

# Microbiological Profile of Urinary Tract Infections Associated with Indwelling Urinary Catheter in Adult Intensive Care Units in the Federal District

Perfil Microbiológico das Infecções do Trato Urinário Associadas à Cateter Vesical de Demora em Unidades de Terapia Intensiva Adulto no Distrito Federal

Perfil Microbiológico de las Infecciones del Tracto Urinario Asociadas al Catéter Vesical de Demora en Unidades de Cuidados Intensivos para Adultos del Distrito Federal

## RESUMO

**Objetivo:** Analisar o perfil microbiológico das infecções do trato urinário associadas ao uso de cateter vesical de demora em unidades de terapia intensiva adulto no Distrito Federal. **Método:** Estudo ecológico, retrospectivo e descritivo com análise de dados secundários coletados entre 2019 e 2023 a partir de relatórios oficiais sobre infecções associadas à assistência à saúde. **Resultado:** *Klebsiella pneumoniae* foi o principal agente isolado, com altos índices de resistência a antimicrobianos, seguido por *Escherichia coli* e *Pseudomonas aeruginosa*. A resistência a carbapenêmicos e polimixina mostrou tendência crescente. Observou-se também a presença de *Enterococcus faecalis* como agente Gram-positivo relevante. **Conclusão:** A alta prevalência de microrganismos multirresistentes reforça a necessidade de medidas eficazes de controle de infecção, uso racional de antimicrobianos e vigilância contínua para conter a disseminação bacteriana nos ambientes hospitalares críticos.

**DESCRIPTORES:** Infecção urinária; Cateterismo; Terapia intensiva; Resistência microbiana; Vigilância epidemiológica.

## ABSTRACT

**Objective:** To analyze the microbiological profile of urinary tract infections associated with indwelling urinary catheter use in adult intensive care units in the Federal District. **Method:** Ecological, retrospective and descriptive study using secondary data from official reports on healthcare-associated infections collected from 2019 to 2023. **Results:** *Klebsiella pneumoniae* was the most frequently isolated agent, showing high antimicrobial resistance, followed by *Escherichia coli* and *Pseudomonas aeruginosa*. Resistance to carbapenems and polymyxins showed an increasing trend. *Enterococcus faecalis* was also identified as a relevant Gram-positive agent. **Conclusion:** The high prevalence of multidrug-resistant microorganisms highlights the urgent need for effective infection control strategies, rational use of antimicrobials, and ongoing surveillance to prevent bacterial spread in critical care environments.

**DESCRIPTORS:** Urinary tract infection; Catheterization; Intensive care; Microbial resistance; Epidemiologic surveillance.

## RESUMEN

**Objetivo:** Analizar el perfil microbiológico de las infecciones del tracto urinario asociadas al uso de sonda vesical de demora en unidades de cuidados intensivos de adultos en el Distrito Federal. **Método:** Estudio ecológico, retrospectivo y descriptivo basado en datos secundarios de informes oficiales sobre infecciones asociadas a la atención sanitaria, recopilados entre 2019 y 2023. **Resultados:** *Klebsiella pneumoniae* fue el agente más aislado, con alta resistencia a antimicrobianos, seguido por *Escherichia coli* y *Pseudomonas aeruginosa*. Se observó una tendencia creciente de resistencia a carbapenémicos y polimixinas. *Enterococcus faecalis* también fue identificado como agente Gram positivo relevante. **Conclusión:** La alta prevalencia de microorganismos multirresistentes resalta la necesidad de implementar medidas eficaces de control de infecciones, uso racional de antimicrobianos y vigilancia continua en ambientes hospitalarios críticos.

**DESCRIPTORES:** Infección urinaria; Cateterismo; Cuidados intensivos; Resistencia microbiana; Vigilancia epidemiológica.

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**INTRODUCTION**

Healthcare-associated urinary tract infection is one of the most prevalent complications among patients admitted to intensive care units (ICUs), especially when there is prolonged use of indwelling urinary catheters<sup>1</sup>. In the ICU setting, predisposing factors—such as immunosuppression, organ dysfunction, and invasive procedures—increase the risk of colonization and infection of the urinary tract<sup>2</sup>. The burden of this infection goes beyond clinical discomfort, leading to increased morbidity, prolonged hospital stays, and higher healthcare costs<sup>3</sup>.

