

# Bacterial colonization and antimicrobial resistance in healthcare workers: an integrative review

Colonização bacteriana e resistência antimicrobiana em trabalhadores de saúde: revisão integrativa

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## Keywords

Health personnel; Colonization; Drug resistance, microbial

## Descritores

Trabalhadores de saúde; Colonização; Resistência microbiana a medicamentos

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## Abstract

**Objective:** To analyze the scientific evidence in the literature on microorganisms that colonize in healthcare workers and the association with antimicrobial resistance.

**Methods:** Integrative review. The search for primary studies was conducted in the following information databases: National Library of Medicine - National Institutes of Health, Cumulative Index to Nursing and Allied Health Literature, Web of Science, Scopus, and Virtual Health Library. The descriptors used were applied according to the particularities of each database and obtained through consulting the Health Sciences Descriptors and Medical Subject Headings.

**Results:** The review was made up of 14 primary studies. In the analysis of the samples, the searches mainly found *Staphylococcus aureus* and methicillin-resistant *Staphylococcus aureus* colonizing in healthcare workers. Bacterial resistance to clindamycin and oxacillin was more predominant in the samples.

**Conclusion:** In the studies, *Staphylococcus aureus* was the main colonizing bacteria in healthcare workers. The concern is that these bacteria have a strong resistance capacity to beta-lactam antibiotics.

## Resumo

**Objetivo:** Analisar as evidências científicas disponíveis na literatura sobre os microrganismos que colonizam os trabalhadores de saúde e sua associação com a resistência a antimicrobianos.

**Métodos:** Revisão integrativa de literatura. A busca dos estudos primários foi realizada nas bases de informação: *National Library of Medicine National Institutes of Health, Cumulative Index to Nursing and Allied Health Literature, Web of Science, Scopus* e Biblioteca virtual em saúde. Os descritores utilizados foram aplicados de acordo com particularidades de cada base de dados e obtidos por consulta nos Descritores de Ciências em Saúde e *Medical Subject Headings*.

**Resultados:** A revisão foi composta de 14 estudos primários. Na análise das amostras as pesquisas encontraram principalmente *Staphylococcus aureus* e *Staphylococcus aureus* resistente a metilina colonizando os trabalhadores de saúde. A resistência das bactérias à clindamicina e oxacilina apresentaram maior destaque nas amostras.

**Conclusão:** O *Staphylococcus aureus* foi evidenciado nos estudos como principal bactéria colonizadora dos trabalhadores de saúde. A preocupação é que essas bactérias apresentam grande capacidade de resistência aos antibióticos beta-lactâmicos.

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## Introduction

Antimicrobial resistance is considered a global health problem that undermines the effectiveness of antibiotics and prevents treatment of common infections. Resistance occurs when microorganisms undergo genetic mutation through exposure to antimicrobial drugs. These microorganisms are referred to as “superbugs”. During the mutation phenomenon, bacteria are protected from antimicrobial effects, which will result in bacterial multiplication and will impede treatment and the curing of diseases.<sup>(1)</sup>

Certain groups of healthcare workers are in direct and constant contact with patients colonized by multi-resistant bacteria. Health professionals interacting with such patients are susceptible to becoming reservoirs and spreaders of microorganisms. In various studies on healthcare workers, scientific evidence has shown the presence of methicillin-resistant *Staphylococcus aureus* (MRSA), *Staphylococcus ssp*, *Enterococcus faecalis*, *Acinetobacter baumannii*, *Streptococcus ssp* and *Serratia ssp*, colonizing the nasal cavity, white coats and saliva of hospital workers.<sup>(2-4)</sup>

Direct contact between health workers and infected patients can propagate the contamination of these superbugs, which increases the possibility of professionals acquiring resistance to available antimicrobials for treating diseases.<sup>(2)</sup> To prevent this risk, individual and collective protection measures need to be adopted. Workers should use personal protective equipment (PPE) that is appropriate for the type of work being performed and under adequate working conditions. Failure to use PPE when in contact with colonized patients can enhance the risk of contamination of workers and dissemination of healthcare-associated infections (HAIs). Health professionals should use gloves, aprons, masks and goggles when handling patients contaminated with multi-resistant microorganisms, in accordance with the recommendations from NR 32.<sup>(5)</sup> The proper use of this equipment forms a mechanical barrier between the biological agent and health professionals.

