



PRIMARY BLOODSTREAM INFECTIONS IN INTENSIVE CARE UNITS: RETROSPECTIVE STUDY OF SECONDARY DATA

INFECÇÕES PRIMÁRIAS DE CORRENTE SANGUÍNEA EM UNIDADES DE TERAPIA INTENSIVA: ESTUDO RETROSPECTIVO DE DADOS SECUNDÁRIOS

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How to cite: Paviani TF, Boneli V, Linch GFC, Paz AA, Lima AAA. Primary bloodstream infections in intensive care units: retrospective study of secondary data. *Online Braz J Nurs.* 2025;24(Suppl 2):e20256894. <https://doi.org/10.17665/1676-4285.20256894>

RESUMO

Objetivo: Descrever a distribuição espacial de microrganismos causadores de infecções primárias de corrente sanguínea em unidades de terapia intensiva no Brasil. **Método:** Estudo observacional, retrospectivo de análise documental, conduzido conforme o STROBE, baseado em dados secundários da Agência Nacional de Vigilância Sanitária e do Instituto Brasileiro de Geografia e Estatística, referentes a 2019–2022. Realizou-se análise descritiva com auxílio dos recursos do Microsoft Excel®, obtendo frequências absolutas e relativas, taxas por 100 mil habitantes e comparação entre as cinco regiões brasileiras. **Resultados:** Identificaram-se heterogeneidades regionais na composição microbiológica: entre os Gram-negativos, destacou-se a *Klebsiella pneumoniae* em todas as regiões; dos Gram-positivos, o *Staphylococcus* coagulase-negativa foi o mais frequente, especialmente no Sul, Centro-Oeste e Sudeste. A *Candida* não-albicans predominou entre os fungos, na maioria das regiões. Observou-se aumento expressivo em 2021, seguido de redução em 2022. **Conclusão:** O padrão espacial aponta necessidades regionais distintas na distribuição dos microrganismos causadores de infecções primárias de corrente sanguínea. Os achados refletem também os impactos do período pandêmico sobre a ocorrência dessas infecções e reforçam a necessidade de estratégias regionais de prevenção e controle, com foco em vigilância ativa e integração de dados no sistema público de saúde.

Descritores: Infecção da Corrente Sanguínea; Unidades de Terapia Intensiva; Monitoramento Epidemiológico; Infecções Relacionadas à Assistência à Saúde; Infecções Relacionadas a Cateter.

ABSTRACT

Objective: To describe the spatial distribution of microorganisms responsible for primary bloodstream infections in intensive care units in Brazil. **Method:** Observational and retrospective study with documentary analysis conducted in accordance with STROBE, based on secondary data from the National Health Surveillance Agency and the Brazilian Institute for Geography and Statistics referring to 2019–2022. Descriptive analysis was performed using Microsoft Excel® resources, obtaining absolute and relative frequencies, rates per 100,000 inhabitants, and comparisons among the five Brazilian regions. **Results:** Regional heterogeneity was identified in microbiological composition: among Gram-negatives, *Klebsiella pneumoniae* predominated in all regions; among Gram-positives, coagulase-negative *Staphylococcus* was most frequent, especially in the South, Central-West, and Southeast. Non-albicans *Candida* predominated among fungi in most regions. A considerable increase was observed in 2021, followed by a reduction in 2022. **Conclusion:** The spatial pattern reveals distinct regional needs regarding the distribution of microorganisms causing primary bloodstream infections. The findings also reflect the pandemic period's impact on these infections' occurrence and emphasize the need for regional prevention and control strategies focused on active surveillance and data integration within the public health system.

Descriptors: Bloodstream Infection; Intensive Care Units; Epidemiological Monitoring; Healthcare-Associated Infections; Catheter-Related Infections.

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What is already known:

- Primary bloodstream infections are frequent events among critically ill patients admitted to ICUs.
- Multidrug-resistant microorganisms such as *Klebsiella pneumoniae* and coagulase-negative *Staphylococcus* are prevalent in critical settings.
- Nursing professionals play a crucial role in preventing and controlling BSIs.

