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Antimicrobial resistance in hospital bacteria

Antimicrobial resistance among hospital bacterial pathogens

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Summary

Antimicrobial resistance in hospital-acquired bacteria constitutes a significant public health problem, compromising the effectiveness of treatments, increasing mortality, prolonging hospital stays, and raising healthcare costs. This study aimed to analyze antimicrobial resistance in hospital-acquired bacteria, considering the main resistance mechanisms, dissemination factors, clinical and economic impacts, and prevention and control strategies described in the literature. This is a qualitative, descriptive, and exploratory bibliographic research study, developed from the analysis of scientific articles, guidelines, institutional documents, and technical publications. The literature review revealed that bacterial resistance involves mechanisms such as modification of the antimicrobial site of action, enzymatic inactivation, reduction of cell permeability, efflux pump action, horizontal gene transfer, and biofilm formation. It was also observed that factors such as inappropriate antibiotic use, invasive devices, prolonged hospital stays, and failures in infection control measures favor the dissemination of these microorganisms in the hospital environment. It is concluded that tackling antimicrobial resistance requires integrated actions, with emphasis on the rational use of antimicrobials, epidemiological and microbiological surveillance, and the strengthening of prevention and control measures in health services.

Keywords: Antimicrobial resistance. Bacterial resistance. Hospital-acquired infections. Multidrug-resistant bacteria. Infection control.

Abstract

Antimicrobial resistance in hospital bacteria is a major public health problem because it compromises treatment effectiveness, increases mortality, prolongs hospital stays, and increases healthcare costs. This study aimed to analyze antimicrobial resistance in hospital bacteria, considering the main resistance mechanisms, dissemination factors, clinical and economic impacts, and prevention and control strategies described in the literature. This is a bibliographic study with a qualitative, descriptive, and exploratory approach, developed through the analysis of scientific articles, guidelines, institutional documents, and technical publications. The results showed that bacterial resistance involves mechanisms such as modification of the antimicrobial target site, enzymatic inactivation, reduced cellular permeability, efflux pump activity, horizontal gene transfer, and biofilm formation. It was also observed that factors such as inappropriate antibiotic use, invasive devices, prolonged hospitalization, and failures in infection control measures favor the spread of these microorganisms in the hospital setting. It is concluded that tackling antimicrobial resistance requires integrated actions, with emphasis on the rational use of antimicrobials, epidemiological and microbiological surveillance, and the strengthening of prevention and control measures in healthcare services.

Keywords: Antimicrobial resistance. Bacterial resistance. Hospital infections. Multidrug-resistant bacteria. Infection control.

1. Introduction

Antimicrobial resistance is one of the major current challenges for public health.

as highlighted by the World Health Organization, and this concern becomes even more evident in

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hospital environment, where the frequent use of antibiotics and the presence of patients in certain conditions More severe clinical conditions favor the selection of resistant bacteria (WHO, 2023). This phenomenon It compromises the effectiveness of treatments and contributes to increased morbidity and mortality, and to longer treatment times. of hospitalization and healthcare costs (GBD 2021 Antimicrobial Resistance Collaborators, 2024).

In hospitals, this scenario is exacerbated by the performance of invasive procedures, prolonged use of medical devices and recurrent exposure to broad-spectrum antimicrobials spectrum, factors that favor colonization and infection by multidrug-resistant microorganisms (Geng *et* al., 2025).

Furthermore, failures in infection prevention and control measures, such as hygiene. Inadequate hand washing and insufficient surface cleaning contribute to the maintenance of Bacterial transmission in healthcare institutions (Boyce, 2024). Among the most common pathogens Given its relevance in this context, the World Health Organization highlights microorganisms such as Methicillin-resistant *Staphylococcus aureus ,* carbapenemase-producing *Klebsiella pneumoniae* and Multidrug-resistant *Pseudomonas aeruginosa ,* frequently associated with serious and difficult-to-treat infections. treatment (WHO, 2024).