Recent studies have highlighted that the incidence density of urinary tract infections associated with bladder catheterization can reach significant levels: for example, a study in critically ill patients reported 15.8 episodes per 1,000 catheter use days in the context of COVID-19, with a marked impact on mortality and length of stay<sup>4</sup>. Another recent study showed that about 95% of urinary tract infections in ICUs are associated with the use of indwelling catheters, reinforcing their centrality to the problem<sup>5</sup>. These data underscore that, even with advances in prevention and control, urinary tract infection (UTI)

in the ICU remains a clinical and epidemiological challenge<sup>6</sup>.

The etiological microorganisms of UTIs associated with bladder catheterization in the ICU environment often exhibit antimicrobial resistance, which complicates therapeutic choices and can delay infection control<sup>7</sup>. In recent cohorts, a high prevalence of Gram-negative strains producing ESBL (Extended-Spectrum Beta-Lactamases) and other resistance enzymes has been observed in patients with catheter-related UTI<sup>4,8</sup>. This resistance not only limits therapeutic options, but may also promote nosocomial spread and increase mortality<sup>9</sup>.

In addition, several individual and organizational risk factors have been identified as associated with the development of healthcare-associated UTI (HCAUT) in adult ICUs. These include prolonged catheterization, reduced mobility, comorbidities (such as diabetes and renal failure), failures in sterile maintenance of the closed system, and breaches of safety barriers<sup>2,10</sup>. In this regard, a recent multicenter study demonstrated that prolonged stay in the ICU and other hospital wards, in addition to the duration of catheter use, were independent predictors of associated UTI<sup>4</sup>.

Given the severity and repercus-

sions of this complication, preventive strategies have been intensively studied. The application of care bundles—sets of standardized practices for catheter insertion, maintenance, and early removal—has shown promising results in reducing the incidence of CAUTI in critical care settings<sup>11</sup>.

In a study that implemented a *bundle* in a coronary ICU, there was a statistically significant reduction in the rate of UTI, reaching zero incidence for periods<sup>3,12</sup>. Another recent study highlighted that nursing staff training and automatic orders for catheter suspension are essential components in the effectiveness of these interventions<sup>8,13</sup>.

However, the adoption and effective adherence to these measures depend heavily on organizational culture, the psychological safety of the team, and institutional discipline in monitoring and feedback<sup>14</sup>.

A Polish study published in 2025 documented an increased incidence of UTI in ICU patients in the context of COVID-19, emphasizing that even in exceptional circumstances, it is urgent to maintain prevention standards<sup>6</sup>. In the context of a pandemic and under healthcare overload, there have been reports of increased rates of UTI-RAS in ICUs, possibly due to the relaxation of protocols and

increased staff turnover<sup>6</sup>. This shows that, although healthcare challenges are increasing, vigilance and rigor in preventive measures cannot be neglected.

Thus, to fully understand the landscape of healthcare-associated urinary tract infections in adult ICUs, it is necessary to analyze data on prevalence, risk factors, microbiological profile, and the effectiveness of interventions implemented in recent years. This approach allows us to identify practical gaps and point to ways to improve patient safety.

Thus, the objective of this article is to explore the microbiological profile of healthcare-associated urinary tract infections in adult intensive care units in the Federal District, as well as the antimicrobial resistance of the pathogens found.

## METHOD

This is an ecological, retrospective, observational, descriptive, and analytical study. The ecological approach allowed for the analysis of data at the population level, presenting epidemiological patterns of urinary tract infections associated with indwelling urinary catheters (UTI-AC) in adult intensive care units in the Federal District over a five-year period, corresponding to 2019-2023.

