

Epidemiology of Gram-positive and Gram-negative Pathogens in Brazil: An Integrative Review Based on BR-GLASS Data

Epidemiologia dos Patógenos Gram-positivos e Gram-negativos no Brasil: Revisão Integrativa Baseada em Dados do BR-GLASS

Epidemiología de los Patógenos Grampositivos y Gramnegativos en Brasil: Revisión Integrativa Basada en Datos del BR-GLASS OMS

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REVISA

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RESUMO

A resistência antimicrobiana constitui um dos maiores desafios de saúde pública atuais, sendo responsável por custos hospitalares em alta escala e alta morbimortalidade. Objetivase com essa revisão integrativa da literatura a investigação sobre o tema, visando desacelerar a epidemiologia dos patógenos Gram-positivos e Gram-negativos no Brasil, com base nos relatórios do BR-GLASS e da OMS. O percurso metodológico iniciou-se com a seleção de descritores, encontrados no dicionário Descritores em Ciências da Saúde (DeCS), possibilitando o achado de 21 artigos publicados em bases de dados, como National Library of Medicine (PubMed). A triagem seguiu os critérios do fluxograma PRISMA, e a análise crítica foi conduzida por abordagem qualitativa. Os resultados evidenciaram que, entre 2018 e 2022, os principais patógenos isolados em hospitais brasileiros foram *Escherichia coli*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa* e *Staphylococcus aureus*, com destaque para a alta prevalência de genes de resistência como blaKPC, blaNDM e OXA-48. Observou-se aumento significativo na detecção de carbapenemases, especialmente no período pós-pandemia, além de elevadas taxas de multirresistência, incluindo MRSA e VRE, evidenciando a gravidade do cenário da resistência antimicrobiana no país.

Palavras-chave: Epidemiologia; Resistência Antimicrobiana; GLASS-BR.

ABSTRACT

Antimicrobial resistance (AMR) is one of the most pressing public health issues today, contributing to increased hospital costs and high morbidity and mortality. This integrative literature review aimed to analyze the epidemiology of Gram-positive and Gram-negative pathogens in Brazil, using data from BR-GLASS and WHO reports. Using Health Sciences Descriptors (DeCS), 21 relevant articles were selected from databases such as PubMed, following PRISMA guidelines. A qualitative analysis revealed that, from 2018 to 2022, the most commonly isolated hospital pathogens in Brazil were *Escherichia coli*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*. A high prevalence of resistance genes—particularly blaKPC, blaNDM, and OXA-48—was found. The post-pandemic period showed a marked increase in carbapenemase detection and multidrug-resistant strains, including MRSA and VRE, underscoring the severity of AMR in the country.

Keywords: Epidemiology; Antimicrobial Resistance; GLASS-BR.

RESUMEN

La resistencia antimicrobiana (RAM) representa uno de los desafíos más críticos para la salud pública, generando elevados costos hospitalarios y una alta morbimortalidad. Esta revisión integrativa de la literatura tuvo como objetivo analizar la epidemiología de patógenos Gram positivos y Gram negativos en Brasil, con base en los datos del BR-GLASS y de la OMS. A través de descriptores del DeCS, se seleccionaron 21 artículos relevantes en bases como PubMed, siguiendo los criterios del diagrama PRISMA. El análisis cualitativo mostró que entre 2018 y 2022, los principales patógenos hospitalarios en Brasil fueron *Escherichia coli*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa* y *Staphylococcus aureus*. Se identificó una alta prevalencia de genes de resistencia, especialmente blaKPC, blaNDM y OXA-48. El período pospandemia evidenció un aumento significativo en la detección decarbapenemasas y en cepas multirresistentes como MRSA y VRE, lo que refuerza la gravedad del escenario de la RAM en el país.

Descriptores: Epidemiología; Resistencia Antimicrobiana; GLASS-BR.

