction (PCR).* ***Results*****:** *Overall prevalence of MRSA was 4.4% [95% confidence interval (CI): 2.5% – 6.2%], determined using mecA gene detection. Women carried 75% of the MRSA strains, and dentists accounted for 60%. Carrier rates were 4.03% [95% CI: 1.8% - 6.2%] for dentists, and 5.03% [95% CI: 1.6% - 8.4%] for other personnel. These rates did not differ significantly from each other (Fisher's exact test, p=0.67). A personal history of hospitalization over the previous year was identified as a predisposing factor for the host (p=0.033).* ***Conclusion****: This multicenter study reveals a 4.4% MRSA carriage rate among Colombian dental healthcare providers. MRSA-carrying dental healthcare workers did not appear to have risk factors associated with professional activity.*

Keywords: *methicillin resistant staphylococcus aureus – prevalence – dentists - dental health services - carrier state*

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Tasa de portación de SAMR entre el personal de atención odontológica: un estudio transversal multicéntrico

RESUMEN

El Staphylococcus aureus resistente a la meticilina (SARM) representa un desafío global significativo para la salud, aunque su prevalencia entre el personal dental sigue siendo poco comprendida. ***Objetivo:*** *La colonización por Staphylococcus aureus resistente a la meticilina (SARM) entre profesionales odontológicos es incierta. Este estudio tuvo como objetivo determinar la tasa de portación y los factores de riesgo relacionados con portación de SARM entre profesionales de la salud bucodental colombianos. Diseño del estudio: Estudio transversal multicéntrico.* ***Materiales y Método:*** *Se obtuvieron aleatoriamente hisopados nasales en 457 profesionales de la salud en servicios odontológicos de ocho ciudades de Colombia. La tinción de Gram, las pruebas de catalasa y coagulasa indicaron colonias de S. aureus. El fenotipo de resistencia a la meticilina se detectó mediante el método del disco de Kirby-Bauer. Los genes que codifican el factor de virulencia mecA y la leucocidina de Panton Valentine (PVL) se detectaron mediante reacción en cadena de la polimerasa (PCR).* ***Resultados:*** *La prevalencia general de SARM fue del 4,4 % [intervalo de confianza (IC) del 95 %: 2,5 % – 6,2 %], determinada mediante la detección del gen mecA. Por sexo se observó que las mujeres portaban el 75% de las cepas de SARM, y por ocupación los profesionales portaban el 60%. Los odontólogos presentaron una tasa de portación del 4,03% [IC del 95%: 1,8% - 6,2%], mientras que el resto del personal tuvo un 5,03% [IC del 95%: 1,6% - 8,4%]. Entre las estimaciones no se observó diferencias estadísticamente significativas (prueba exacta de Fisher, p = 0,67). El antecedente personal de hospitalización durante el año previo se identificó como un factor predisponente para el huésped (p = 0,033).* ***Conclusión:*** *La prevalencia de SARM entre el personal odontológico es moderada. Los trabajadores de la salud dental portadores de SARM no parecieron tener factores de riesgo asociados con su actividad profesional.*

Palabras clave: *staphylococcus aureus resistente a la meticilina – prevalencia – odontólogos - servicios de salud dental - portador sano*

INTRODUCTION

Staphylococcus aureus is a common commensal bacterium found in normal human microbiota, primarily on skin, gastrointestinal tract, and nasal mucosa. Nasal colonization by *S. aureus* begins within the first month of life, with carriage rates of approximately 40 to 50% during the first 8 weeks, decreasing to 21% by six months of age. The mother is the usual source[1,2]. In healthy adults, review studies have reported frequencies of approximately 20 and 30% for permanent and intermittent carriers, respectively[3,4]. Methicillin-resistant *Staphylococcus aureus* (MRSA) was first reported in 1961, after it acquired the staphylococcal cassette chromosome *mec* element through gene transfer of the *mecA* gene encoding PBP-2α. It has become a significant global healthcare challenge and a major cause of a wide range of hospital-acquired infections, posing substantial threat to patient safety[5].