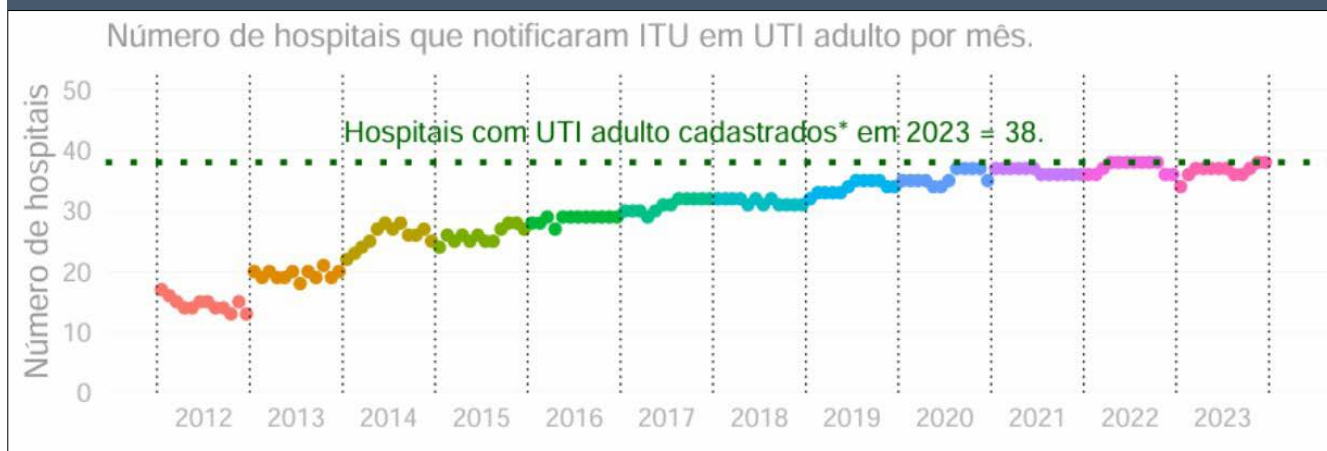
The data analyzed in this study refer to the period from January 2019 to December 2023, collected from the report "Healthcare-associated infections (HAIs) and antimicrobial resistance in health services in the Federal District"<sup>15</sup>. These secondary IRAS data were collected by hospitals according to ANVISA's national

definitions, and monthly reporting was carried out using electronic forms available on the LimeSurvey system. Microsoft Office Excel was used for data analysis and processing.

## RESULTS

Graph 1 shows the number of notifications of Urinary Tract Infection (UTI) in adult Intensive Care Units (ICUs) per month from January 2012 to December 2023 in the Federal District. The series reveals a progressive increase in the number of adult ICUs registered in the Federal District over time. In addition, the graph also shows a gradual improvement in notifications, which may reflect advances in epidemiological surveillance processes, data recording, and awareness among healthcare teams.

**Graph 1. Notifications of urinary tract infections in Adult Intensive Care Units in the Federal District, January 2012 to December 2023, according to the list sent to Anvisa by CECIH.**



Source: Brazil (2024).

Graph 2 shows the number of Gram-negative bacteria isolated per year from 2019 to 2023. It can be seen that *Klebsiella pneumoniae* was consistently the most isolated microorganism in all the years analyzed, with a significant peak in 2021, exceeding 90 isolates. This increase may be related to local outbreaks, changes in laboratory surveillance protocols, or

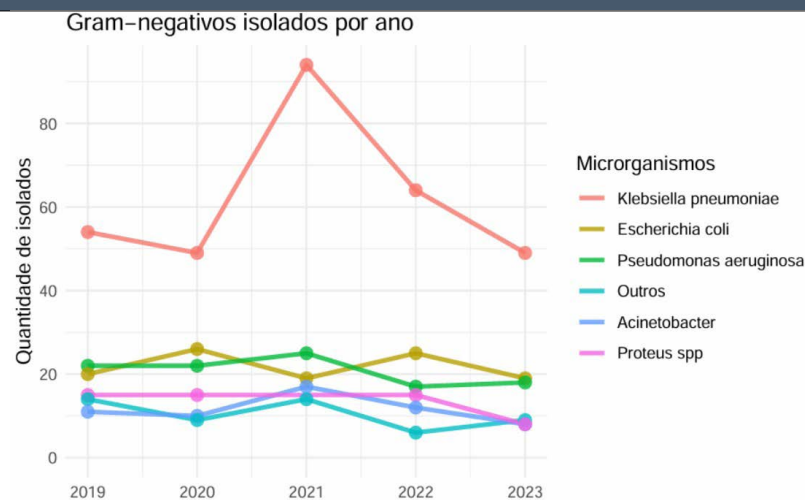
even the impact of the COVID-19 pandemic on hospital environments, especially in ICUs, where there is greater selective pressure from antimicrobials.