Another important factor that should be taken into account is the handling of antimicrobials by healthcare workers. A study which used penicillin as a sensitivity test found that frequent and prolonged exposure to any drug tends to increase the risk of drug hypersensitivity. It is recommended that people handling beta-lactam antibiotics be protected with gloves during their preparation and administration to avoid exposure and sensitivity risk.<sup>(6)</sup> In such cases, the use of gloves is a protection factor against drug hypersensitivity.

There is scientific evidence that antibiotics can remain suspended in the air. During some processes, such as fermentation of penicillin, for example, workers can inhale dust, solutions and aerosols of these drugs while handling them.<sup>(7)</sup> A study with workers in contact with penicillin dust concluded that there is high exposure to this dust and associated antimicrobial resistance,<sup>(8)</sup> although no studies were found that related this process to infections caused by superbugs.

The present study sought to summarize the knowledge derived from studies on the main microorganisms that colonize in healthcare workers and the antimicrobial resistance indicators. The objective of the study was to examine the scientific evidence found in the literature on microorganisms that colonize in healthcare workers and the association with antimicrobial resistance.

## Methods

This was an integrative review, whose methodology was based on a summary of the diverse results from various studies on the same theme, and which presented the scientific evidence available.<sup>(9)</sup>

To systematize the construction of the review, specific stages were carried out: formulation of the research question, search in the databases, categorization of the studies, evaluation, interpretation of the results, and summarization of the knowledge.<sup>(10)</sup>

The guiding question of this study was formulated by inserting the identification of essential words in order to locate primary studies in the databases: “What are the main organisms that colonize in healthcare workers in direct contact with patients and what is the antimicrobial resistance of these microorganisms?”

The search for primary studies was done in the following information bases: National Library of Medicine - National Institutes of Health (PubMed), Cumulative Index to Nursing and Allied Health Literature (CINAHL), Web of Science, Scopus, and Virtual Health Library (BVS).

The descriptors and keywords used in the search were applied according to the particularities of each database and obtained by consulting Health Sciences Descriptors (DeCS) and Medical Subject Headings (Mesh). During the search the descriptors were crossed using the booleans “OR” and “AND. A data filter (2007 to 2017) was used in all the searches. The descriptors were inserted in English, since the descriptors for the articles in all the indexed journals in these databases were in English, with the exception of the BVS where the descriptors were inserted in English and Portuguese. Chart 1 presents the descriptors used in this study, summarizing how the search was performed.

After the search stage, original articles were selected, based on a review of their titles and abstracts, according to the following inclusion criteria: original articles available in full on the databases or selected virtual library, openly accessible online, in Portuguese, English or Spanish, published within the last ten years, dealing with the population of healthcare workers in direct contact with patients. The full text of each article was read, in order to choose studies that responded to the research question. After this process, publications were excluded that failed to meet the aforementioned selection criteria, did not respond to the research question, or were duplicates. Opinion articles, theoretical reflections, theses, dissertations and book chapters were also excluded.

**Chart 1.** Descriptors used in the search strategy for primary articles

Origin of the data
<b>Descriptors and keywords</b>
BVS
"Trabalhador de saúde" e " Resistência Microbiana a Medicamentos"
"Trabalhador de saúde" e "Colonização"
"Health worker" e "Colonization"
"Health worker" e "Antibiotic resistance"
PubMed
"Health worker" ou "Pharmacy Technician" ou "health personnel" e "antibiotic resistance"
CINAHL
"Health worker" e "Colonization"
"Health worker" e "Antibiotic resistance"
Web of Science
"Health worker"* e "Antibiotic resistance"
"Health worker"* e "Colonization"
Scopus
"Health personnel" e "Antibiotic resistance"

The studies included in the review are presented in figure 1.