What this study adds:

- It revealed regional variations in the microbiological profile of BSIs in Brazilian ICUs.
- It identified a significant increase in microorganisms in 2021, followed by a decline in 2022.
- It reinforced the relevance of active and integrated microbiological surveillance within the Unified Health System (Sistema Único de Saúde, SUS).

INTRODUCTION

Healthcare-associated infections (HAIs) are complications that arise during or after hospitalization, provided they are associated with procedures, care, or exposures within the hospital environment⁽¹⁾. They constitute one of the most frequent adverse events related to healthcare and represent a serious public health problem, as they increase morbidity, mortality, length of hospital stay, and care-related costs. HAIs also compromise patient safety and the quality of healthcare services⁽²⁻⁴⁾. From an international perspective, HAIs remain a public health priority, with substantial clinical and economic impact and uneven implementation of prevention and control practices across countries⁽²⁾. In intensive care units (ICUs), the risk is significantly higher; European surveillance estimates indicate that approximately 16% of patients hospitalized for more than 48 hours present at least one HAI⁽⁵⁾.

In ICUs, a specific type of HAI that deserves attention is primary bloodstream infection (PBSI), which affects patients using a central venous catheter (CVC) for at least 48 hours, considering “Day 1” as the first day the device is used. The CVC usually remains for long periods and is frequently handled throughout the day by different healthcare professionals. Infection may occur while the CVC is still in place or up to one day after its removal⁽⁶⁾.

The CVC is a widely used device in ICUs because it provides direct access to the vascular system. However, it is directly related to the occurrence of PBSI due to exposure of the intravascular environment to external contamination. This vulnerability results from the possibility that microorganisms present on the skin may enter the bloodstream during catheter handling, particularly through healthcare workers’ hands, in addition to the patient’s severe clinical condition, which compromises immune response⁽⁶⁾.

The nursing team plays a strategic role in preventing and controlling PBSI, especially in ICUs, where it provides direct patient care, including routine management of invasive devices such as CVCs. Recent guidelines indicate that the consistent implementation of infection prevention and control practices, including hand hygiene, aseptic technique during catheter insertion and handling, skin antisepsis with alcohol-based chlorhexidine, proper device maintenance, and daily reassessment of catheter need, as well as continuous education and auditing actions, is associated with reduction of HAIs^(2,7).

Nursing practice, therefore, goes beyond technical execution, encompassing active surveillance, care management, and effective contribution to quality and safety within the Unified Health System (SUS). However, despite the central role of nursing in infection prevention and surveillance, structural challenges persist that hinder a comprehensive understanding of the microbiological profile in Brazilian ICUs.

Despite advances in HAI prevention and control protocols, there remains a significant gap in identifying the mi-

crobiological profile of microorganisms responsible for PBSI across different Brazilian regions. Previous studies have addressed isolated or regional data, which limits an integrated view of microorganism distribution over time⁽⁸⁻⁹⁾. The COVID-19 pandemic changed ICU care dynamics, including human resource availability, intensified use and duration of invasive devices, and training routines, factors that may influence infection prevention and control measures^(8,10). In this context, expanding the understanding of regional and temporal distribution of these microorganisms using national data is essential to support more effective prevention strategies within SUS. This study aimed to describe the spatial distribution of microorganisms responsible for primary bloodstream infections in intensive care units in Brazil.

METHOD

Study design

Observational and retrospective study with documentary analysis based on the recommendations of the Strengthening of Reporting of Observational Studies in Epidemiology (STROBE) checklist, according to Equator Network guidelines. The study was conducted using publicly available secondary data obtained from two main sources: the Patient Safety and Quality in Health Services Information Bulletin – Evaluation of National Indicators of Healthcare-Associated Infections (HAI) and Antimicrobial Resistance (AMR), published by the National Health Surveillance Agency (*Agência Nacional de Vigilância Sanitária, ANVISA*); and population estimates from the 2010 Census for the period 2019 to 2021, as well as the 2022 Census of the Brazilian Institute for Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística, IBGE*), specifically population estimates for 2010–2021 and results from the 2022 Demographic Census⁽¹¹⁻¹³⁾. The period of analysis covered 2019 to 2022.

