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Cost of antimicrobial therapy in hospitalized adult patients with multidrug-resistant microorganism infections

Custo da terapia antimicrobiana em pacientes adultos hospitalizados com infecções por microrganismos multirresistentes

Costo de la terapia antimicrobiana en pacientes adultos hospitalizados con infecciones por microorganismos multirresistentes

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ABSTRACT

Introduction: Antimicrobial resistance has increased alarmingly in recent decades and makes a challenge to health systems; it increases hospital stays, expenses, and the risk of disability and death. Objective: To rate the costs of antimicrobial treatment in adults infected with multidrug-resistant microorganisms in a tertiary hospital. Method: A retrospective, cross-sectional study with a quantitative approach was carried out in a tertiary hospital in southern Brazil, from January 2018 to December 2023. Clinical, demographic, and cost variables were accessed from the electronic medical records of patients >18 years old with positive microbiological cultures. The data were subjected to descriptive statistical analysis and multiple linear regression using the "enter" method. Results: Among 3,452 hospitalizations, 781 patients had positive cultures, 73.1% for multidrug-resistant microorganisms. The median age was 65 years, with a predominance of males (60.7%). 57.2% died; 73.6% had cultures for multidrug-resistant microorganisms. The average cost of antimicrobials for patients with infections caused by multidrug-resistant microorganisms was US$684.77; and for patients with infections caused by sensitive microorganisms, it was US$333.10. Conclusion: The expense of antimicrobial treatment in adult patients infected with multidrug-resistant microorganisms was twice as high as in infections caused by antimicrobial-sensitive microorganisms.

DESCRIPTORS

Multiple bacterial drug resistance. Hospital infection. Health care costs. Drug costs. Nursing.

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INTRODUCTION

Antimicrobials have saved millions of lives and converted healthcare. However, they are becoming less effective due to the increase in antimicrobial resistance and the shortage in the development of new drugs[5].

The indiscriminate use of antimicrobials, whether empirically, preventively or even without confirmation of the pathogen, contributes significantly to the increase in antimicrobial resistance. Worldwide, there is a predominance of approximately 90% in the prescription of empirical antimicrobials, with most indications being unnecessary. This contributes to several harms to the patient[21].

This fact has made antimicrobial resistance one of the priorities of the World Health Organization (WHO), since multidrug-resistant microorganisms (MDRs) threaten centuries of advances in health and put the health of humanity at risk[9].

Infections caused by bacterium continue to be one of the main causes of mortality and morbidity in the world population[20].

Antimicrobial resistance is responsible for at least 700,000 deaths per year worldwide. If no effective action is taken, this number is estimated to grow alarmingly by 2050, when approximately 10 million people could die as a result of infections resistant to these drugs[20].

In addition to representing a risk to human life, antimicrobial resistance overloads the budgets of health systems, whether public or private, leads to prolonged therapy and increased hospitalization times[12,20].

The expenses of antimicrobial therapy can range from US$344 to US$23,989 per additional patient during hospitalization when infected with multidrug-resistant microorganisms[16,23].

This study can be justified, since estimates indicate that antimicrobial resistance will cause such catastrophic economic damage that it could push 24 million people into extreme poverty, due to increased health care costs. In addition, one of the gaps in knowledge is the scarcity of studies that address the cost of antimicrobial resistance, especially in developing countries. The lack of concrete data on the economic impact of this problem hinders the implementation of effective policies for the rational management of antimicrobials and the adequate allocation of resources in public health[9].

Considering the relevance of the topic and the scarcity of Brazilian data on this subject, this study aimed to evaluate the costs of antimicrobial treatment in adults infected by multidrug-resistant microorganisms on a highly complex hospital.

METHODS

This is a retrospective, cross-sectional study with a quantitative approach that aimed to compare clinical variables and costs of antimicrobial therapy among hospitalized adults infected with multidrug-resistant microorganisms and those with infections sensitive to antimicrobials, from January 2018 to December 2023.

The study was conducted in a highly complex philanthropic tertiary hospital located in southern Brazil, with 274 beds, of which 48 are intensive care beds. The institution has been a reference in robotic surgery since 2022 and in trauma care, in addition to standing out in specialized care in the areas of orthopedics, neurology, and hemodynamic support. The hospital predominantly cares for adult patients with highly complex clinical and surgical conditions, and is a reference center for several medical specialties. Although the study was conducted during the COVID-19 pandemic, it is important to highlight that the hospital where the research was conducted was not a reference for the care of patients diagnosed with this disease.