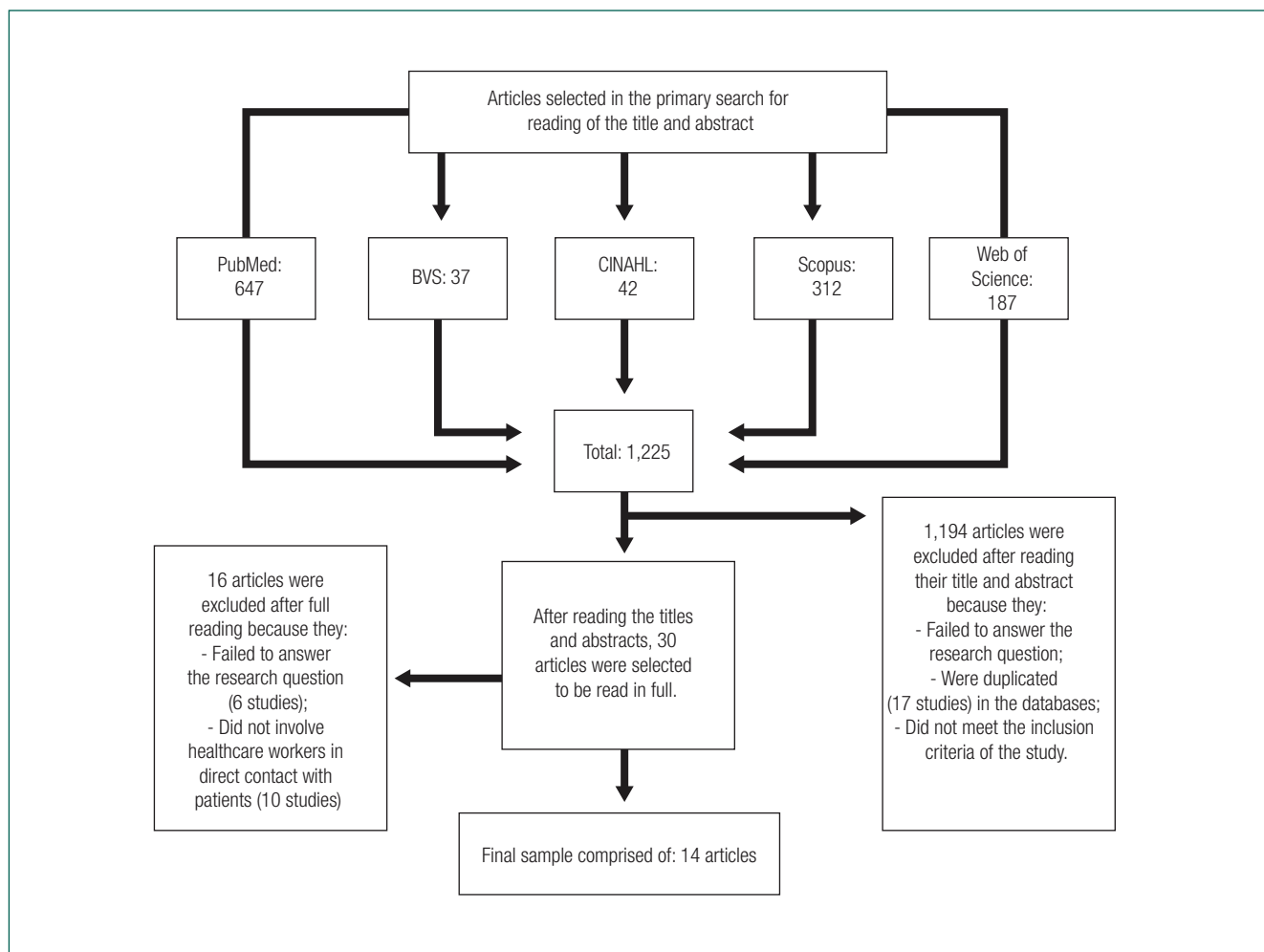
To organize the data, an instrument adapted from the Occupational Health Nursing Network Form (Red ENSO International) was used. This instrument has been used in various studies conducted by the Occupational Health Nursing Network (Red ENSO - Brazil).<sup>(11)</sup> Identification of the publication (title, volume, number and year), authorship, location where the study was conducted, objectives of the study, type of study, and level of evidence were analyzed.

The levels of evidence (LE) considered in this study were: Level 1- studies with a meta-analysis or systematic review methodological design; Level 2- randomized controlled clinical trials; Level 3- non-randomized clinical trials; Level 4- cohort and case-control studies; Level 5- systematic reviews of descriptive and qualitative studies; Level 6- descriptive or qualitative studies; Level 7- opinions of specialists.<sup>(10)</sup>

The collection was done in June 2017 and the selected articles were analyzed independently through double reading.