While MRSA infections are more common in healthcare settings, they can also affect healthy individuals and veterinary settings, compromising public health because of the high risk of cellulitis, abscesses and invasive infections such as pneumonia and bacteremia[6]. MRSA spreads through direct physical contact with healthy carriers and contaminated personal items, particularly in group settings such as sports teams, schools, households, and nursing homes. MRSA prevalence has been reported as around 14.69 to 22% in non-outbreak scenarios, with the nares being the most frequently colonized body site[7–10].

The emergence and transmission of MRSA among healthcare workers (HCWs) are important aspects of MRSA epidemiology. The prevalence of MRSA carriers among healthcare workers is an indicator of its spread within population groups, and of the increased risk of colonization by multidrug-resistant bacteria. Among HCWs, prospective and cross-sectional studies, mostly carried out in Europe, USA and Asia, have shown a pooled prevalence of MRSA carriage of up to 9.23%, with higher rates in nursing and medical staff involved in patient care[11–13]. However, few studies have examined MRSA nasal colonization prevalence among dental healthcare providers. In Latin America, only two studies, both in Brazil, have investigated the issue in dental personnel[14,15], and they were limited by convenience sampling, non-representative samples, small study populations, and unreported non-response rates. No such study has been conducted in Colombia. We hypothesized that dental healthcare personnel would exhibit a higher prevalence of MRSA carriage than the general population due to frequent occupational exposure to the oral and respiratory tracts of patients. Therefore, the aim of this study was to investigate MRSA carriage prevalence among dental healthcare workers and identify associated risk factors. Understanding MRSA epidemiology in dental personnel can inform targeted infection prevention and control strategies to minimize transmission and protect patients and providers.

MATERIALS AND METHOD

Study design and setting

This descriptive cross-sectional, multi-center study was conducted from January 2023 to April 2024. The study population consisted of active dental healthcare workers in eight cities in Colombia (Armenia, Bogotá D.C., Bucaramanga, Cúcuta, Neiva, Palmira, Popayán and Villavicencio).

Selection of participants

A total 457 participants were included in this study via a probabilistic, stratified sampling process. Initially, dental service institutions were identified from the data reported in the "Special Registry of Health Service Providers" on the website of Ministerio de Salud y Protección Social de Colombia (Colombian Ministry of Health and Social Protection)[16]. In the second phase, institutions were divided based on the city location, after which 400 institutions were selected from this list using random numerical allocation. To ensure geographical representativeness, the number of participants per city was adjusted proportionally to the density of dentists per inhabitant in each city. The samples were drawn from each city using simple random sampling methods. Where access to institutions was restricted or they were not located at the address indicated in the database, recruitment was supplemented by snowball sampling from the initial location. This situation occurred in 29% of cases. At least one participant was randomly selected from each institution. All participants were contacted and informed of the study purpose. Verbal and written consent was obtained from all participants. The study protocol was approved by the Ethics Committee of University of Antonio Nariño/Santo

Tomás (Approval number 2022220/May 2022).
As this is the first study of its kind in Colombia, a review of MRSA prevalence studies in other countries was conducted to calculate the sample size. The calculation considered 2.9% minimum expected prevalence[17], 95% confidence level, and 5% estimated margin of error. The sample size calculation for a proportion was based on the formula provided by García-García et al.[18]. The total number of samples was 385, increased by 18% to account for potential sampling issues and to achieve greater statistical power for detecting lower prevalence data.
Inclusion criteria were: (i) being a full-time worker in a dentistry setting and (ii) being healthy, with no upper respiratory tract infection, fever, or use of antimicrobial therapy in the last three months. Participants who refused to take part were excluded. The study achieved 100% response rate, with no data loss or refusals by participants during the nasal swab collection process. A questionnaire was used to record demographic and epidemiological data concerning the determinants of human carriage (e.g. family cohabitation, morbidity, history of hospitalization and risk factors such as drug exposure) and use of personal protective equipment.