Bacterial resistance results from mechanisms such as modification of the site of action of the antibiotics, enzyme inactivation, reduction of cell permeability, action of efflux pumps and Horizontal transfer of resistance genes, central processes for adaptation and survival. of microorganisms even in the face of appropriately indicated therapies (Darby *et* al., 2023). By For this reason, antimicrobial resistance goes beyond the microbiological field and comes to represent... also a problem related to patient safety, quality of care and effectiveness of infection control policies.

Given this context, the study of antimicrobial resistance in hospital bacteria It proves relevant because it allows for an understanding of the mechanisms involved in the development of resistance, factors that favor its spread, and clinical and economic impacts. associated with these infections. Discussing the topic also contributes to strengthening practices focused on the rational use of antimicrobials and the improvement of prevention and control measures. in a hospital setting.

Thus, the present study aims to analyze antimicrobial resistance in bacteria. hospital settings, covering the mechanisms by which these bacteria develop resistance, the factors that favor its spread, the clinical impacts associated with resistant infections, and the main prevention and control strategies described in the literature.

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2. Theoretical Framework / Results

2.1 Fundamental concepts of bacterial resistance

Antimicrobial resistance refers to the ability developed by microorganisms to to survive the action of drugs that were previously effective against them, a definition highlighted by World Health Organization (WHO, 2023). When the focus shifts to bacteria, this discussion This gains particular relevance in the hospital setting, since many infectious conditions depend on it. Effective antibiotics for a rapid and safe response in the patient, as noted by the CDC (2025) and Ho *et al.* (2025).

Bacterial resistance can manifest itself in different ways, depending on the unique characteristics of each species and the changes that occur over time in response to the environment. In this sense, Belay *et al.* (2024) explain that it can be present naturally. In bacteria, resistance can arise from genetic alterations or the incorporation of resistance elements, in addition to... It can also present itself temporarily in response to exposure to antimicrobials and other pressures. environmental.

Bacterial resistance mechanisms are varied and often act in a way... combined. Darby *et al.* (2023) describe among the best known the modification of the site of action. of the antibiotic, the reduction of drug entry into the cell, the increase in the activity of pumps of efflux and enzymatic inactivation of the drug, while Belay *et al.* (2024) reinforce the relevance these mechanisms contribute to the persistence of infections even with appropriate therapies.

Another fundamental concept for understanding bacterial resistance involves circulation. of resistance genes among bacteria. Wachino *et al.* (2025) highlight that this process occurs by horizontal gene transfer, mainly through conjugation, transformation, and transduction, with significant participation of plasmids, transposons and integrons, whereas Liu *et al.* (2024) Studies show that biofilm formation strengthens bacterial survival and hinders penetration. antibiotics promote persistence and genetic exchange on biomedical surfaces and devices.

The World Health Organization's updated list in 2024 will include 24 new pathogens. priority bacteria with the greatest impact on public health, including Gram-negative bacteria resistant to last-line antibiotics and microorganisms such as *Pseudomonas aeruginosa* and *Staphylococcus aureus* clearly demonstrates the central role that bacterial resistance has become. to occupy positions in the areas of surveillance, research, assistance and development of new therapies (WHO, 2024).

2.2 Dissemination Factors

Understanding how bacterial resistance spreads requires looking at a number of factors. interconnected issues that extend beyond the hospital walls. Problems such as inappropriate prescribing of antibiotics, the constant flow of patients between different units, and basic hygiene failures and

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Sanitation efforts work together. In practice, this dissemination is the result of several situations.
which end up creating the perfect environment for resistant microorganisms to thrive and
circulate freely (WHO, 2023; CDC, 2025).

In the hospital setting, the selective pressure caused by the frequent use of antibiotics...
A broad spectrum plays a central role in this process, as it favors the survival of more bacteria.
Adapted and makes it difficult to control healthcare-associated infections, as discussed by Sartelli *et al.*
(2024). This situation intensifies in more complex sectors, such as therapy units.
Intensive care, where the clinical severity is greatest, there is intensive use of invasive devices, and a need for...
Successive procedures and prolonged exposure to antimicrobials create favorable conditions.
for colonization and infection by multidrug-resistant microorganisms, as pointed out by Geng *et al.*
(2025).