The other microorganisms, such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Acinetobacter*, *Proteus spp.*, and the "Others" category, showed more modest variations over the years, remaining relatively stable

compared to *Klebsiella*.

These data suggest a predominance of *Klebsiella pneumoniae* in the microbiological profile of Gram-negative infections in the period analyzed, which reinforces the importance of specific control and prevention strategies targeting this pathogen, especially in the context of antimicrobial resistance.

**Graph 2. Prevalence of Gram-negative microorganisms causing urinary tract infections in adult ICUs in the Federal District from 2019 to 2023.**



Source: Brazil (2024).

The next image represents graph 3, which shows the annual number of Gram-positive bacteria isolates between 2019 and 2023. It can be observed that *Enterococcus faecalis* peaked sharply in 2021, reaching almost 30 isolates, which highlights it as the main Gram-positive agent in that year. In the following years, there was a significant drop in the number

of isolates of this species, returning to levels similar to those of 2019. This pattern may reflect a specific event in 2021, such as isolated outbreaks, changes in microbiological screening, or the impact of external factors, such as the COVID-19 pandemic.

*Enterococcus faecium*, on the other hand, remained relatively stable over the years, with a slight increase in 2023. The *Enterococcus spp.* cate-

gory had the lowest absolute isolation values, with constant and discreet numbers throughout the analyzed period. Overall, the graph shows a specific dominance of *E. faecalis*, but also shows low variability in other Gram-positive microorganisms, suggesting stability in the microbiological profile of these infections over time.

**Graph 3. Prevalence of Gram-positive microorganisms causing urinary tract infections in adult ICUs in the Federal District from 2019 to 2023.**



Source: Brazil (2024).

Graph 4 shows the evolution of the percentage of non-fermenting Gram-negative bacteria resistant to carbapenems between 2019 and 2023, considering the microorganisms *Pseudomonas aeruginosa* and *Acinetobacter* spp. It can be observed that *P. aeruginosa* shows a general trend of reduced resistance, with a drop from approximately 60% in 2019 to around 38% in 2021, followed by a slight increase until 2023, reaching approximately 50%.

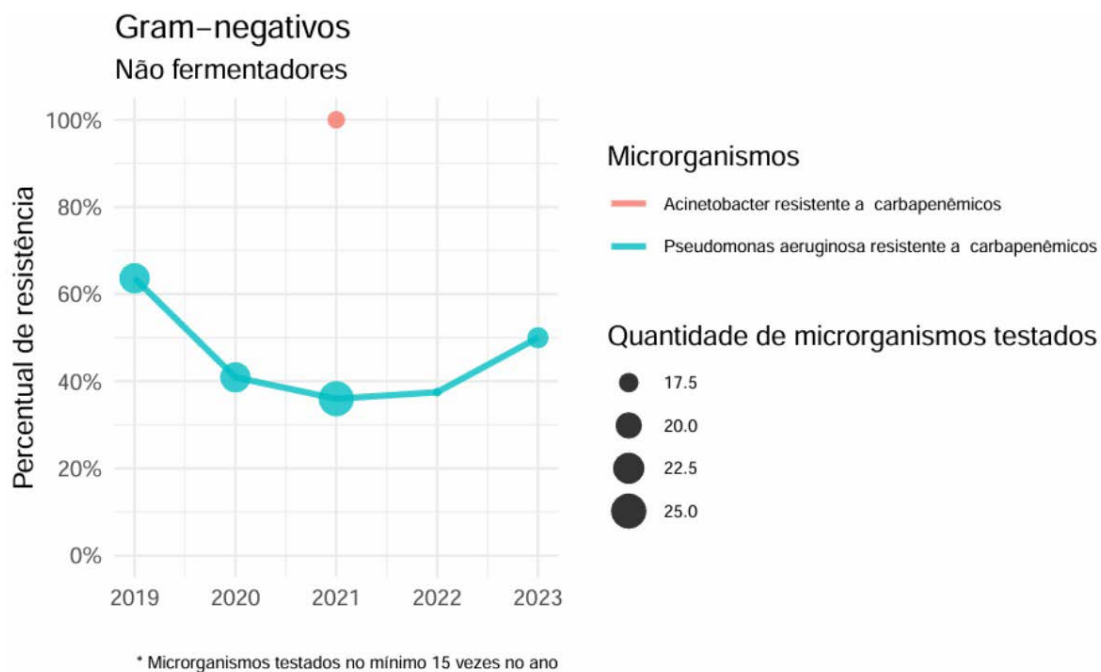
The size of the points suggests that the number of microorganisms tested was relatively constant over the years,