The hospital has a highly qualified Hospital Infection Control and Prevention Committee consisting of a specialized team, including nurses and a physician specializing in the area. The management of antimicrobial use is carried out through a computerized system integrated with the electronic medical record, which signals all medical prescriptions for these drugs. The physician in charge analyzes each prescription and, if non-compliance is identified, the system automatically blocks the release of the antimicrobial, ensuring greater patient safety and promoting more appropriate and effective treatment.

The study population included patients aged 18 years old or older, with positive microbiological cultures for bacterium, who remained hospitalized for more than 72 hours.

Patients whose blood cultures, urine cultures, and tracheal secretion cultures indicated the presence of coagulase-negative Staphylococcus were excluded from the study, since this bacterium is recognized as a common colonizer of human skin and mucous membranes, without necessarily indicating infection. These microorganisms are frequently isolated in clinical samples, but are often not associated with disease, and can generate false-positive results and complicate the interpretation of clinical data[14].The exclusion of these cases is essential to ensure the accuracy of the results and avoid overestimating the incidence of relevant bacterial infections.

The studied clinical variables were: sex, age, race, hospitalization period, intensive care unit (ICU) stay, hospital classification (clinical or surgical), and clinical outcome (survivors and non-survivors). The microbiological variables considered the bacterial species and the antimicrobial sensitivity profile. It were classified as multiresistant microbiological cultures: Staphylococcus spp resistant to oxacillin, Enterococcus spp resistant to vancomycin, and gram-negative bacterium resistant to at least one class of antimicrobials, such as carbapenems, polymyxin, cephalosporins, fluoroquinolones, and aminoglycosides, according to the protocol adopted by the institution where the research was driven. Cases of hospital infections were collected from the monthly bulletin produced by the Hospital Infection Control and Prevention Committee of the institution. The definition of Healthcare-Associated Infections (HAIs) is based on the criteria of the *Agência Nacional de Vigilância Sanitária* (ANVISA), updated annually.

Blood cultures were collected by nurses, and samples were sent to the laboratory for inoculation in BD BACTEC™ bottles.

Urine cultures were collected by nurses and sown on plates containing CLED and MacConkey culture media, using the depletion technique for colony isolation. Microbiological confirmation was established with a cutoff point of $\geq 10^5$ CFU/ml.

Tracheal secretion cultures were obtained by nurses or physiotherapists, by aspiration or bronchoscopy, and sown on blood agar base, also using the depletion technique. Microbiological confirmation was defined with a cutoff point of $\geq 10^6$ CFU/ml.

The culture processing was automated by the BACTEC® system (bioMérieux – Brazil), allowing the detection of the growth of microorganisms. The identification of microorganisms and the antimicrobial sensitivity profile of blood cultures, urine cultures and tracheal secretion cultures were obtained by automated culture using the MicroScan® system (Siemens).

To ensure data reliability, several strategies were implemented, especially in relation to differences in the severity of clinical conditions. Variables such as length of hospital stay, necessity of ICU admission, patient age and clinical outcome (survivors and non-survivors) were included as covariates in the analysis. This approach allowed the control of the impact of these variables on costs, since ICU patients generally have higher costs due to the severity of their conditions, age and clinical outcomes can significantly influence the financial results associated with treatment.

The expense of antimicrobials used in the treatment of HAIs were obtained from the hospital's cost department and presented in *Reais (R$)*. After that, the values were converted to US dollars (USD - US$) based on the exchange rate in effect on November 8th, 2024, considering the exchange rate of *R$5.76* per dollar. The antimicrobial costing methodology used in the study considered exclusively the average direct cost of medications administered to patients in a given period and care context.

Direct costs included only the amount spent on the acquisition of antimicrobials, considering the unit price paid by the hospital to the supplier, including any discounts or fees. The quantity consumed was obtained from electronic medical records and hospital pharmacy records, taking into account the dose prescribed per patient, the duration of treatment and the total number of patients who received the antimicrobial in the period analyzed. The average direct cost was calculated using the formula: Average Direct Cost = ∑(Cost of Antimicrobial per Patient) / Total number of patients treated. The costs of materials used in the preparation and administration of antimicrobials, such as syringes, diluents, equipment or the time spent by the nursing staff, were not included in the calculation.