Another decisive factor involves cross-transmission, which can occur through the hands of...
professionals, through contact between patients, through the sharing of equipment and through
Contamination of high-touch surfaces. Boyce (2024) emphasizes that hand hygiene remains
as an essential measure to reduce the spread of multidrug-resistant organisms, while
Geng *et al.* (2025) reinforce the importance of daily and terminal environmental cleaning of areas.
care measures to contain pathogens capable of persisting for longer periods in the hospital environment.

It is necessary to understand that the spread of resistance goes far beyond physical contact or...
contaminated surfaces. There is an invisible and rapid dynamic at play: resistance genes are able to
They can jump between different bacteria, rapidly reaching new ecosystems and population groups.
This ease of genetic exchange makes controlling the problem much more challenging, which reinforces
The urgency of maintaining active surveillance, coupled with the conscious use of medications and strategies
rigorous prevention measures (CDC, 2025).

2.3 Control strategies

Strategies for controlling bacterial resistance involve coordinated actions that seek to...
improve the use of antimicrobials, reduce the transmission of resistant microorganisms, and qualify
patient safety. In this context, the National Health Surveillance Agency (2023) highlights
antimicrobial stewardship programs as central measures to guide choice,
dose, route and duration of treatment based on evidence and the clinical reality of each service.
while Hadi *et al.* (2024) point out that these programs have shown effectiveness, efficiency and
Efficiency in different hospital settings.

For these strategies to be maintained effectively, it is essential that the institution
Count on management involvement, a clear definition of responsibilities, and integrated action from...
different professionals. The CDC (2025) and the Brazilian ANVISA guideline (2023) reinforce the
importance of leadership commitment, of coordinated participation among the medical team,

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nursing, pharmacy and other sectors, in addition to monitoring, continuing education and continued efforts to control bacterial resistance.

In practical interventions, recent literature points to favorable results for strategies combined, such as prospective auditing with feedback to the team, protocols guided by biomarkers, therapeutic review with de-escalation, restriction or pre-authorization of Antimicrobials and diagnostic *stewardship* actions . In a published systematic review on units In intensive care, Ntim *et al.* (2025) identified different strategies associated with reducing global or targeted use of antimicrobials, as per the Pan American Health Organization (2024) also highlights the relevance of practical interventions aimed at optimizing the use of these medications in healthcare services.

The impact of these strategies tends to be more consistent when they are implemented in conjunction with... prevention and control of infections, microbiological surveillance and ongoing training of teams. In this sense, ANVISA (2023) highlights the importance of integrating the management of antimicrobials are incorporated into institutional routines, so that infection prevention and improvement can be achieved. Continuous hospital practices contribute to reducing selective pressure on bacteria and to limit the spread of resistance in the hospital environment.

2.4 Clinical and economic impacts

The clinical impacts of bacterial resistance are directly evident in the evolution of infections, because they reduce available treatment options, delay treatment response and They increase the likelihood of serious complications. In a global analysis published in The *Lancet,* it was estimated- It is known that, in 2021, bacterial resistance was associated with 4.71 million deaths, of which 1.14 Millions were directly attributable to the phenomenon, which demonstrates the concrete dimension of this. problem for healthcare and patient safety on a global scale (GBD 2021) Antimicrobial Resistance Collaborators, 2024).

This clinical impact becomes even more evident in invasive infections acquired in hospital environment. Allel *et al.* (2024) show that these conditions are often associated with greater length of hospital stay, greater need for intensive care, and higher risk of death, reflecting directly impacting the prognosis and complexity of care provided to the patient. In situations of more advanced resistance, as in cases involving *Enterobacterales* resistant to Carbapenems, De Araujo *et al.* (2025) highlight that treatment becomes more challenging, requiring reserve antibiotics, more careful therapeutic adjustments, and more laboratory support. qualified.

In the economic field, bacterial resistance also imposes high costs on systems. health-related, as it usually requires longer hospital stays, the use of more expensive antibiotics, and greater demand.