with minimal variation. The reduction in resistance in the early years may be associated with improvements in antimicrobial prescribing practices, infection control, and rational use of carbapenems.

On the other hand, the isolated point referring to *Acinetobacter* spp. in 2021 stands out, with 100% resistance to carbapenems, although no data are presented for other years. This indicates a possible isolated outbreak of multidrug-resistant strains, or a small number of isolates tested that ended up representing a maximum resistance rate.

This observation is critical, as *Acinetobacter* is often associated with serious and difficult-to-treat infections, especially in hospital settings and ICUs. The lack of consistent data for this microorganism in other years may reflect limitations in surveillance or low isolation frequency. These findings reinforce the need for continuous surveillance and specific interventions for non-fermenting microorganisms, especially in view of the risk of spreading pan-resistant strains.

**Graph 4. Resistance of gram-negative (non-fermenting) microorganisms to antimicrobials per year, in urinary tract infections associated with indwelling urinary catheters, in adult ICUs in the Federal District.**



Source: Brazil (2024).

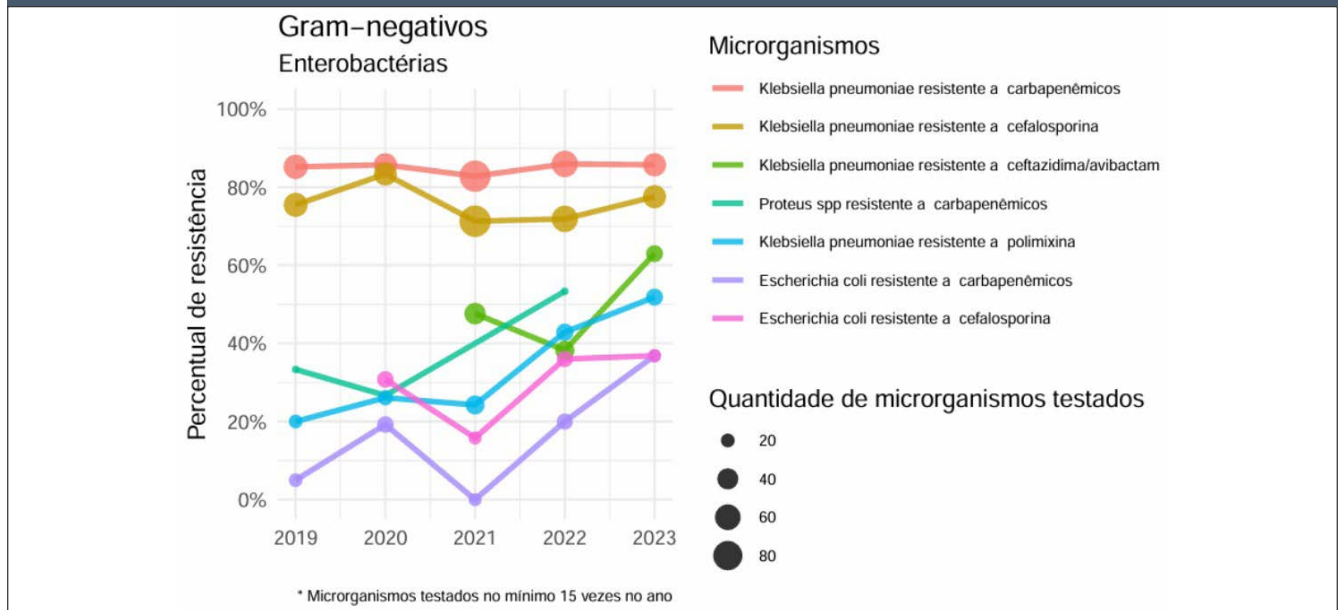
Graph 5 shows the percentage of resistance of different enterobacteria to various antimicrobials in the period from 2019 to 2023. It can be observed that *Klebsiella pneumoniae* resistant to carbapenems and cephalosporins remained consistently high

over the years, around 80% to 90%, showing a worrying and stable pattern of multidrug resistance.