The Business Intelligence® (BI) system was used to extract and analyze the data. It integrates and processes information from various sources, such as electronic medical records and administrative databases, providing a comprehensive view of institutional performance. This tool allows predictive analyses to be performed, patterns to be identified and anomalies to be detected, which contributes to the optimization of resources and improvement of the quality of care. In addition, BI includes previously parameterized formulas and cost calculations, which ensures standardization, agility and accuracy in financial analysis and enables the obtaining of consistent and reliable data for hospital management. Through BI, it was possible to access information from the electronic medical record, process it and export it to Microsoft Excel®. Based on these generated spreadsheets, a detailed analysis was performed using IBM SPSS Statistics software, version 20.

Patients were classified according to their antimicrobial sensitivity profile and divided into two groups: sensitive and resistant, according to the criteria of the Brazilian Committee on Antimicrobial Susceptibility Testing - BrCAST. To compare the antimicrobial costs of sensitive patients with antimicrobial-resistant patients, the nonparametric Mann-Whitney U test was used, since the normality of the data in both groups was rejected at 5% significance.

Pearson's chi-square test was used to verify the association of the sensitivity profile with the other qualitative variables (sex, age group, race, hospitalization period, ICU stay, reason for hospitalization and clinical outcome).

Spearman's correlation coefficient was calculated to estimate bivariate correlations, since the normality of the data was not confirmed.

After identifying the possible variables associated and correlated with the costs of antimicrobials, multiple linear regression analysis was conducted using the "enter" method, which inserts all independent variables into the model simultaneously, without prior selection based on statistical criteria.

The models were evaluated in terms of adjusted R^2(Adjusted Coefficient of Determination), interpreted in percentage values to assess the correlation between the variables. The standardized adjusted residuals were used to identify possible discrepancies in the distributions.

Multicollinearity was assessed using the Variance Inflation Factor (VIF), with variables with scores greater than 10 considered to be problematic.

One indicator of multicollinearity is the value of the variance inflation factor (VIF), which measures how much the variance of the estimated coefficient for a variable is inflated due to multicollinearity with the other independent variables. VIFs greater than 10 indicate high multicollinearity, while values between 5 and 10 may be concerning.

Another indicator of multicollinearity is tolerance. Tolerance values are a measure used to assess collinearity between independent variables. A tolerance value close to 1 indicates that the independent variable is not linearly related to the other independent variables, that is, there is little or no multicollinearity. On the other hand, a low tolerance value (a value below 0.1 or 0.2 is generally considered to be a concern) suggests that the variable in question is highly correlated with other variables in the model, indicating the presence of multicollinearity.

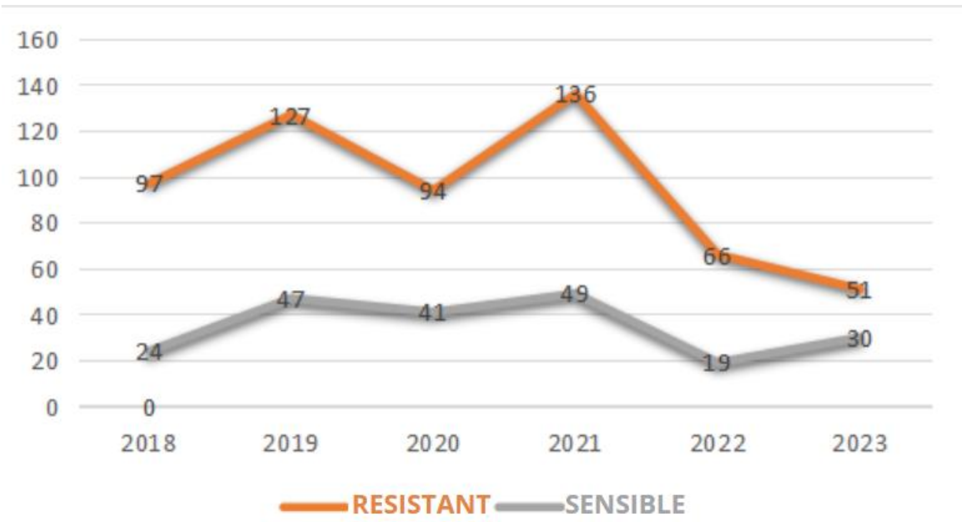
This research is part of the project "Clinical and economic impact of antimicrobial resistance on hospital costs", approved by the Research Ethics Committee involving human beings of the Irmandade Santa Casa de Londrina, through an Amendment (Opinion No. 5,632,608) and Certificate of Presentation for Ethical Assessment (No. 24711718.8.0000.0099).