ANVISA bulletins provide detailed information on the microbiological profile of laboratory-confirmed primary bloodstream infections, while IBGE censuses supply demographic data to support contextual interpretation of the microbiological analysis.

Study setting

The study encompassed the five major geographic regions of Brazil: North, Northeast, Central-West, Southeast, and South.

Data collection

The period of analysis spanned 2019 to 2022, covering the year preceding and the years following the onset of the COVID-19 pandemic in Brazil. Data collection occurred

between June and July 2024 through extraction of publicly accessible information available in ANVISA and IBGE platforms.

Study variables

Variables extracted from the selected databases included: identified microorganism (laboratory-confirmed PBSI), taxonomic group (Gram-positive, Gram-negative, fungi), year of record, geographic region, and number of cases by region and year. From IBGE, population counts by region and year were obtained to calculate rates per 100,000 inhabitants.

Data analysis

Data were organized in Microsoft Office Excel® spreadsheets and subjected to descriptive statistical analysis. The analysis involved distribution of microorganisms in absolute (n) and relative (%) values, adjusted for 100,000 inhabitants according to region and year (IBGE denominator), stratified by year (2019–2022), region, and taxonomic group, and, when applicable, by species with higher incidence. For period synthesis, means for 2019–2022 by region and microorganism, annual percentage variation, and absolute differences between 2019 and 2022 were estimated, emphasizing regional distribution and temporal evolution.

Bias control

Microbiological nomenclature was standardized among bulletins; records without microorganism identification and/or without regional indication were excluded from comparative analyses. Rates per 100,000 inhabitants were used to mitigate population differences across regions.

Ethical aspects

As this research relied exclusively on publicly available and unrestricted-access sources, submission to a Research Ethics Committee was not required, in accordance with Resolution No. 466/2012 of the National Health Council. All ethical principles related to the use of secondary data were respected, including appropriate citation of sources and protection of personal information, in compliance with copyright provisions established by Law No. 12.853/2013.

RESULTS

In adult ICUs nationwide, 18,847 primary bloodstream infection (PBSI) cases were recorded in 2019, 26,503 in 2020, 41,902 in 2021, and 28,810 in 2022. The corresponding national rates per 100,000 inhabitants were 8.97, 12.52, 19.64, and 14.19, respectively, with a peak in 2021 followed by a reduction in 2022. The following sections present regional and microorganism group variations.

In Figure 1, higher cumulative incidence (2019–2022) was observed in the Southeast (59.8 per 100,000 inhabitants) and Central-West (54.1 per 100,000 inhabitants) regions, followed by the South (53.9 per 100,000 inhabitants), while the Northeast (38.2 per 100,000 inhabitants) and North (24.4 per 100,000 inhabitants) showed lower figures. By category, Gram-positive and Gram-negative microorganisms dominated the profile across all regions, whereas fungi

accounted for a smaller share (approximately 5.7% of the total during the period). Nationwide, Gram-positive microorganisms slightly predominated (48.1%) compared with Gram-negatives (46.1%). Regionally, Gram-negatives were relatively higher in the Central-West and Northeast, while Gram-positives prevailed in the South, Southeast, and North. Colors are not comparable across panels, as each map uses an independent color scale.

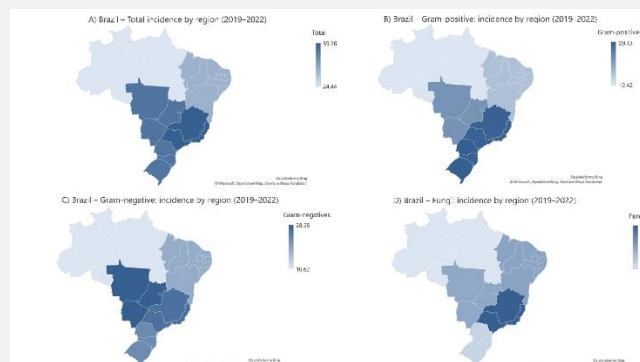


Figure 1 - Spatial distribution of incidence per 100,000 inhabitants by region in Brazil, 2019–2022: (a) Total; (b) Gram-positive microorganisms; (c) Gram-negative microorganisms; (d) fungi. Darker shades indicate higher incidence. Independent color scales for each panel
 Source: prepared by the authors, 2025.