REVISÃO

Introduction

Antimicrobial resistance (AMR) is one of the most pressing public health issues today, contributing to increased hospital costs and high morbidity and mortality. It consists of strains of microorganisms that multiply in the presence of antimicrobial concentrations higher than the therapeutic doses used in humans. Bacterial infections acquired in the hospital environment, which were not present or incubating at the time of admission, are especially targeted by the scientific community, particularly for being frequently caused by multidrug-resistant strains.^{1, 2, 7}

In addition to the main problem of resistance, the landscape of multidrug-resistant Gram-positive and Gram-negative pathogens is composed of a high capacity for dissemination and elevated mutagenesis. Currently, the main bacteria that fit into this category are: among Gram-positives, Oxacillin-resistant *Staphylococcus aureus* (MRSA) and Vancomycin-resistant *Enterococcus* (VRE) stand out; among Gram-negatives, there are CESP group bacteria, mainly *Citrobacter spp* and *Enterobacter spp*, as well as carbapenemase-producing *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* (carbapenem-hydrolyzing enzymes).^{3,4,5, 6, 8}

In 2017, following the standard of the World Health Organization (WHO), which created the Global Action Plan applied to epidemiological surveillance, Brazil established its own surveillance system: BR-GLASS (Brazilian Antimicrobial Resistance Surveillance System), a project that aims to cover 95 hospitals across the national territory, gathering critical data on the main pathogens isolated in different clinical contexts.^{1, 2, 9}

Thus, the objective of this integrative review is to investigate antimicrobial resistance, aiming to slow down the epidemiology of Gram-positive and Gram-negative pathogens in Brazil, based on BR-GLASS and WHO reports, in order to identify trends, gaps, and potential strategies to support public policies, guide clinical protocols, and direct future research.

Method

This is an integrative literature review, with the objective of gathering, analyzing, and synthesizing information about the use of the epidemiology of Gram-positive and Gram-negative pathogens in Brazil. The guiding research question was: "What is the current epidemiological panorama of Gram-positive and Gram-negative pathogens in Brazil, according to BR-GLASS and WHO data?" The bibliographic research was conducted between July and August 2025, covering articles published between June 2005 and January 2025, ensuring a comprehensive view of the theme. The methodological system used began with the selection of descriptors, found in the Health Sciences Descriptors (DeCS) dictionary, such as "Epidemiology" and "Antimicrobial Resistance," which were combined, using the Boolean operator "AND," with the descriptor: "Brazil." This systematization strategy enabled the finding of 21 articles published in databases, such as the National Library of Medicine (PubMed). In the screening phase, three researchers independently selected and excluded the articles. Four were excluded for duplication, 2 for not using BR-GLASS or WHO GLASS criteria for analysis, and 4 for not addressing antimicrobial resistance, resulting in 11 final selected articles. The selection

and exclusion of studies followed the PRISMA flowchart criteria, and the critical analysis followed a qualitative approach, seeking to identify convergences and divergences between the studies, as well as research gaps. All included articles fully provided data and were available in Portuguese and/or English. The limitations of this review include the temporal restriction and the reduced number of studies; the contributions involve the critical systematization of recent literature and the identification of gaps for future research. Regarding ethical aspects, as this is an integrative review based exclusively on already published secondary data, submission to the Research Ethics Committee was not required.

Results

In order to facilitate the synthesis of the studies present in the analysis, the information was categorized in Table I, including: author, title, methodology, and main results found.

Table I - Categorization of studies.