## Results

This study had a sample of 14 primary articles which were characterized, taking into consideration



Source: Adapted from the Prisma model

**Figure 1.** Flowchart for the selection of primary studies included in the integrative review according to the databases

the title, authors, year of publication, level of evidence, objective and type of study of the publications included in this review, as shown in chart 2.

The studies were published in 2008,<sup>(22)</sup> 2009,<sup>(14,15)</sup> 2010,<sup>(25)</sup> 2011,<sup>(23)</sup> 2012,<sup>(21)</sup> 2013,<sup>(12,13,16)</sup> 2014,<sup>(14,15,18)</sup> 2016,<sup>(20)</sup> 2017,<sup>(24)</sup> all in English.<sup>(12-25)</sup> In terms of level of evidence, 13 articles were cross-sectional, observational studies (level of evidence 6),<sup>(12-24)</sup> whereas one was a cohort study (level of evidence 4).<sup>(25)</sup>

The studies were conducted in the following locations: USA,<sup>(12)</sup> Iran,<sup>(23,13)</sup> Brazil,<sup>(14,16,17,19,22)</sup> Ethiopia,<sup>(15)</sup> Sri Lanka,<sup>(18)</sup> Switzerland,<sup>(20)</sup> Libya,<sup>(21)</sup> Gaza,<sup>(24)</sup> and Egypt.<sup>(25)</sup>

The population examined by the researchers was made up of nurses, physicians and nursing technicians.<sup>(12-24)</sup>

The main data collection sectors in the articles were intensive care units,<sup>(17,22,25,27)</sup> emergency departments,<sup>(12,17,18)</sup> operating rooms,<sup>(17,22)</sup> and hemodialysis and nephrology units.<sup>(22)</sup>

To detect colonizing microorganisms, the samples were collected through nasal swab specimen techniques,<sup>(12-15,20-24)</sup> as well as from saliva<sup>(17,19)</sup> and the hands.<sup>(18)</sup> Some studies collected samples from more than one anatomic site.<sup>(16,22,25)</sup>

In the analysis of the sample, it was detected that *Staphylococcus aureus* was colonizing in workers.<sup>(12-24)</sup> Two studies, besides identifying *Staphylococcus aureus*, also found *Staphylococcus epidermidis* and *Staphylococcus auricularis*, *Staphylococcus capitis*, *Staphylococcus haemolyticus*, *Staphylococcus hominis*, *Staphylococcus intermedius*, *Staphylococcus lentus*, *Staphylococcus lugdun-*