RESULTS

From 2018 to 2023, there were 53,452 hospitalizations. Among the hospitalized patients, 781 had positive cultures during hospitalization. Of these, 73.1% (571) had at least one culture with multidrug-resistant microorganisms, while 26.9% (210) had cultures sensitive to antimicrobials.

The commonness of microbiological cultures sensitive and resistant to antimicrobials over the years shows a significant predominance of patients with resistant cultures. Among the years analyzed, 2019 and 2021 were the ones with the highest prevalence of antimicrobial resistance (Figure 1).

Figure 1 – Frequency of resistant microbiological cultures and microbiological cultures sensitive to antimicrobials in a tertiary hospital. Londrina-PR, Brazil, 2018 to 2023 (N=781)



RESISTANT - Resistant microbiological culture*;
SENSITIVE - Sensitive microbiological culture**

The main medical specialties affected by healthcare-associated infections (HAIs) were: internal medicine (25.2%), neurosurgery (20.1%), nephrology (10.5%), neurology (9.6%), and orthopedics (7.4%).

Of the 571 patients who presented cultures with multidrug-resistant microorganisms, 70.3% were identified as gram-negative, while 29.6% were gram-positive.

The most prevalent microorganisms in laboratory samples from hospitalized patients with antimicrobial-resistant infections were K. pneumoniae (25.3%), A. baumannii (21.7%), P. aeruginosa (9.0%), E. coli (8.5%), and S. marcescens (3.7%).

During hospitalization, 37 different intravenous antimicrobials were used in the 781 patients who presented HAIs. The most expensive antibiotics for the institution were ceftazidime+avibactam (1.0%), ceftolozane+tazobactam (0.02%) and tigecycline (3.7%).

Among the antimicrobials analyzed, the most requested were meropenem (15%), vancomycin (14.7%), piperacillin+tazobactam (13.2%), ceftriaxone (8.0%) and polymyxin B (5.6%).

The therapeutic classes with the highest consumption identified in the study were: glycopeptides (15.6%), carbapenems (14.9%), cephalosporins (14.9%), beta-lactams (14.3%) and polymyxins (10.4%).

Below, the median costs of antimicrobials for patients with sensitive and resistant microbiological cultures are presented (Table 1).

Table 1 – Analysis by the Mann-Whitney test of the cost of antimicrobials in dollars (US$) by sensitivity profile in a tertiary hospital. Londrina-PR, Brazil, 2018 to 2023 (N=781).

			p-value	
	Median	**IIC**	***Shapiro Wilk***	***Mann-Whitney***
CMR	293,63	123,65 – 756,04	<0,001	<0,001
CMS	131,12	57,77 – 309,65	<0,001	

CMR-Resistant microbiological culture*; CMS-Sensitive microbiological culture**; IIC – interquartile range.

The results of the Mann-Whitney test confirmed that antimicrobial costs are significantly higher during hospitalization of patients with resistant cultures, with a median of US$293.63, compared to patients with sensitive cultures, whose median was US$131.12. In view of this difference, it is important to investigate the factors that may be associated with antimicrobial resistance. Table 2 presents the frequency data and the p-value of the Chi-square test for the variables potentially related to the sensitivity profile (Table 2).