Resistance to polymyxin, although lower, showed progressive growth, rising from approximately 20% in 2019 to around 50% in 2023, indicating a gradual loss of efficacy of one of the

last available therapeutic resources. Resistance to ceftazidime/avibactam, a newer antibiotic, also increased significantly, especially between 2021 and 2023, exceeding 60%.

**Graph 5. Resistance of gram-negative microorganisms (enterobacteria) to antimicrobials per year, in urinary tract infections associated with indwelling urinary catheters, in adult ICUs in the Federal District.**



Source: Brazil (2024).

On the other hand, *Escherichia coli* showed lower levels of resistance, but with an upward trend. Resistance to carbapenems, although starting from almost zero values in 2019, reached about 20% in 2023, which represents a warning for the possible emergence and spread of highly resistant strains. As for resistance to cephalosporins, the percentages varied between 20% and 35%, remaining relatively stable but still considerable. The behavior of carbapenem-resistant *Proteus spp.* also followed an upward trend, approaching 40% in 2023. These data reinforce the growing threat of resistance among enterobacteria, especially *K. pneumoniae*, and highlight the urgency of implementing effective infection control strategies and rational use of antimicrobials.

## DISCUSSION

The data presented suggest that, in adult ICUs in the Federal District, from 2019 to 2023, Gram-negative isolates were clearly dominated by

*Klebsiella pneumoniae*, with a significant peak in 2021, followed by a decline in subsequent years. Other Gram-negative bacteria (such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Acinetobacter*, etc.) showed modest fluctuations and a comparatively smaller range.

This pattern indicates a strong predominance of *K. pneumoniae* in the scenario of Gram-negative infections in the evaluated environment. This finding is consistent with recent reports in Brazil that point to high rates of multidrug-resistant *K. pneumoniae* in community and hospital infections, with considerable therapeutic implications<sup>16</sup>.

In addition, outbreaks of carbapenem- and colistin-resistant *K. pneumoniae* have been described in Brazilian hospitals, with evidence of clonal transmission and control difficulties<sup>17</sup>. Such outbreaks may contribute to the abrupt increase in isolates in certain years, as observed in 2021. It is also plausible that changes in surveillance protocols, antibiotic use, laboratory method sensitivity, and

patient flow have influenced these fluctuations.

In the case of Gram-positive bacteria, *Enterococcus faecalis* peaked in 2021 but returned to lower levels in subsequent years, while *Enterococcus faecium* remained at comparatively low levels, with a slight increase in 2023. The small proportion of generic *Enterococcus spp.* also indicates that the dominant species in these isolates were the two mentioned above.

This distribution is consistent with the behavior described in the literature, in which *E. faecalis* is often the most isolated enterococcus in the hospital setting, although *E. faecium* is gaining importance, especially in cases of resistance and ICU-related infections<sup>18</sup>.

In international multicenter studies, growth of *E. faecium* bacteria has been observed, particularly vancomycin-resistant strains (VRE), driving the overall increase in Gram-positive bacteria in hospital environments<sup>19</sup>. This phenomenon may be associated with the intensive use of antibiotics, invasive procedures, and the selection

of adapted hospital clones. In Brazilian hospitals, although resistant enterococci are not as prevalent as resistant Gram-negative bacteria, they have been reported in controlled outbreaks and local surveillance.

A comparison between the two groups shows a clear dominance of Gram-negative bacteria, especially *K. pneumoniae*, in the microbiological profile of recorded infections. Gram-positive bacteria have a smaller and more stable participation, with occasional fluctuations. This contrast has important implications for infection control policies, rational use of antibiotics, and local microbiological surveillance.

From an epidemiological point of view, the predominance of *K. pneumoniae* may reflect its ability to acquire virulence factors, resistance, and adaptation to the hospital environment. For example, the production of carbapenemases (such as KPC, NDM, OXA) by *K. pneumoniae* is one of the main threats in global hospital infection, limiting therapeutic options and favoring dissemination in institutional environments<sup>20</sup>.