In Figure 2a, Gram-negative microorganisms showed an upward trend in all regions up to 2021, followed by decline in 2022. This pattern was most pronounced in the Central-West, which recorded the highest rates throughout the period, in contrast with the North, where incidence remained consistently low.

In Figure 2b, Gram-positives also increased until 2021 and then declined. The South stood out with the highest values in that year, while the Northeast maintained a continuous upward trajectory, differing from other regions by the absence of decline in 2022.

In Figure 2c, fungi became evident from 2020 onwards, with initial growth in all regions followed by slight reduction in 2022. The highest concentration occurred in the Southeast, while the North maintained residual levels throughout the analyzed period.

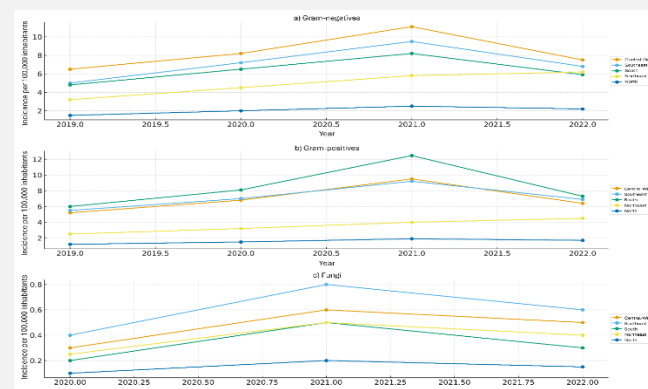


Figure 2 - Time series of incidence per 100,000 inhabitants of microorganisms by taxonomic group and region in Brazil, 2019–2022: (a) Gram-negatives; (b) Gram-positives; (c) fungi. Fungal records from 2020 onwards. Lines represent the five Brazilian regions
 Source: prepared by the authors, 2025.

In the 2019–2022 mean (Table 1), among Gram-negatives, *Klebsiella pneumoniae* stood out in all regions, with higher values in the Central-West (2.72 per 100,000 inhabitants) and South (2.14 per 100,000 inhabitants). Among Gram-positives, coagulase-negative *Staphylococcus* showed the highest values, mainly in the South (4.18 per 100,000 inhabitants), Central-West (3.54 per 100,000 inhabitants), and

Southeast (3.43 per 100,000 inhabitants). Regarding fungi, non-*albicans Candida* predominated across most regions, with higher values in the Southeast (0.60 per 100,000 inhabitants) and Northeast (0.46 per 100,000 inhabitants), while in the North, *Candida albicans* prevailed (0.18 per 100,000 inhabitants).

Table 1 - Mean incidence (2019–2022) of the most frequent microorganisms by region in Brazil

Region	Gram- negatives			Gram- positives		Fungi	
	<i>Klebsiella pneumoniae</i>	<i>Acinetobacter</i>	<i>Pseudomonas aeruginosa</i>	Coagulase-negative <i>Staphylococcus</i>	<i>Staphylococcus aureus</i>	Non- <i>albicans Candida</i>	<i>Candida albicans</i>
Central-West	2.72	1.26	1.2	3.54	1.08	0.4	0.28
Southeast	1.94	1.68	0.99	3.43	2.38	0.6	0.48
South	2.14	0.64	0.82	4.18	1.83	0.23	0.22
Northeast	1.54	0.92	0.83	2.87	0.86	0.46	0.25
North	0.78	0.55	0.4	1.73	0.5	0.16	0.18

Source: prepared by the authors, 2025.

When comparing microorganism incidence across Brazilian regions, Gram-negative and Gram-positive bacteria displayed similar patterns in most regions, with progressive increases until 2021 followed by decline in 2022. The exception was the Northeast, where both categories maintained a steady upward trend throughout the study period. The Central-West recorded the highest Gram-negative rates in 2021 (11.10 per 100,000 inhabitants), whereas the South showed the highest Gram-positive values that same year (12.46 per 100,000 inhabitants). The North consistently presented the lowest bacterial rates in all evaluated years, with little annual variance.