Table 2 - Association between clinical variables and sensitivity to microbiological cultures in a tertiary hospital. Londrina-PR, Brazil, 2018 to 2023 (N=781),

Variables	Total N (781)	Pacients CMR n= 571	Pacients CMS n= 210	*p*-value
Sex				
Male	474 (60,7%)	355 (74,9%)	119 (25,1%)	0,163
Female	307 (39,3%)	216 (70,4%)	91 (29,6%)	
Age Group				
>18 a <30 years old	27 (3,5%)	23 (85,2%)	4 (14,8%)	0,032*
≥30 a ≤59 years old	270 (34,5%)	209 (77,4%)	61 (22,6%)	
≥60 years old	484 (62,0%)	339 (70,0%)	145 (30,0%)	
Race				
White	628 (80,4%)	447 (71,2%)	181 (28,8%)	0,041*
Non-white	144 (18,4%)	116 (80,6%)	28(19,4%)	
Non-declared	9 (1,2%)	8 (88,9%)	1 (11,1%)	
Hospitalization period				
>15 days	582 (74,5%)	451 (77,5%)	131 (22,5%)	<0,001**
≤15 days	199 (25,5%)	120 (60,3)	79 (39,7%)	
ICU Stay				
Yes	665 (85,1%)	498 (74,9%)	167 (25,1%)	0,007*
No	116 (14,9%)	73 (62,9%)	43 (37,1%)	
Hospitalization Reason				
Clinical	411 (52,6%)	291 (70,8%)	120 (29,2%)	0,125
Surgical	370 (47,4%)	280 (75,7%)	90 (24,3%)	
Clinical Outcome				
Hospital discharge	334 (42,8%)	242 (72,5%)	92 (27,5%)	0,721
Death	447 (57,2%)	329 (73,6%)	118 (26,4%)	

CMR-Resistant microbiological culture*; CMS-Sensitive microbiological culture**; 1 p-value refers to the Chi-square test.

In the variables analyzed, it was found that age group, race, hospitalization period and length of stay in the Intensive Care Unit (ICU) are associated with antimicrobial resistance in hospitalized patients. However, no evidence was found to support a relationship between the antibiotic sensitivity profile and sex, reason for hospitalization or clinical outcome.

When analyzing the percentages in each category, it was observed that elderly patients, those identified as non-white or who did not declare their race, in addition to those who remained hospitalized and in the ICU for longer periods, presented a higher frequency of antimicrobial-resistant cultures.

In the study of the correlation between the costs of antimicrobials, hospitalization period and ICU stay, it was decided to use the Spearman correlation coefficient due to the non-normality of the data. The analysis revealed a significant relationship between the overall stay and the number of days in the ICU, with a coefficient of 0.670 and a p-value lower than 0.001. The correlation between the days in the ICU and the total stay was also significant, with a coefficient of 0.639, with a p-value lower than 0.001.

To analyze the cost of antimicrobials in relation to age, overall and ICU stay days, sensitivity profile and race, a multiple linear regression model was adjusted (Table 3).

Table 3 - Multiple linear regression analysis of demographic, clinical and antimicrobial cost variables in a tertiary hospital. Londrina-PR, Brazil, 2018 to 2023 (N=781).

Predictor Variables	β	Standardized coefficients βeta	*p*-value	Tolerance	VIF
Age	-48,856	-0,143	<0,001	0,938	1,066
Days of stay in ICU	105,227	0,268	<0,001	0,702	1,424
Days of hospitalization	98,086	0,352	<0,001	0,698	1,432
Sensitive profile (sensible or resistant)	589,760	0,048	0,101	0,947	1,056
Race	527,404	0,042	0,146	0,977	1,024

β - Standardized coefficients βeta; p-value - significance value; Tolerance - measure of multicollinearity; VIF - Variance inflation factor.

As shown on Table 3, all VIF values are below 5, and tolerance values are close to 1 and well above 0.2, suggesting the absence of multicollinearity.

Analysis of variance demonstrated that the adjusted regression model is significant, with an adjusted coefficient of determination of 0.362, indicating that the model explains only 36% of the variation in antimicrobial costs.

In addition, the coefficients for sensitivity profile and race showed no significance in the adjustment. Among the standardized coefficients of the significant factors (age, days of ICU stay, and days of hospitalization), days of hospitalization demonstrated the greatest impact on antimicrobial costs.