Methods of measurement

Microbiological methods. Nasal swabs were obtained from all study participants. Nasal samples were collected by standardized students at the School of Dentistry. A sterile single-headed polystyrene swab was inserted into both the left and right nostrils of each study subject, touching the nasal vestibule and rotating for 5-10 seconds in each. The swabs were transferred in Amies transport medium CM0425-OXOID to the microbiology laboratory within 2 hours, and processed immediately upon arrival.
In the laboratory, the swabs were streaked onto Mannitol Salt Agar to enable selective growth of *S. aureus*. The bacterial strains were transferred to Blood Agar and incubated for 24 h at 36 °C. Suspected colonies were subjected to Gram staining, β-hemolytic phenotype analysis, and coagulase test (Bactident® coagulase EDTA-rabbit plasma). The susceptibility pattern for several antibiotics was determined using the disk diffusion method according to the Clinical & Laboratory Standards Institute (CLSI) guidelines. Oxacillin (1μg), rifampicin (5 μg), vancomycin (30 μg), gentamicin (10 μg), clindamycin (2 μg) and cefoxitin (10 μg) were tested, and the strains classified as susceptible or resistant based on the *S. aureus* epidemiological cut-off values issued by CLSI[19].

Polymerase chain reaction (PCR). Cefoxitin-resistant isolates were analyzed for the presence of *mecA* and Panton-Valentine Leukocidin (PVL) genes. The primers used to amplify the *mecA* gene were forward: 5'-AAAATCGATGGTAAAGGTTGGC- 3'and reverse: 5'-AGTTCTGCAGTACCGGATTTGC-3', as previously described by Sanchez M. et al.[20]. The expected amplicon size was 533 bp (GenBank: KC243783.1). For the *Luk-PV* gene, the forward primer was 5'-GTAAAATGTCTGGACATGATCCA- 3'and the reverse was 5'-TCTGCCATATGGTCCCCAAC-3.' The expected amplicon size was 969 bp (GenBank: MK902786.1). We amplified only one region, consisting of the last section of *lukS*-PV and the beginning of l*ukF*-PV, as previously described by Johnsson et al.[21]. Primer specificity was assessed using BLAST. DNA was extracted using the QIAamp DNA kit according to the manufacturer's guidelines. The concentration, purity and integrity of the DNA were checked using a NanoDrop 2000c spectrophotometer (Thermo Scientific). Conventional PCR was performed in a TC32 Mini Thermal cycler (Benchmark), in a final volume of 25 μL using GoTaq® Green Master Mix (Promega). Amplification was performed under the following conditions: initial denaturation 95 °C, 1 min, denaturation 94 °C, 1 min; annealing at 55 °C for 1 min; and extension at 72 °C for 1 min. PCR products were resolved at 100V on 1.5% agarose gel in 1X TAE buffer for 60 min using a 1000 bp DNA ladder, and visualized with SYBR™ Safe DNA stain gel (Invitrogen) under UV light in a myGel InstaView electrophoresis system (Accuris instruments). *Staphylococcus aureus subsp. aureus* derived from ATCC25923 (*mecA* -; PVL +) and ATCC33591 (*mecA* +; PVL -) were used as a quality positive control, and pure water was used as a negative control in every assay.

Data analysis

The proportion of *S. aureus* and MRSA carriage was measured by positive testing and calculating

95% confidence intervals (CIs). Chi-square test or Fisher's exact two-tailed test, as appropriate, were used to compare the prevalence proportions based on occupation and personal risk factors between the groups of *S. aureus* carriers and MRSA carriers, as well as between dentists and other dental worker groups, with P values set at <0.05 to indicate statistical significance. Statistical analyses were performed using GraphPad Prism version 10.

RESULTS

The characteristics of the samples studied are listed in Table 1. A total 457 nasal swabs were analyzed. The study sample was divided into two groups according to place of residence: Bogotá and other cities. Mean age and time since graduation differed significantly between dentistry professionals residing in Bogotá and those residing in other cities in Colombia.

Prevalence of MRSA carriers

Of the 457 dental services workers, 95 (20.8%; 95%CI: 17.1% - 24.5%) were nasal carriers of *S. aureus*. According to the cefoxitin test, 27 (5.91%; 95% CI: 3.7% – 8.1%) were MRSA carriers, and based on PCR *mecA* gene detection, 20 were confirmed as MRSA carriers (4.4%; 95% CI: 2.5% – 6.2%). Of the cefoxitin-resistant strains, 74.1% tested positive for *mecA*. 75% of the strains were found in women, and 60% in dental professionals. Regarding occupational distribution, phenotypic methods identified 17 dental professionals (dentists and specialists) as MRSA carriers, while genotypic methods identified 12.