Regarding fungi, records began only in 2020. Overall, there was an increase from 2020 to 2021 across all regions, followed by stabilization and moderate decline in 2022. The South showed more pronounced fluctuations, while the North and Northeast maintained more stable patterns.

Analyzing microorganism types, among Gram-negative bacteria, *Klebsiella pneumoniae* had the highest incidence in all regions. In the Central-West, 2.72 cases per 100,000 inhabitants were recorded, followed by *Acinetobacter* spp. with 1.26 and *Pseudomonas aeruginosa* with 1.20. In the Southeast, *Klebsiella pneumoniae* registered 1.94, followed by *Acinetobacter* spp. (1.68) and *Pseudomonas aeruginosa* (0.99). In the South, data showed 2.14 for *Klebsiella pneumoniae* as the most frequent organism, followed by *Pseudomonas aeruginosa* (0.82) and *Acinetobacter* spp. (0.64). In the Northeast, *Klebsiella pneumoniae* recorded 1.54, followed by *Acinetobacter* spp. (0.92). In the North, *Klebsiella pneumoniae* reached 0.78 as the most frequent organism, while *Acinetobacter* spp. presented 0.55 per 100,000 inhabitants.

Among Gram-positive bacteria, coagulase-negative *Staphylococcus* was the most frequent microorganism in all five regions, with higher values in the South (4.18), followed by the Central-West (3.54), Southeast (3.43), Northeast (2.87), and North (1.73). *Staphylococcus aureus* ranked second in all regions, with 1.83 (South), 2.38 (Southeast), 1.08 (Central-West), 0.86 (Northeast), and 0.50 (North).

The highest fungal incidence occurred in the Southeast, especially for non-*albicans Candida* (0.60). The Northeast reported 0.46 for this species, followed by the Central-West (0.40) and South (0.23). In the North, *Candida albicans*

predominated, with 0.18 per 100,000 inhabitants.

DISCUSSION

This study analyzed the spatial distribution of microorganisms responsible for primary bloodstream infections (PBSI) in Brazilian intensive care units (ICUs) during 2019–2022, using national secondary data. The Gram-negative bacterium *Klebsiella pneumoniae* predominated, particularly in the Central-West region. Among Gram-positive bacteria, coagulase-negative *Staphylococcus* was the most frequent microorganism across all regions. Regarding fungi, non-*albicans Candida* prevailed in most areas, except in the North, where *Candida albicans* was predominant. Beyond regional differences, there was a marked increase in microorganism incidence in 2021, possibly related to the repercussions of the COVID-19 pandemic on care workflows and infection control practices⁽¹⁰⁾.

Although the increase observed in 2021 may reflect heightened risk due to care overload, intensified surveillance and notification must also be considered during this period. The prioritization of healthcare-associated infections (HAIs) within institutional agendas and the requirement of mandatory national reporting may have improved case detection sensitivity, resulting in higher rates that do not necessarily indicate proportional increases in actual incidence⁽⁶⁾. This distinction is relevant, as it implies different strategic approaches: strengthening operational capacity and adherence to prevention practices on one side, and ensuring stability and standardization of surveillance and reporting processes on the other, to avoid measurement bias between years and regions⁽¹¹⁾.

From an international perspective, the findings align with reference reports describing high HAI burdens in ICUs and marked heterogeneity between countries and regions. In European surveillance networks, for instance, nearly one in six patients hospitalized for more than 48 hours in ICUs presented at least one HAI in 2021⁽⁵⁾. The World Health Organization’s 2024 global report reinforced that prevention and control practice implementation remains uneven across countries and that integrated surveillance systems are essential to reduce variability and guide interventions⁽²⁾. Within this context, the predominance of Gram-negative bacilli ob-

served in Brazil is consistent with other critical international scenarios and supports the adoption of prevention bundles and integrated surveillance, emphasizing local and regional adaptation rather than uniform approaches^(2,5,14).