In a recent study in Brazil, multidrug-resistant *K. pneumoniae* isolates were identified in community infections, reinforcing that this microorganism is not restricted to the hospital environment<sup>16</sup>.

As for *Enterococcus*, although less prevalent, attention should be paid to its resistance to glycopeptides (VRE) and its adaptability to the hospital environment (especially *E. faecium*), which can emerge in contexts of high antimicrobial pressure and frequent use of broad-spectrum antibiotics<sup>18,19</sup>. In addition, the coexistence of resistant Gram-positive and Gram-negative bacteria may increase the risk of inappropriate empirical treatment, prolong hospitalization, and increase mortality.

Analysis of antimicrobial resistance data between 2019 and 2023

reveals a worrying scenario regarding the spread of multidrug-resistant strains among both non-fermenting Gram-negative bacilli and enterobacteria.

The results show that resistance to carbapenems, considered last-line antimicrobials for many serious infections, remains high and, in some cases, shows an upward trend. This pattern is especially striking in *Klebsiella pneumoniae*, whose isolates showed resistance to carbapenems and cephalosporins greater than 80% throughout the period analyzed.

These data reinforce the role of *K. pneumoniae* as the main agent associated with multidrug-resistant Enterobacterales infections in hospital settings, in line with national and international data that point to this species as highly adaptable and frequently associated with the production of carbapenemases such as KPC<sup>21,22</sup>.

Another highlight is the significant increase in resistance to ceftazidime/avibactam and polymyxin in *K. pneumoniae*. Ceftazidime/avibactam, introduced as a therapeutic option to deal with KPC-producing strains, is already showing a loss of efficacy, exceeding 60% resistance in 2023. This data is especially concerning and signals the emergence of additional resistance mechanisms, such as mutations in  $\beta$ -lactamase genes or the presence of metallo- $\beta$ -lactamase enzymes<sup>23</sup>.

As for polymyxin, considered a "last resort" therapeutic resource, the increase in resistance from about 20% to 50% over the period reveals intense selective pressure, probably resulting from its increasing use in infections caused by pan-resistant bacteria. A similar situation is observed in non-fermenters, particularly *Pseudomonas aeruginosa*, whose resistance to carbapenems remained above 40% in all years, with a recent upward trend. *Acinetobacter spp.* showed 100% resistance to carbapen-

ems in 2021, albeit with a low sample frequency, indicating a potential local outbreak of pan-resistant strains<sup>24,25</sup>.

The trends observed are not isolated. Surveillance data from Brazil, such as those presented by the National Health Surveillance Agency (ANVISA) and the National Antimicrobial Resistance Surveillance Network (RENAVE), confirm that KPC-producing enterobacteria and carbapenem-resistant *Acinetobacter baumannii* are among the main agents associated with hospital infections with high mortality rates<sup>26</sup>.

The situation is even more critical when considering the clinical impact of combined resistance—that is, microorganisms resistant to multiple classes of antimicrobials, drastically reducing the available therapeutic options. In addition, the spread of resistance genes by plasmids in hospital environments facilitates horizontal transmission between species, accelerating the advance of resistance.

## CONCLUSION

Thus, the results of this study suggest that local surveillance and control strategies should prioritize *K. pneumoniae* and other Gram-negative bacteria as primary targets, without neglecting emerging Gram-positive bacteria. It is recommended to establish routine resistance monitoring, review antimicrobial protocols, and implement transmission prevention measures (hand hygiene, control of invasive devices, isolation, environmental disinfection). Future studies integrating microbiological data with clinical and antimicrobial prescription information will be essential to understand the local dynamics of resistance.

Therefore, the findings reinforce the urgency of adopting robust containment measures, such as rational antimicrobial stewardship programs, active microbiological surveillance,

isolation of patients colonized by multidrug-resistant microorganisms, and continuous training of healthcare teams. In addition, investment in re-

search and development of new antimicrobial molecules, as well as the use of rapid diagnostic technologies, is increasingly necessary to mitigate the

impacts of resistance and preserve the effectiveness of available treatments.

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