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through isolation, additional tests, and intensive support. Naylor *et al.* (2025) point out, in modeling internationally, the financial impact of the resistance extends beyond the immediate hospital environment and It reaches families, public services and the economy more broadly, while the OECD (2023) It reinforces that this problem also manifests itself in productivity losses and structural overload. for healthcare systems.

Thus, understanding antimicrobial resistance in hospital bacteria It needs to encompass a perspective that goes beyond the microbiological dimension, reaching directly... The quality of care and the clinical prognosis of patients. The data discussed by GBD 2021. Antimicrobial Resistance Collaborators (2024), Allel *et al.* (2024), De Araujo *et al.* (2025), Naylor *et al.* (2025) and OECD (2023) show that its effects are reflected in increased mortality, in prolonged hospital stay, increased need for intensive care support, and increased of the social and welfare costs, which reinforces the importance of continuous monitoring and diagnosis. timely and permanent prevention and control measures.

3. Materials and Methods

This study is characterized as a bibliographic research, with a qualitative approach. with descriptive and exploratory purposes. The bibliographic research was developed from material already published, such as scientific articles, guidelines, institutional documents and technical publications, being suitable for analyzing topics already discussed in the scientific literature. The qualitative approach, In turn, it allowed for the interpretation and understanding of the phenomenon studied through critical analysis of information gathered without using statistical data as the central focus of the investigation (Gil, 2019; Lakatos; Marconi, 2021).

Regarding the objectives, the research is descriptive in nature, as it presents and discusses the... main aspects related to antimicrobial resistance in hospital bacteria, and exploratory, as it seeks greater familiarity with the topic and broadens understanding based on... Collection and organization of relevant scientific productions (Gil, 2019; Lakatos; Marconi, 2021).

For the study, a literature review was conducted using databases. scientific and institutional sources recognized in the health field, with the purpose of gathering Updated publications on antimicrobial resistance in hospital settings were used. as primary sources of information, databases such as *PubMed* and scientific journals in the field, in addition to technical documents and guidelines published by leading institutions, such as the Organization World Health Organization (WHO), the *Centers for Disease Control and Prevention* (CDC), the Agency The National Health Surveillance Agency (ANVISA), the Pan American Health Organization (PAHO), and Organisation for Economic Co-operation and Development (OECD).

The literature search was conducted using descriptors related to the topic, in

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In Portuguese and English, in order to bring together productions that directly engaged with the proposal of study. In selecting the material, priority was given to more recent works, especially those from the last five years, without disregarding previous publications that presented conceptual relevance. for understanding the topic.

The selection of material included scientific articles, reviews, technical documents, and guidelines. focused on antimicrobial resistance in hospital bacteria, prioritizing approaches on biological mechanisms, dispersal, control, and clinical and economic impacts. Conversely, Duplicate productions or those with low adherence to the theme were discarded, as well as texts whose analyses proved insufficient for the scope of the research or lacked scientific validation and Recognized institution.

Once the data collection phase was completed, a detailed examination of the material was carried out using... exploratory and analytical readings, followed by an interpretative synthesis of the content. This This approach allowed for the structuring of information into thematic areas, providing a solid foundation. The theoretical framework necessary for the proposed discussion. Given that the research was limited to a survey. Bibliographical, without the participation of human beings or animals, the submission to was dispensed with. instances of ethics in research.

4. Results and Discussion

The studies analyzed show that antimicrobial resistance in hospital bacteria already exists. It presents itself as a well-established problem in healthcare practice, with particular emphasis on its presence. in intensive care units, respiratory infections, bloodstream and circulatory infections of multi-resistant Gram-negative bacteria, as demonstrated by Machado *et al.* (2025). This The panorama also shows that national and international surveillance has reinforced centrality. of the topic, both through the identification of priority pathogens with high clinical and epidemiological impact, according to the World Health Organization (2024), as well as by strengthening notification and Monitoring in health services, as highlighted by the National Health Surveillance Agency. (2025).