In light of this spatial landscape, practical implications should be adapted to each region's microbiological profile. In areas with a higher burden of Gram-negative bacilli, priority measures include reducing central venous catheter (CVC) days through daily reassessment, maintaining active insertion and maintenance audits, and ensuring rigorous disinfection of connections and hubs. Where Gram-positive bacteria predominate, emphasis should be placed on cutaneous antisepsis with alcohol-based chlorhexidine, aseptic technique, and dressing integrity. In contexts with greater frequency of non-*albicans Candida*, risk assessment intensification, early catheter removal when indicated, and species-level identification are recommended. Consistent use of prevention bundles, audit and feedback cycles, and integrated surveillance enhances response capacity and enables early detection of microbiological pattern changes^(2,7).

The rise in microorganism incidence in 2021 may be attributed to the consequences of the COVID-19 pandemic within healthcare services, particularly ICUs. During this period, studies reported increased HAI rates linked to hospital system overload, shortage of skilled professionals, workforce turnover, and intensified use of invasive devices such as CVCs^(8,10). Furthermore, prolonged prone positioning, limited in-person training, and increased clinical severity among patients may have undermined adherence to preventive practices, contributing to PBSI occurrence⁽¹⁵⁾.

The high incidence of *Klebsiella pneumoniae* and *Acinetobacter* spp. observed in various Brazilian regions raises concerns about the progression of antimicrobial resistance, particularly in ICU settings. These microorganisms are widely recognized for their multidrug-resistant potential, which limits therapeutic options, worsens clinical prognosis, and increases hospital costs. Recent reviews highlight the association between inappropriate antimicrobial use and the emergence of resistant strains, reinforcing the need for continuous microbiological monitoring, implementation of rational antibiotic use protocols, and active surveillance of bacterial sensitivity profiles⁽¹⁵⁻¹⁶⁾.

The prevention of PBSI in ICUs depends directly on nursing performance, as this team provides continuous care to critically ill patients and routinely handles invasive devices such as CVCs. Evidence shows that the systematic implementation of insertion and maintenance bundles consistently reduces PBSI. In the national context, nursing adherence to institutional protocols, combined with ongoing education, is associated with reduced infectious complications^(7,17).

Continuing education in health is a crucial component in addressing HAIs, particularly in ICUs, where clinical complexity demands strict technical skills and continuous professional updating. Periodic educational initiatives aligned with institutional patient safety guidelines contribute significantly to adherence to effective PBSI prevention practices. Additionally, fostering a culture of safety promotes effective team communication, early risk identification, and strengthened collaborative work⁽¹⁷⁻¹⁹⁾.

REFERENCES

1. Brasil. Agência Nacional de Vigilância Sanitária.

Beyond continuing education, integration between information systems is vital to improve HAI surveillance quality. Cross-matching institutional data sources, such as ANVISA bulletins, with IBGE population information and hospital records allows more accurate monitoring of epidemiological trends, supports clinical decision-making, and guides control policies. International evidence indicates that system interoperability is among the most effective strategies for strengthening public health surveillance, promoting coordinated responses, and optimizing resources in multicenter healthcare systems^(8,20).

This study presents limitations inherent to the use of publicly available secondary data, which may contain inconsistencies or underreporting, as well as potential absence of detailed clinical information. In addition, the pandemic context may have altered case composition, resource availability, care processes, and reporting practices, introducing possible measurement biases and limiting comparability between years. Finally, the analysis restricted to 2019–2022 prevents assessment of the impact of recent prevention and control measures for PBSI.

Despite these limitations, the findings provide valuable insight into the regional distribution of microorganisms causing PBSI and highlight the need for future studies exploring the relationships among antimicrobial resistance, care workload, and the effectiveness of educational and surveillance interventions within Brazilian ICUs.

CONCLUSION

This study presented a detailed analysis of the microbiological profile distribution of microorganisms responsible for PBSI in ICUs across the five Brazilian regions during 2019–2022. Among Gram-negative bacteria, *Klebsiella pneumoniae* showed the highest incidence. Regionally, Gram-negative rates were higher in the Central-West and Southeast, whereas Gram-positives predominated in the South. A significant overall increase in microorganism incidence was observed in 2021, followed by a reduction in 2022.