Prevalence in each group of dental health workers is shown in Table 2. Among assistant personnel, students and hygienists (159 subjects; 34.8% of the

Table 1. Participant characteristics

Variable	Bogotá D.C. (n= 243)	Other cities (n=214)	Total (n=457)
Age (years) Mean ± SD (range)	**30.6 ± 9.7 (19 – 76)**	**36 ± 11 * (18 – 69)**	**33 ± 11 (19 – 76)**
Sex n (%)			
Female	168 (69.1%)	156 (72.9%)	324 (70.9%)
Male	75 (30.9%)	58 (27.1%)	133 (29.1%)
Occupation n (%)			
Dentist	107 (44.0%)	71 (33.2%)	178 (38.9%)
Dental specialist	47 (11.1%)	73 (34.1%)	120 (26.3%)
Assistant	50 (20.6%)	46 (21.5%)	96 (21.0%)
Oral hygienist	7 (2.9%)	19 (8.9%)	26 (5.7%)
Student	32 (13.2%)	5 (2.3%)	37 (8.1%)
Place of employment n (%)			
Student (University)			6 (1.3%)
Private Dental office			330 (72.2%)
Health provider entity			5 (1.1%)
Public Health service			44 (9.6%)
Private Health service			56 (12.3%)
Dental center			16 (3.5%)
Time since graduation (months) Median (CI 95%)			
Dentists	**60 (36 – 72)**	**120 (96 – 139) ***	**84 (72 - 96)**
Assistants, hygienists, students	**12 (9 – 23)**	**84 (60 – 104) ***	**30 (24 – 48) ***
Total	**24 (24 – 36)**	**102 (91 – 120) ***	**60 (48 – 72)**

Statistically significant difference, Mann-Whitney U-test $p < 0.001$

Table 2. Prevalence of *S. aureus* and MRSA in dental healthcare workers

Occupation	Total sample	% of S. *aureus* carriers	% (95% CI)	% MRSA carriers	% (95% CI)
Dentist	178	21.9%	22.5% (17.9% - 27.6%)	3.9%	4.03% (3.1%-8.3%)
Dental specialist	120	23.3%		4.2%	
Assistant	96	18.7%	17.6% (12.0% - 24.4%)	5.2%	5.03% (2.5%-10%)
Oral hygienist	26	15.4%		7.7%	
Student's test	37	16.2%		2.7%	
Fisher's test			*p*=0.059		*p*=0.670

sample), MRSA prevalence was identified as 6.3% [95% CI: 2.5%–10.1%] using phenotypic methods, and 5.03% [95% CI: 1.6% - 8.4%] using genotypic methods. There was no statistically significant difference between the dentists and other dental worker groups, according to Fisher's exact test (p=0.67). Prevalence of MRSA carriers was high among oral hygienists.

Most *S. aureus* and MRSA carriers resided in Bogotá D.C., accounting for 25%. In other cities, the prevalence of *S. aureus* carriers was 15.4%, and that of MRSA carriers was 2.3%. There was no statistically significant difference between the groups.

PCR amplification of the *mecA* gene (Fig. 1A) and *Luk-PV* gene were performed on all twenty-seven cefoxitin-resistant isolates. *Luk-PV* gene was detected in only 30% of the *mecA* gene carriers (Fig. 1B).

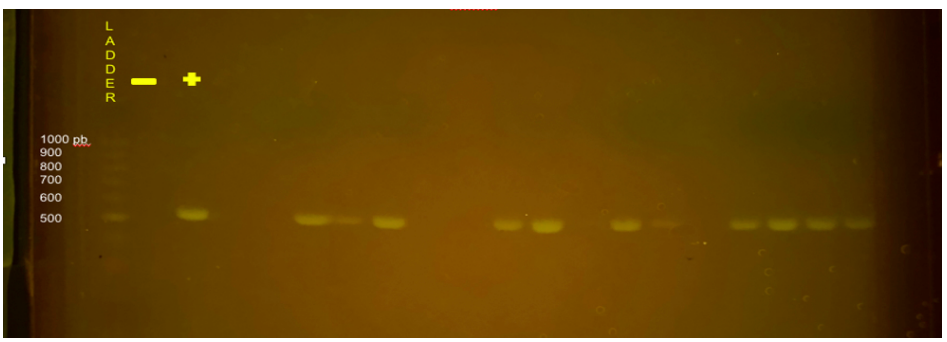


Fig. 1A: Gel electrophoresis - *mecA* gene: *Agarose gel electrophoresis for the detection of the mecA gene (533 bp) in Staphylococcus aureus strains by conventional PCR. Lane 1: molecular weight marker (1000 bp); lane 2: negative control (S. aureus ATCC 25923); lane 3: positive control (S. aureus ATCC 33591); lane 4: water; lanes 5–20: sample strains.*