**Chart 2.** Characterization of the studies included in the review

Title	Authors	Year	LE	Country	Objective	Type of study
Methicillin-resistant <i>Staphylococcus aureus</i> colonization among pediatric healthcare workers from different outpatient settings.	Immergluck LC, et al. <sup>(12)</sup>	2013	LE: 6	USA	Determine the <i>Staphylococcus aureus</i> colonization rates in healthcare workers from different types of pediatric outpatient configurations.	Observational, cross-sectional, quantitative study
Nasal colonization of mecA-positive, oxacillin-susceptible, methicillin-resistant <i>Staphylococcus aureus</i> isolates among nursing staff in an Iranian teaching hospital.	Jannati E, et al. <sup>(13)</sup>	2013		Iran	Determine the prevalence of nasal colonization and the antibiotic resistance profile of strains of MRSA among nursing staff in a teaching hospital.	Cross-sectional quantitative study
Risk factors for <i>Staphylococcus aureus</i> and methicillin-resistant <i>S. aureus</i> colonization among healthcare workers in pediatrics departments.	Gomes IM, et al. <sup>(14)</sup>	2014	LE: 6	Brazil	Determine whether healthcare workers in a pediatric department of a Brazilian public hospital have lower colonization rates than other health professionals.	Cross-sectional quantitative study
Antimicrobial susceptibility pattern of nasal <i>Staphylococcus aureus</i> among Dessie Referral Hospital healthcare workers, Dessie, Northeast Ethiopia.	Shibabaw A, et al. <sup>(15)</sup>	2014	LE: 6	Ethiopia	Determine the antimicrobial susceptibility pattern of <i>Staphylococcus aureus</i> strains, MRSA prevalence, and the rate of nasal transport in healthy hospital workers.	Cross-sectional quantitative study
Phenotypic methods for determination of methicillin resistance in <i>Staphylococcus spp.</i> from healthcare workers.	Rabelo MA, et al. <sup>(16)</sup>	2013	LE: 6	Brazil	Determine the occurrence of colonization by methicillin-resistant <i>Staphylococcus spp.</i>	Cross-sectional quantitative study
Prevalence of methicillin-resistant and methicillin-susceptible <i>S. aureus</i> in the saliva of health professionals.	Carvalho MJ, et al. <sup>(17)</sup>	2009	LE: 6	Brazil	Analyze the prevalence of methicillin-susceptible <i>Staphylococcus aureus</i> (MSSA) and methicillin-resistant <i>S. aureus</i> (MRSA).	Cross-sectional quantitative study
Methicillin-resistant <i>Staphylococcus aureus</i> among nurses in a tertiary care hospital in northern Sri Lanka.	Mahalingam U, et al. <sup>(18)</sup>	2014	LE: 6	Sri Lanka	Identify the occurrence of MRSA transport among nursing staff in different units of the Jaffna teaching hospital.	Observational, cross-sectional, quantitative study
Detection of mecA gene in oxacillin-resistant coagulase-negative <i>Staphylococci</i> isolated from the saliva of nursing professionals.	Rosa JO, et al. <sup>(19)</sup>	2009	LE: 6	Brazil	Identify species of coagulase-negative staphylococci isolated from the saliva of nursing professionals, determine the resistance profile, and detect the mecA gene.	Cross-sectional quantitative study
Antibiotic Resistance of Commensal <i>Staphylococcus aureus</i> and Coagulase-Negative <i>Staphylococci</i> in an International Cohort of Surgeons: A Prospective Point-Prevalence Study.	Morgenstern M, et al. <sup>(20)</sup>	2016	LE: 6	Switzerland	Identify the prevalence of antibiotic-resistant <i>Staphylococci</i> present in the nostrils of orthopedic surgeons.	Cross-sectional quantitative study
Isolation and screening of methicillin-resistant <i>Staphylococcus aureus</i> from healthcare workers in Libyan hospitals.	Ahmed MO, et al. <sup>(21)</sup>	2012	LE: 6	Libya	Investigate the prevalence and antimicrobial susceptibility of resistance to MRSA among health workers in Tripoli, Libya.	Cross-sectional quantitative study
Prevalence and Risk Factors for <i>Staphylococcus aureus</i> in Healthcare Workers from a University Hospital in Recife-PE.	Silva EC, et al. <sup>(22)</sup>	2008	LE: 6	Brazil	Assess the epidemiological and sensitivity profile of <i>S. aureus</i> , isolated in healthcare workers from a university hospital in the state of Pernambuco.	Cross-sectional quantitative study
The Frequency of MRSA carriers in healthcare workers in Gorgan, North of Iran.	Alang SR, et al. <sup>(23)</sup>	2011	LE: 6	Iran	Determine the frequency of MRSA and its sensitivity to antibiotics among healthcare workers in Gorgan, located in northern Iran.	Cross-sectional quantitative study
Nasal carriage of methicillin-resistant <i>Staphylococcus aureus</i> among health care workers at Al Shifa hospital in Gaza Strip.	El Aila NA, et al. <sup>(24)</sup>	2017	LE: 6	Palestine	Determine the nasal transport rate of <i>Staphylococcus aureus</i> and MRSA among health professionals in Al Shifa, the largest hospital in Gaza.	Cross-sectional quantitative study
Antimicrobial resistant bacteria among healthcare workers in intensive care units at Ain Shams University Hospitals.	Rahman A, et al. <sup>(25)</sup>	2010	NS: 4	Egypt	Detect bacterial resistance among healthcare workers.	Quantitative cohort study

*ensis*, *Staphylococcus saprophyticus* and *Staphylococcus warneri*.<sup>(16,20)</sup> There was evidence in two other studies of higher colonization by *Staphylococcus epidermidis*, *Staphylococcus saprophyticus*, *Staphylococcus haemolyticus*, *Staphylococcus cohnii*, *Staphylococcus lugdunenses*, *Staphylococcus capitis*, and *Staphylococcus simulans*.<sup>(19,25)</sup>