The study results provide important guidance for nursing within the Unified Health System (SUS), particularly regarding the improvement of care practices, decision-making, and professional development. Recommended actions include daily reassessment of CVC necessity and early removal when indicated; implementation and monitoring of standardized insertion and maintenance bundles with active audits and feedback cycles; continuing education aligned with local profiles; rational antimicrobial use programs guided by the most frequent regional microorganisms; and integrated surveillance (interoperability among hospital databases, ANVISA, and population information) for early detection of changes and regional prioritization of resources. These actions are feasible within SUS and tend to reduce PBSI rates while optimizing resource utilization in Brazilian ICUs.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

Medidas de Prevenção de Infecção Relacionada à

- Assistência à Saúde [Internet]. Brasília (DF): ANVISA; 2017 [cited 2024 Jul 15]. Available from: <https://www.gov.br/anvisa/pt-br/centraisdeconteudo/publicacoes/servicosdesaude/publicacoes/caderno-4-medidas-de-prevencao-de-infeccao-relacionada-a-assistencia-a-saude.pdf>
- World Health Organization. Global report on infection prevention and control 2024 [Internet]. Geneva: WHO; 2024 [cited 2025 Sep 13]. Available from: <https://www.who.int/publications/i/item/9789240103986>
 - Gidey K, Gidey MT, Hailu BY, Gebreamlak ZB, Niriayo YL. Clinical and economic burden of healthcare-associated infections: A prospective cohort study. *PLoS One*. 2023;18(2):e0282141. <https://doi.org/10.1371/journal.pone.0282141>
 - Moradi S, Najafpour Z, Cheraghian B, Keliddar I, Mombeyni R. The Extra Length of Stay, Costs, and Mortality Associated With Healthcare-Associated Infections: A Case-Control Study. *Health Sci Rep*. 2024;7(11):e70168. <https://doi.org/10.1002/hsr2.70168>
 - European Centre for Disease Prevention and Control. Healthcare-associated infections acquired in intensive care units: annual epidemiological report for 2021 [Internet]. Stockholm: ECDC; 2024 [cited 2025 Sep 13]. Available from: <https://www.ecdc.europa.eu/sites/default/files/documents/healthcare-associated-infections-acquired-intensive-care-units-2021.pdf>
 - Brasil. Agência Nacional de Vigilância Sanitária. Nota técnica GVIMS/GGTES nº 07/2021. Critérios diagnósticos das infecções relacionadas à assistência à saúde (IRAS): notificação nacional obrigatória para o ano de 2022 [Internet]. Brasília (DF): ANVISA; 2021 [cited 2025 Sep 13]. Available from: <https://www.saude.df.gov.br/documents/37101/0/NT+Critérios+diagnósticos+de+IRAS+de+notificação+obrigatória+-+29.12.2021.pdf/365b6ca4-1ddf-288c-747d-ec405a0b6466?t=1683292131256>
 - Buetti N, Marschall J, Drees M, Fakhri MG, Hadaway L, Maragakis LL, et al. Strategies to prevent central line-associated bloodstream infections in acute-care hospitals: 2022 Update. *Infect Control Hosp Epidemiol*. 2022;43(5):553-569. <https://doi.org/10.1017/ice.2022.87>
 - Zimmermann G dos S, Freitas AA de, Abraão LM, Bohomol E. Healthcare-associated infections in the Intensive Care Unit during the COVID-19 pandemic. *Acta Paul. Enferm. (Online)*. 2025;38:eAPE0003152. <http://dx.doi.org/10.37689/acta-ape/2025AO0003152i>
 - Melo RC de, Araújo BC de, Bortoli MC de, Toma TS. Prevention and control of antimicrobial stewardship: a review of evidence. *Rev Panam Salud Publica*. 2020;44:e35. <https://doi.org/10.26633/RPSP.2020.35>