In the body of literature analyzed, the following stand out as recurring mechanisms of resistance. The modification of the drug's site of action, enzyme inactivation, and reduction of permeability. cellular and efflux pump activity, as described by Darby *et al.* (2023) and Belay *et al.* (2024). A Horizontal gene transfer and biofilm formation also appear as processes. relevant to bacterial persistence and dissemination, as pointed out by Liu *et al.* (2024) and Wachino *et al.* (2025). These mechanisms are related to factors present in the hospital environment, such as use Inadequate use of antimicrobials, invasive devices, prolonged hospital stay, and failures. in infection prevention and control measures, a scenario discussed by Geng *et al.* (2025).

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Analysis of the studies also shows that bacterial resistance has a direct impact on...
patient safety and hospital dynamics are associated with increased mortality,
prolonged hospital stays and a greater need for intensive care, as indicated
the global study of GBD 2021 Antimicrobial Resistance Collaborators (2024) and Allel's findings
et al. (2024). In more severe contexts, such as bloodstream infections by
Carbapenem-resistant Enterobacterales, De Araujo *et al.* (2025) also relate this profile.
infectious to death. Added to this are the economic impacts, as Naylor *et al.* (2025)
They demonstrate that the limitation of therapeutic options, the use of more expensive antibiotics, and the
Increased diagnostic and therapeutic support increases the financial pressure on healthcare services.
health.

Regarding coping strategies, the results reinforce that the most effective measures are...
Effective measures are those applied in an integrated manner. (National Health Surveillance Agency, 2023)
highlights the importance of antimicrobial stewardship and the institutional organization of these measures.
actions, while Ntim *et al.* (2025) point to favorable results for structured interventions in
intensive care units. Similarly, Geng *et al.* (2025) show that measures such as
Contact precautions, environmental cleaning, and stewardship achieve better results when
developed in a combined manner, and Carneiro *et al.* (2025) reinforce the relevance of surveillance.
microbiological and the strengthening of institutional policies for the control of resistance.

Thus, the results and discussion indicate that confronting resistance
Antimicrobial resistance in hospital-acquired bacteria depends on continuous monitoring and rational use of...
antimicrobials and strengthening of care and institutional practices aimed at prevention,
as highlighted by the National Health Surveillance Agency (2023) and Geng *et al.* (2025). The literature
The analysis also shows that preserving the effectiveness of these medications involves not only advances
scientific, but also the ongoing improvement of health services and the consolidation of
Integrated control strategies in the hospital environment, a perspective reinforced by Carneiro *et al.*
(2025).

Final Considerations

Antimicrobial resistance in hospital bacteria is a major problem.
Its relevance to healthcare is due to its association with increased mortality.
prolonged hospitalization, limited treatment options, and increased costs
hospitals. Throughout this study, it was possible to understand that this phenomenon involves not only
the biological behavior of microorganisms, but also factors related to use.
Inadequate use of antimicrobials, the dynamics of the hospital environment, and the use of devices
invasive procedures, patient circulation, and failures in infection prevention and control measures.

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It has been identified that bacterial resistance results from a wide range of processes.
adaptive factors, whose spread is amplified in critical care settings marked by the use of...
extensive use of antibiotics and operational weaknesses in infection control. The severity of
The clinical and financial consequences confirm the need for continuous healthcare governance.
capable of supporting integrated prevention strategies based on the epidemiological reality of each
health service.

It is understood that the objective of the study was achieved, since the analysis allowed for an understanding of the
Antimicrobial resistance in hospital bacteria under different aspects, including their
resistance mechanisms, dissemination factors, clinical and economic impacts, and the main
prevention and control strategies. The findings discussed show that addressing this
The problem depends on integrated actions, with emphasis on the rational use of antimicrobials, and
epidemiological and microbiological surveillance, qualification of laboratory support, education
Permanent staffing of the teams and the strengthening of infection prevention and control measures.

It is concluded that antimicrobial resistance in hospital bacteria remains a
This is a significant challenge for health services and requires constant attention from the scientific community.
from managers and professionals in the field. Continued studies on the subject can contribute
for the improvement of surveillance policies, the strengthening of control strategies and the
quality of care provided to patients.

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