Of the samples with colonization by *Staphylococcus aureus*, some researchers isolated strains of methicillin-resistant *Staphylococcus aureus* (MRSA) from strains that were susceptible to methicillin (MSSA).<sup>(12,13,15,17,18,21,24)</sup> These strains of MRSA were resistant to antibiotics such as ciprofloxacin,<sup>(12,17)</sup> clindamycin,<sup>(12,17,21)</sup> pristinamycin,<sup>(13)</sup> oxacillin,<sup>(13,17,21,24)</sup> penicillin G,<sup>(15)</sup> ampicillin,<sup>(15)</sup> amoxicillin,<sup>(15)</sup> tetracycline,<sup>(13)</sup> erythromycin,<sup>(17,21)</sup> mupirocin,<sup>(21)</sup> sul-

famethoxazole<sup>(21)</sup> and cefoxetin.<sup>(17)</sup> A study which considered *Staphylococcus aureus* as the colonizer of its samples and did not separate the MRSA and MSSA strains noted there was resistance to Imipenem.<sup>(23)</sup> In studies that found bacteria other than *Staphylococcus aureus* in their sample, there was resistance to methicillin,<sup>(16)</sup> oxacillin,<sup>(19)</sup> mupirocin,<sup>(19)</sup> and cefoxitin.<sup>(19)</sup>

## Discussion

Colonization by *Staphylococcus aureus* was predominant in this review, but it must be taken into account that *Staphylococcus aureus* is bacte-



rium from the normal microbiota of the human organism. This bacterium is mainly found in the nostrils and its prevalence is around 40% in adults.<sup>(28)</sup> According to the studies analyzed, the hands and nostrils were the main reservoirs of the microorganisms.<sup>(29-31)</sup>

The ability of *Staphylococcus aureus* to become pathogenic to individuals is a matter of great concern. In recent years, bacteria have become an increasingly prominent cause of occupational health-related infections.<sup>(32)</sup> The strains of methicillin-resistant *Staphylococcus aureus* (MRSA) are even more disturbing. Methicillin resistance is caused by *Staphylococcal Cassette Chromosome Mec* (SCCmec), a genetic element with mobile capacity that transports the *mecA* gene and codifies methicillin resistance. This gene has little affinity with all the beta-lactam antimicrobials currently used.<sup>(33)</sup>

Antibiotic resistance among *Staphylococcus aureus* strains has become a focus of attention in the treatment of staphylococcal infections because of the rapidity with which they have acquired resistance to all antibiotics that have been used clinically.<sup>(33)</sup> Recent articles have proven the resistance to beta-lactams, such as erythromycin, ciprofloxacin and clindamycin.<sup>(29,30)</sup> All this evidence demonstrates the need to produce new antibiotics to combat multi-resistant strains of *Staphylococcus aureus*.<sup>(28)</sup>

More recently, mutation has favored the emergence of vancomycin-resistant strains of *Staphylococcus*, and it has been possible to identify that these bacteria are progressing in their resistance capability due to the uncontrolled use of pharmaceutical drugs.<sup>(28)</sup> This resistance has also been confirmed in health workers.<sup>(30)</sup>

Another factor that could be taken into consideration is the sectors where the studies were conducted, since most occurred in emergency departments and intensive care units,<sup>(12,17,18,22,25,27)</sup> environments characterized by weakened people in need of high complexity care, including antibiotic drug treatments. This could affect resistance to antimicrobials and continuously expose workers to this type of drug. Contact with superbugs

leaves this population susceptible to an extreme range of pathogenic microorganisms. The ability to fight infections caused by these pathogens is a serious concern.

The limitation of this study is the fact that it was carried out within a 10-year time frame, which restricted the study to a set of more recent productions on the topic. In addition, it only used primary data, which could result in subjectivity in the analysis. On the other hand, the results of this study will hopefully contribute to advances in further studies on the protection of workers from contamination by antimicrobial-resistant bacteria that could affect the health and quality of life of health workers. It is essential to review the practices of workers involved in the preparation of antibiotics and thereby ensure not only the safety of patients but also those who continuously provide direct care.

## Conclusion

*Staphylococcus aureus* was identified in the studies as the main colonizing bacteria of healthcare workers. These bacteria have tremendous resistance to beta-lactam antibiotics which are commonly used in hospital settings. It was detected that although a large number of studies have been conducted on the subject, the level of clinical evidence in these studies was low. It is suggested that further studies be conducted employing more robust methodologies to enable generalization of the data and translation of the ensuing scientific knowledge into health practices.

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