DISCUSSION

The presence of microbiological cultures with antimicrobial-resistant microorganisms influenced the clinical variables and expenses associated with the treatment of HAIs in hospitalized patients during the study period. A significant increase in resistant microbiological cultures was observed in 2021, compared to the other years analyzed. This increase can be attributed to several factors, including the inappropriate or excessive use of antimicrobials, as well as the impact of the COVID-19 pandemic. Although the hospital where the research was conducted was not a reference for care of patients with COVID-19, the pandemic substantially changed the dynamics of public health and treatment protocols. The study indicated that the increasing pressure on health systems, the increased use of antimicrobials to treat viral and bacterial infections, and the greater hospitalization of patients with severe conditions probably contributed to the intensification of microbial resistance during this period(2).

The results indicated that most of the patients who presented both CMR and CMS were elderly, predominantly male and white. Antimicrobial resistance was present in all age groups, with almost all of those over 60 years of age developing antimicrobial-resistant infections. This finding is similar to a study that evaluated the epidemiological profile of HAIs in a tertiary public hospital and found a higher incidence in elderly patients(17).

However, with regard to the elderly population, intrinsic and extrinsic factors are predictors of vulnerability to the occurrence of HAIs, and this age group deserves attention(18).

The prevalence of chronic diseases, weakened immunity, associated with more complex therapeutic interventions favor the development of infections, which are generally more serious and complicated to treat when compared to the adult population, in addition to increasing hospital stays and mortality(1,15).

In this study, it was verified that the age of patients showed an inverse relation with the costs of antimicrobials (β = -47.67, p <0.001). This phenomenon may be related to the high mortality rate in the elderly population due to infectious causes. In order to their vulnerability to complications, older patients often die before even starting or completing antimicrobial treatment. This profile is especially relevant in the hospital where the research was conducted, a reference institution in specialties such as orthopedics, neurology and hemodynamics, which predominantly treats elderly patients, due to the high prevalence of degenerative diseases, strokes and cardiovascular pathologies in this age group. Thus, the representation of these specialties reflects the demand for care focused on this population group, which requires more specific and specialized care. In addition, the severity of infections may lead to a more conservative approach, where treatment is avoided or interrupted in the face of an unfavorable prognosis. Clinical decisions may also prioritize quality of life, leading to reduced use of antimicrobials in terminal illness situations. Thus, poor health and high rates of comorbidities in this age group may result in less aggressive treatment, directly impacting the costs associated with antimicrobial use.

The results highlighted that factors such as age, length of stay in the ICU, and length of hospitalization are significant predictors of antimicrobial costs. It is possible to observe that the cost of antimicrobials in younger patients was higher compared to those over 60 years of age.

Confirming these findings, a study that evaluated the cost of infectious adverse events in a public teaching hospital found a difference in the cost of antimicrobials between the age groups >70 years and 31 to 50 years. Younger patients had higher costs compared to those over 70 years of age. Approximately 49.5% of patients had antimicrobial costs greater than 50% of the total cost of medications during hospitalization[7].

In the context of this study, the high prevalence of HAIs in patients who remained in the ICU stands out, the majority of whom had cultures for multidrug-resistant microorganisms. This data follows the standards already established by health authorities in Brazil, which highlighted the prevalence of HAIs in the intensive care setting[13,24].

With regard to the length of hospitalization, a study carried out in a general hospital in northern Brazil showed a significantly higher median value for hospitalization time among patients with HAIs (27 days) and the majority (75.2%) remained hospitalized for more than 15 days[3].

Another study focusing on the clinical profile of patients with HAIs demonstrated a shorter average number of days of hospitalization, the difference was 5.61 days less[7] when compared to the results of the present study in which the average was 23.5 days and 43% remained hospitalized for more than 15 days.

Hospitalized patients for more than 15 days showed a predominance of infections caused by microorganisms resistant to antimicrobials, which resulted in higher treatment costs. Each patient with a positive culture for resistant microorganisms generated an approximate cost of US$694.44, twice as much as that observed in patients with infections caused by sensitive microorganisms. The minimum cost of antimicrobials during hospitalization was US$0.20, while the maximum reached US$7,132.10.

Studies conducted in different countries confirmed these results. In university hospitals in Brazil, infections caused by multidrug-resistant A. baumannii were responsible for prolonging hospitalization by 12 days, with an increase in cost of US$3,125.00 per patient[4].