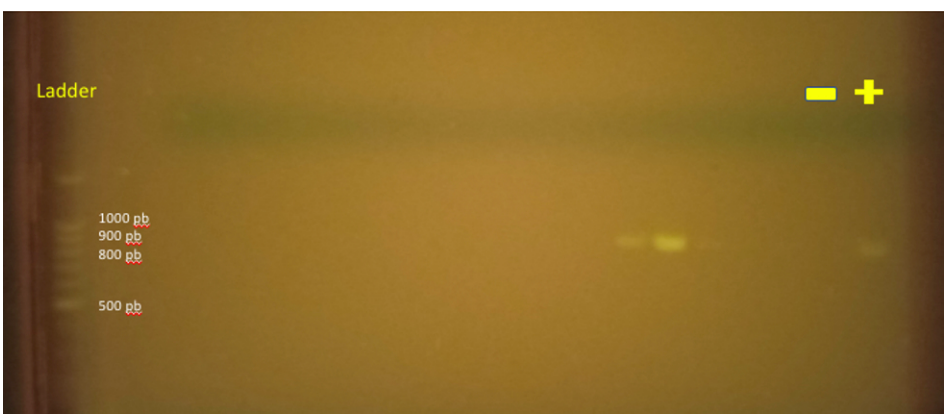


Fig. 1B: Gel electrophoresis - Luk-PV gene: *Agarose gel electrophoresis was used to detect the Luk-PV gene (969 bp) in Staphylococcus aureus strains by conventional PCR. Lane 1: molecular weight marker (1000 bp); lane 3: water; lanes 4–18: sample strains; lane 19: negative control (S. aureus ATCC 33591); lane 20: positive control (S. aureus ATCC 25923).*