Author	Title	Methodology	Results
Pillonetto Jordão Andraus GS, et al. ¹	The Experience of Implementing the National Antimicrobial Resistance Surveillance System in Brazil.	Retrospective descriptive study, with analysis of clinical samples processed by 3 hospitals in the state of Paraná, Brazil, in 2018.	The BR-GLASS 2018 analysis included 11,347 bacterial isolates from blood, urine, and respiratory tract samples, 43.6% of which were from hospital outpatients. A total of 200,874 antimicrobial susceptibility tests were performed on these samples, with 24.5% indicating resistance (overall result: 30.8% (hospital result)). The most identified organisms were: <i>Escherichia coli</i> (32.5%) followed by <i>Staphylococcus aureus</i> (12.5%).
Kiffer Rezende Costa-Nobre I et al. ²	A 7-Year Brazilian National Perspective on Plasmid-Mediated Carbapenem Resistance in Enterobacterales and the Impact of the Coronavirus Disease 2019 Pandemic on Their Occurrence.	Retrospective study, analyzing data sent by Brazilian hospitals to the National Antimicrobial Resistance Surveillance Network between 2015 and 2021, aiming at carbapenem resistance testing.	The analysis of microorganisms regarding the presence of carbapenemases in Enterobacterales showed a detection rate of 68.6% for blaKPC gene and 14.4% for blaNDM. An annual trend showed a 41.1% increase in blaKPC detection and an annual reduction of 4% in blaNDM was observed. Comparing pre-pandemic and pandemic periods, there was a 65.2% increase in the number of isolates of carbapenem-resistant Enterobacterales.

Gales AC, HS, Ribeiro J, et al	Antimicrobial susceptibility of gram-positive bacteria isolated from Brazilian hospitals participating in the SENTRY Program (2005-2011)	Retrospective laboratory surveillance, in which 10,000 samples of Gram-positive cocci isolated from Brazilian hospitals participating in the SENTRY international surveillance program were collected.	The main identified pathogens were <i>Staphylococcus aureus</i> (30.3%); 31% of <i>S. aureus</i> strains were resistant to Oxacillin (MRSA). Daptomycin demonstrated more than 90% susceptibility to <i>S. aureus</i> , being highly effective.
Bittencourt Faustino Batista PM, et al	Activity of ceftolozane/tazobactam against Gram-negative bacilli: Results from the SMART Study for Monitoring Antimicrobial Resistance Trends (SMART - Brazil), 2018-2021.	Retrospective, descriptive and multicenter laboratory study, with analysis of 3,994 isolates by microdilution method followed by molecular analysis for the detection of resistant genes.	3,994 Gram-negative bacilli isolates were analyzed in two distinct periods: 2018-2019 and 2020-2021. The most identified microorganisms were <i>Escherichia coli</i> and <i>Klebsiella pneumoniae</i> , with 43% susceptibility to ceftolozane/tazobactam. <i>E. coli</i> was susceptible to antimicrobial activity. <i>K. pneumoniae</i> presented 43% susceptibility, due to the presence of the bla _{KPC} gene, responsible for carbapenemase production. There were no significant differences between the analyzed periods.
Silveira Rocha-de-Souza CM, de Oliveira Santos IC, et al	Genetic Basis of Antimicrobial Resistant Gram-Negative Bacteria Isolated From Bloodstream Infections in Brazil.	Complete genomic analysis of Gram-negative bacilli from hospital samples, seeking to identify the genetic basis of antimicrobial resistance.	The main genetic lineages of Gram-negative risk clones identified were <i>Klebsiella pneumoniae</i> (clonal sequence CC258), <i>Acinetobacter baumannii</i> (clonal sequence ST79), and <i>Pseudomonas aeruginosa</i> (clonal sequence ST233). Such clones are considered high risk due to their multiple resistance capacity.