On the same way, in Europe, the treatment of infections resistant to the carbapenem class increased hospital costs in countries such as Italy, where spending reached €25,000.00 (US$4,340.27) per patient[22].

In contrast, a study in China found lower costs in antimicrobial treatment. The average cost of medication during hospitalization was US$1,457.72, while the treatment of resistant infections had an average cost of US$367.48[10].

In Brazil, a study conducted in an Intensive Care Unit highlighted the significant economic impact of the use of antimicrobials. The annual cost was US$496,851.90, representing 25% of total hospital medication expenditure. The average cost per patient was US$1,514.79, with emphasis on the use of tigecycline, piperacycline, ertapenem and polymyxin B, which together totaled US$347,092.77, corresponding to 57.8% of total antibiotic costs[11].

Another Brazilian study indicated that infections caused by multidrug-resistant microorganisms can represent up to 45% of infection-related hospital costs, including the need for prolonged stays. Similarly, in the United States, it was reported that the treatment of resistant infections can increase total costs by up to 70%, due to the use of last-line antimicrobials, such as ceftazidime-avibactam and colistin, in addition to additional measures, such as patient isolation[6,19].

An additional study corroborated these findings, revealing that medical costs for patients with antimicrobial-resistant infections were significantly higher compared to those with sensitive infections.

The median hospital costs reached US$22,962 for resistant infections, while for sensitive infections it was US$11,755. Furthermore, the average cost of antimicrobials to treat resistant infections was US$1,006.00, in contrast to US$592.00 for sensitive infections[8].

A cohort study conducted in Colombia analyzed the excess costs associated with infections caused by resistant and sensitive microorganisms, with the highest costs being related to the use of broad-spectrum antibiotics (US$1,827, 95% CI: US$1,005 to 2,648) and prolonged hospital stay (US$1,015, 95% CI: US$163 to 1,867) [23].

These studies have shown that antimicrobial-resistant infections generate significantly higher costs than those observed in sensitive infections, as verified in this study. Patients with healthcare-associated infections require specialized care and expensive treatments, which has a significant economic impact on healthcare institutions.

Knowledge about the expense of antibiotics by health managers and professionals can help in the formation of institutional protocols that promote the rational use of antimicrobials, in addition to strategies for controlling and preventing infections related to health care.

Although the results of this study provide relevant information on the cost of antimicrobial therapy in patients with multidrug-resistant infections, the sample was limited to a single hospital and may not reflect the diversity of infectious cases encountered in different hospital settings or in other regional contexts. This limitation may be attributed to the variability in infection control policies, antimicrobial use, and isolation practices adopted by different institutions. In addition, hospital infrastructure and costs related to medications and the work process of the health care team vary widely between hospitals and regions, which limits the generalizability of the results. The prevalence of specific pathogens and the local epidemiological profile may also influence the observed costs, making the data from this hospital context-specific.

It is recommended that studies in multiple hospitals or across multiple regions be conducted to obtain a comprehensive and accurate view of the costs involved in treating multidrug-resistant infections.

CONCLUSION

The results of the study highlighted that factors such as age, length of hospitalization and ICU stay were predictors of antimicrobial expenses. These findings suggest that interventions aimed at reducing the length of hospital stay, both in the ICU and in general hospitalization, as well as measures to prevent HAIs, can be effective in reducing antimicrobial costs.

However, the absence of a significant association between antimicrobial susceptibility profile and expenses indicates that other factors may mediate these results. Furthermore, antimicrobial resistance in hospitalized patients represents a considerable negative impact, increasing morbidity, prolonging hospitalization time and increasing treatment costs.

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AUTHOR CONTRIBUTIONS

Dias NLP and Pimenta RA contributed to the conception and design of the study, literature review, manuscript writing, and assisted in data analysis. Pimenta SF performed statistical data analysis and interpretation, as well as content review. Andrade LR contributed to the critical intellectual review of the content. All authors reviewed and approved the final version to be published and declare responsibility for all aspects of the work, ensuring accuracy and integrity.

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Approved by the Research Ethics Committee of Irmandade Santa Casa de Londrina, opinion no. 5.632.608, Certificate of Presentation for Ethical Consideration (CAAE) no. 24711718.8.0000.0099.

CONFLICT OF INTEREST

The authors declare no conflict of interest.