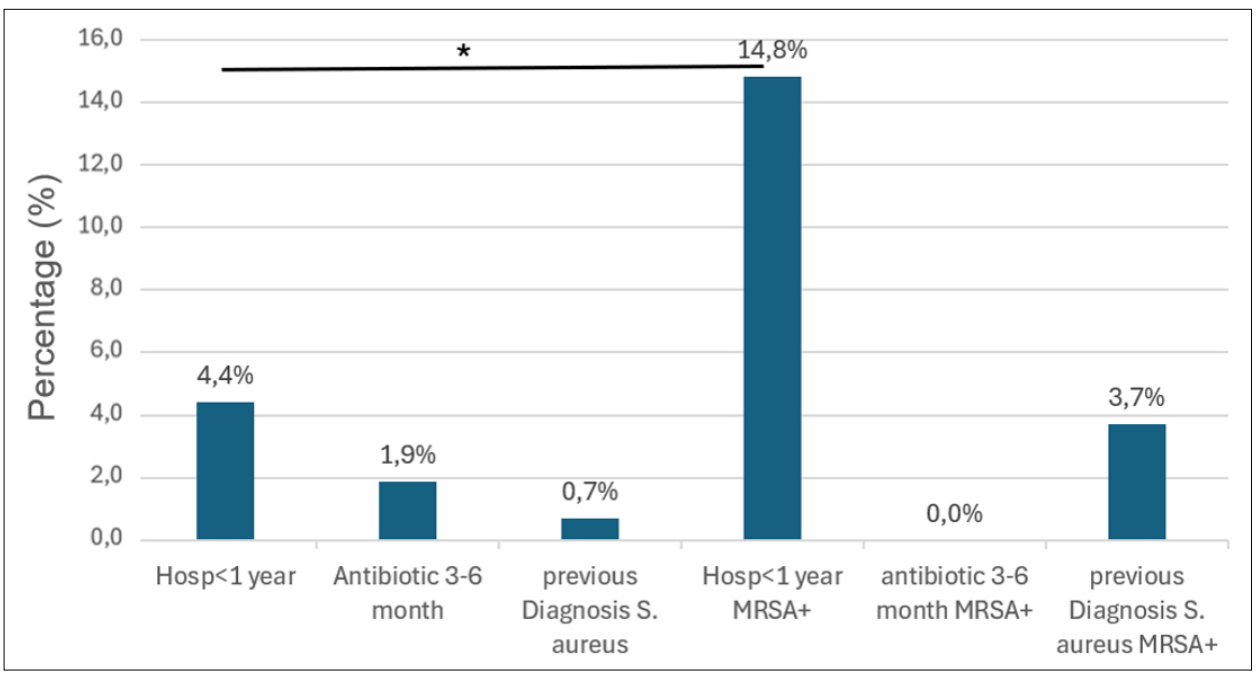
Factors associated with MRSA carriage

Host predisposing characteristics involving personal and drug exposure risk factors were analyzed and correlated with self-reported use of personal protective equipment. There was no statistically significant difference in the presence of risk factors between *S. aureus* and MRSA carriers (Table 3). Almost 52% of MRSA carriers did not live with other healthcare workers. However, among the dental staff living with HCWs, most MRSA carriers (61.5%, 8/13) lived with physicians and nurses. The history of hospitalization in the previous year was the only factor associated with MRSA carrier status (Fig. 2).

Table 3. Distribution of personal risk factors by carriage status

		Total sample	*S. aureus* carriers	MRSA carriers	*p value*
Family cohabitants	Any HCW	48.6%	48.4%	51.8%	*0.828*
	Physician/nurse	19.9%	21.0%	29.6%	*0.436*
	Dentist	19.3%	20.0%	18.5%	*1.000*
	Dental assistant	5.3%	5.3%	0.0%	*0.585*
	Other HCW	7.0%	5.3%	0.0%	*0.585*
	Total	457	95	27	
Morbidity	Any HCW	90.4%	89.7%	96.3%	*0.433*
	Obesity	3.5%	2.9%	0%	*1.000*
	Diabetes	0.9%	1.5%	3.7%	*0.489*
	Rheumatoid arthritis	0.2%	0.0%	0%	N/A
	Atopic dermatitis	4.8%	5.9%	0%	*0.575*
	Recurrent boils/chronic furunculosis	0.2%	0%	0%	N/A
	Total	457	68	27	

HCW= Healthcare worker



* Fisher exact test p <0.05

Fig. 2: Drug exposure risk factors

The analysis of use of personal protective equipment demonstrated exemplary compliance: over 98% for gloves and facemasks, 82.3% for face shields (masks and eye protection), and 74.2% for disposable gowns. The regular use of disposable gowns was lower among MRSA carriers than *S. aureus* carriers; however, this disparity was not statistically significant (p=0.621).

Antibiotic resistance patterns of *S. aureus* strains

All *S. aureus* strains isolated were tested for susceptibility to oxacillin, clindamycin, gentamicin and rifampicin. Approximately 90% of the isolates were susceptible to oxacillin and clindamycin, and 97% were susceptible to gentamicin and rifampicin. MRSA strains were 100% susceptible to gentamicin and 88.9% susceptible to rifampicin. The resistance rates to oxacillin and clindamycin were 55.6% and 14.8%, respectively. The antibiotic sensitivity patterns of *S. aureus* and MRSA strains are presented in Table 4.

Table 4. Antibiotic-resistance profile in *S. aureus* and MRSA strains

	Antibiotic	Susceptible %	Intermediate %	Resistant %
S. aureus	Oxacillin	89.7	5.1	5.1
	Gentamicin	96.2	2.6	1.3
	Clindamycin	88.5	9.0	1.3
	Rifampicin	98.7	1.3	0.0
MRSA	Oxacillin	44.4	0	55.6
	Gentamicin	100	0	0
	Clindamycin	70.4	14.8	14.8
	Rifampicin	88.9	11.1	0

DISCUSSION

The study found that *S. aureus* was consistently prevalent across all staff groups. MRSA carrier rates varied, with oral hygienists showing the highest rates, followed by assistants, dental professionals, and students. The analysis of risk factors indicated that a personal history of hospitalization in the past year was the only factor associated with being a carrier among dental healthcare staff. Adherence to protective equipment use was high.