<p>SANTOS, Elaine REZENDE, Da & ÁV Cristiane.⁶</p>	<p>Infecção de corrente sanguínea e multirresistência em unidades de terapia intensiva.</p>	<p>Observational retrospective study conducted in a tertiary hospital in North Minas Gerais, Brazil, between January 1, 2019, and October 31, 2022.</p>	<p>Between 2019 and 2022, Gram-positive bacteria were the most isolated. However, a gradual increase in Gram-negative etiology was observed. Resistance to more than 50% of the antimicrobials tested was observed in at least 3 classes of Gram-negative bacteria, indicating multidrug resistance.</p>
<p>Naue, Carin Ribeiro, Térc Ribeiro, Rafael Batista, et al.⁷</p>	<p>Ocorrência e perfil bacteriano de culturas coletadas em pacientes internados na unidade de terapia intensiva em um hospital terciário.</p>	<p>Analysis of tracheal secretion, blood culture, and urine culture from hospitalized patients between January and December 2018.</p>	<p>The bacterial species with the highest resistance were <i>Acinetobacter baumannii</i>, <i>Klebsiella pneumoniae</i>, <i>Pseudomonas aeruginosa</i>, <i>Escherichia coli</i>, <i>Stenotrophomonas maltophilia</i>, and <i>Enterobacteriaceae</i>.</p>
<p>Mota FS, Oliveira HA, Souto RC</p>	<p>Perfil e prevalência de resistência aos antimicrobianos de bactérias Gram-negativas isoladas em pacientes de uma unidade de terapia intensiva.</p>	<p>Descriptive retrospective study of medical records of patients hospitalized in the Intensive Care Unit of Hospital Santa Casa de Misericórdia de Goiânia.</p>	<p><i>K. pneumoniae</i> presented greater resistance to ampicillin and cephalosporins; in <i>E. coli</i>, resistance was greater to ampicillin and ciprofloxacin. For <i>A. baumannii</i>, cephalosporins, quinolones, and carbapenems obtained the highest resistance. In <i>P. aeruginosa</i>, the greatest resistance was observed to cephalosporins and carbapenems.</p>
<p>Dos Santos Cayô R, Valiati et al.⁹</p>	<p>Biodiversidade de carbapenemase resistente em bactérias em amostras de pacientes internados em unidades de terapia intensiva (Rondônia/Brazil).</p>	<p>Retrospective study conducted at the Central Public Health Laboratory of Rondônia (LACEN), Brazil, between 2018 and 2022.</p>	<p>Carbapenemase genes were found in 25 resistant species. <i>A. baumannii</i> showed the highest detection, followed by <i>K. pneumoniae</i>, <i>P. aeruginosa</i>, and <i>E. coli</i>. The total number of carbapenemase genes detected increased from 18 (2018) to 448 (2022), representing a growth of 140.86%.</p>

Source: Personal collection (2025).

Discussion

The results highlighted in this article demonstrate the complexity of antimicrobial multidrug resistance after hospital admission in Brazil, given the high rates of morbidity and mortality due to Gram-negatives, such as *Klebsiella pneumoniae*, *Enterobacter spp.*, *Citrobacter spp.*, and *Pseudomonas aeruginosa*, often associated with the production of carbapenemases, and Gram-positives, such as oxacillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant *Enterococcus* (VRE).

The genetic diversity of these enzymes, such as KPC, NDM, and OXA-48, complicates treatment and increases the risk of intra-hospital dissemination. Recent data from the Brazilian Amazon region highlighted the biodiversity of carbapenem-resistant strains, showing the presence of high-risk clones and reinforcing the need for regional containment strategies.

Finally, it is understood that, despite the great advance established with BR-GLASS, the surveillance system still proves to be limited, especially regarding the collection of longitudinal data that allow for the understanding of resistance trends. Furthermore, it is emphasized that the increased empirical use of antibiotics during the COVID-19 pandemic may have contributed to the amplification of resistant strains, given the increase in resistance rates during this period.

Final Considerations

Antimicrobial resistance in Brazil should not only be seen in an epidemiological context but also a cultural and structural one, as it reflects a set of measures and determinants of the national health system. The lack of effective public policies related to the rational use of medicines, associated with hospital overload and the heterogeneity of epidemiological surveillance, favor the high mutability of multidrug-resistant strains, such as the Gram-positive and Gram-negative pathogens cited in this article.

Therefore, it becomes essential to strengthen epidemiological surveillance programs, such as BR-GLASS, and invest in new therapeutic alternatives, simultaneously with the elaboration of more assertive therapeutic protocols and the planning of effective public policies.

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