 - Patel PR, Weiner-Lastinger LM, Dudeck MA, Fike LV, Kuhar DT, Edwards JR, et al. Impact of COVID-19 pandemic on central-line-associated bloodstream infections during the early months of 2020, National Healthcare Safety Network. *Infect Control Hosp Epidemiol*. 2022;43(6):790-793. <https://doi.org/10.1017/ice.2021.108>
 - Brasil. Agência Nacional de Vigilância Sanitária. Boletins e relatórios das notificações de IRAS e outros eventos adversos: boletins e relatórios [Internet]. Brasília (DF): ANVISA; 2024 [cited 2024 Jul 11]. Available from: <https://www.gov.br/anvisa/pt-br/centraisdeconteudo/publicacoes/servicosdesaude/boletins-e-relatorios-das-notificacoes-de-iras-e-outros-eventos-adversos-1/boletins-e-relatorios-das-notificacoes-de-iras-e-outros-eventos-adversos>
 - Brasil. Instituto Brasileiro de Geografia e Estatística. Estimativas de população [Internet]. Rio de Janeiro: IBGE; 2023 [cited 2024 Jul 15]. Available from: https://www.ibge.gov.br/estatisticas/sociais/populacao/9103-estimativas-de-populacao.html?=&t=download_s
 - Brasil. Instituto Brasileiro de Geografia e Estatística. Censo Demográfico 2022 [Internet]. Rio de Janeiro: IBGE; 2023 [cited 2024 Jul 15]. Available from: <https://www.ibge.gov.br/estatisticas/sociais/populacao/22827-censo-demografico-2022.html?edicao=35938>
 - Parveen R, Thakur AK, Srivastava S, Puraswani M, Srivastava AK, Chakrabarti A, et al. Profile of central line-associated bloodstream infections in adult, paediatric, and neonatal intensive care units of hospitals participating in a health-care-associated infection surveillance network in India: a 7-year multicentric study. *Lancet Glob Health*. 2025;13(9):e1564-e1573. [https://doi.org/10.1016/s2214-109x\(25\)00221-9](https://doi.org/10.1016/s2214-109x(25)00221-9)
 - Wesselovicz RM, Campos TN de, Tonon PHC, Bail L, Ito CAS, Arcaro G, et al. Impacto da pandemia de COVID-19 nas infecções relacionadas à assistência à saúde na Unidade de Terapia Intensiva de um hospital brasileiro. *Res Soc Dev*. 2024;13(9):e9213946928. <https://doi.org/10.33448/rsd-v13i9.46928>
 - Silva JMA, Filho JVC, Alves LB, Santos ACD dos. Análise dos impactos da resistência antimicrobiana e suas implicações na saúde pública brasileira: uma revisão integrativa. *Pensar Acad. (Online)*. 2025;23(1):58-68. <https://doi.org/10.21576/pensaracadmico.2025v23i1.4306>
 - Lino AR dos SD, Gonçalves A, Domingos RM da S. Atuação da enfermagem no controle e prevenção de infecções relacionadas a assistência à saúde. *Revista Ibero-Americana de Humanidades, Ciências e Educação*. 2024;1(01):125-137. <https://doi.org/10.51891/rea.v1i01.17348>
 - Gomes BF, Ribeiro JH de M. A educação permanente em saúde para a enfermagem de cuidados críticos: estudo qualitativo. *J Nurs Health*. 2023;13(2):e1322575. <https://doi.org/10.15210/jonah.v13i2.22575>
 - Silva SEH de L dos S, Oliveira MMA de, Silva MC da, Melo HSLC de, Silva AJM da, Silva VVC, et al. A importância da educação permanente hospitalar no período da covid-19. *RECISATEC*. 2022;2(1):e2160. <https://doi.org/10.53612/recisatec.v2i1.60>
 - Carter ED, Stewart DE, Rees EE, Bezuidenhout JE, Ng V, Lynes S, et al. Surveillance system integration: reporting the results of a global multicountry survey. *Public Health*. 2024;231:31-38. <https://doi.org/10.1016/j.puhe.2024.03.004>

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All authors are responsible for the textual writing and critical review of the intellectual content, for the final published version, and for all ethical, legal, and scientific aspects related to the accuracy and integrity of the study.



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