To the best of our knowledge, this is the first multicenter observational study conducted in a Latin American population. A review of the literature revealed eight studies of dental healthcare professionals in Ukraine[22], Germany[23], Seul[17], United Arab Emirates[24], Egypt[25], India[26] and Brazil[14,15]. Only Lerche et al.[23] and Salmanov et al.[22] used large, randomly selected samples from different dental settings. The remaining studies used data from only one or two institutions with dental services. The largest Brazilian study included 31 participants and assessed colonization prevalence in salivary and nasopharyngeal secretions from professionals at two academic dental clinics[14]. Dental assistants provided data in half of these studies. The current study has the largest sample size and, unlike other studies, includes a randomly selected sample of dental graduates and specialists, assistants, and dentistry students.

Comparison of our results to those of other similar studies with randomly selected populations showed that the *S. aureus* carriage rate was very similar, with values between 22 and 30.9%, while the MRSA carriage rate was quite variable, with values of 0% in Mecklenburg Western Pomerania, Germany[23], 9.7% in Kyiv Ukraine[22], and 4.03% in Colombia, as reported herein. The prevalence of virulence factor *Luk*-PV genes was 55.5% in MRSA strains of dentistry staff from Kyiv, which was higher than the 30% of MRSA strains that were found in the current study. *Luk*-PV genes are mostly associated with community-acquired S. *aureus* strains and recognized as markers for virulent strains because they code for a cytotoxin that causes tissue necrosis and leukocyte destruction, which are related to furunculosis, cutaneous abscesses, severe necrotizing pneumonia, and sepsis. This finding indicates that one out of every ten MRSA strains is highly invasive, most probably community-acquired MRSA, and represents a serious health threat for carriers[27,28].

Previous studies on other Colombian populations have shown similar MRSA prevalence rates. For example, Rebollo-Perez J et al.[29] found a prevalence of 4.8% in preschool children. Their risk factors analysis showed no association with household healthcare workers but did find an association with antibiotic use in the previous 3 months. Unlike our findings, the authors identified that all MRSA strains were PVL-positive, suggesting community-associated MRSA (CA-MRSA) strains. Other researchers[30] have also suggested that outpatient treatment and antimicrobial therapy during hospitalization are important MRSA risk factors in Colombia.

Phenotypic resistance without detection of the *mecA* gene occurred in 25.9% of the participants, which may be due to alternative resistance caused by borderline strains with hyperproduction of beta-lactamase or even modified *S. aureus* (MODSA), which has mechanisms other than non-*mecA* and non-*mecC*-mediated resistance[31]. However, these mechanisms were not investigated in the current study.

The current study had some limitations. We did not sample hands, which may have either under or overestimated MRSA colonization frequency. Bacterial carriage varies across body sites[32], but few studies compare *S. aureus* or MRSA carriage data from two or more body sampling sites. The nasal vestibule is the most frequent carriage site, with highest colonization rates[25,33]. Furthermore, our results may not fully represent MRSA prevalence in Colombia or individual cities because we did not sample all regions, and the sample size was not calculated for each city's prevalence. Additionally, the non-probabilistic sampling in 29% of cases compromises statistical representativeness, introduces selection bias, and may limit the external validity of the findings. However, our study provides crucial epidemiologic data on MRSA prevalence in a wide range of healthcare workers, antibiotic resistance monitoring, and factors influencing the circulation of health-threatening microorganisms in healthcare settings. While Fisher's exact test was utilized appropriately for small subgroup analyses, the study may be statistically underpowered to detect significant associations for rare comorbidities or specific living arrangements.

CONCLUSIONS

This multicenter study reveals a 4.4% MRSA carriage rate among Colombian dental healthcare providers. Additionally, 30% of MRSA strains exhibit higher virulence due to the presence of the *luk*-PV gene. Continuous monitoring of MRSA carriers among healthcare workers is essential for understanding and controlling the spread of healthcare-associated infections in dental settings.

CONFLICT OF INTERESTS

All the authors declare that there is no conflict of interest regarding the publication of this manuscript.

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