








Antimicrobial stewardship programs: Progress and challenges in Brazilian pediatric intensive care units

Programa de gerenciamento de antimicrobianos: progressos e desafios nas unidades de terapia intensiva pediátricas brasileiras

Programa de gestión del uso de antimicrobianos: avances y desafíos en las unidades de cuidados intensivos pediátricos brasileñas

Eliane Carlosso Krummenauer¹ ; Mariana Portela de Assis¹ ; Mara Rubia Santos Gonçalves¹ ;
Magda Machado de Miranda Costa¹ ; Rochele Mosmann Menezes¹ ; Jane Dagmar Pollo Renner¹ ; Marcelo Carneiro¹ 

¹Universidade de Santa Cruz do Sul. Santa Cruz do Sul, RS, Brazil; ²Agência Nacional de Vigilância Sanitária. Brasília, DF, Brazil

ABSTRACT

Objective: to assess Leadership Support and Definition of Responsibilities for antimicrobial stewardship programs in Brazilian pediatric intensive care units. **Methods:** a multicenter, cross-sectional study conducted in 219 hospitals using a Leadership Support and Definition of Responsibilities assessment form. The data were analyzed based on location, service profile and institutional size. **Results:** hospitals in the Southeast region, with a private institutional profile, over 200 beds and up to 20 intensive care beds stood out. It was observed that 73.30% of the hospitals had formal documentation of their antimicrobial stewardship program, 90.50% had dedicated teams, 66.21% had sufficient financial resources, and 67.58% had designated a responsible manager. **Conclusion:** inadequate funding and the need to standardize activities are challenges. It is essential to improve multidisciplinary team engagement and to integrate strategies into antimicrobial stewardship programs for antimicrobial safety in children.

Descriptors: Health Resources; Drug Resistance, Microbial; Antimicrobial Stewardship; Leadership; Efficacy.

RESUMO

Objetivo: avaliar o Apoio das Lideranças e a Definição de Responsabilidades dos programas de gerenciamento de antimicrobianos em unidades de terapia intensiva pediátrica no Brasil. **Métodos:** estudo multicêntrico, transversal, realizado em 219 hospitais por meio de formulário de avaliação do Apoio das Lideranças e Definição de Responsabilidades. Os dados foram analisados de acordo com localização, perfil de atendimento e tamanho porte da instituição. **Resultados:** destacaram-se os hospitais localizados na região sudeste, perfil institucional privado, mais de 200 leitos e até 20 leitos de terapia intensiva. Observou-se que 73,30% dos hospitais possuíam documentação formal do programa de gerenciamento de antimicrobiano, 90,50% tinham equipes dedicadas, 66,21% dispunham de recursos financeiros suficientes e 67,58% definiram um gestor responsável. **Conclusão:** a falta de financiamento adequado e a necessidade de padronização das atividades são desafios. Melhorar a adesão da equipe multiprofissional e integrar estratégias dos programas de gerenciamento de antimicrobianos são essenciais para a segurança antimicrobiana em crianças.

Descritores: Recursos em Saúde; Resistência Microbiana a Medicamentos; Gestão de Antimicrobianos; Liderança; Eficácia.

RESUMEN

Objetivo: evaluar el Apoyo de los Directivos y la Definición de Responsabilidades de los programas de gestión de antimicrobianos en unidades de cuidados intensivos pediátricos en Brasil. **Métodos:** estudio multicéntrico, transversal realizado en 219 hospitales mediante un formulario de evaluación de Apoyo de los Directivos y Definición de Responsabilidades. Los datos se analizaron según ubicación, perfil del servicio y tamaño de la institución. **Resultados:** se destacaron los hospitales ubicados en la región Sudeste, el perfil institucional privado y aquellos con más de 200 camas y hasta 20 camas de cuidados intensivos. Se observó que el 73,30% de los hospitales contaba con documentación formal del programa de gestión de antimicrobianos, el 90,50% contaba con equipos dedicados, el 66,21% contaba con recursos financieros suficientes y el 67,58% contaba con un gerente designado. **Conclusión:** los desafíos son la falta de financiamiento adecuado y la necesidad de estandarización de las actividades. Es fundamental mejorar la adherencia del equipo multidisciplinario e integrar estrategias de los programas de gestión de antimicrobianos para la seguridad antimicrobiana en niños.

Descriptor: Recursos en Salud; Farmacorresistencia Microbiana; Programas de Optimización del Uso de los Antimicrobianos; Liderazgo; Eficacia.

INTRODUCTION

Antimicrobial resistance (AMR) poses a growing threat to global public health, compromising the effectiveness of treatments and increasing morbidity and mortality rates. This problem is particularly concerning in Latin America, where several factors, such as inappropriate use of antimicrobials and a lack of control programs, contribute to the rise of

This study was carried out with the support of the Coordination for the Improvement of Higher Education Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, CAPES) – Brazil – Funding code 001.

Corresponding author: Eliane Carlosso Krummenauer Email: elianek@unisc.br

Editor in Chief: Cristiane Helena Gallasch; Scientific Editor: Thelma Spíndola

bacterial resistance^{1,2}. In response to this crisis, the Antimicrobial Stewardship Program (ASP) has emerged as a crucial strategy to promote the rational use of antimicrobials and control the spread of resistant pathogens³.

The World Health Organization (WHO) recognized AMR as a global priority, launching the Global Action Plan to combat antimicrobial resistance in 2015⁴. This plan aims to improve awareness and understanding of AMR, strengthen surveillance and research, reduce the incidence of infections, optimize the use of antimicrobial drugs, and ensure sustainable investments in the AMR response⁵.

In Latin America, several countries have implemented policies and programs to address AMR⁵. In Brazil, the Brazilian Health Regulatory Agency (*Agência Nacional de Vigilância Sanitária*, ANVISA) plays a central role in coordinating actions to promote rational antimicrobial use. In 2017, the country launched its National Plan for Antimicrobial Resistance Prevention and Control, aligned with WHO guidelines⁶. This plan includes ASP implementation in hospitals, aiming to reduce inappropriate antimicrobial use and monitor bacterial resistance⁷.

In 2019 and 2022, national investigations into the Antimicrobial Stewardship Program (ASP) scenario in Brazil were conducted, coordinated by ANVISA. These studies provided a detailed overview of the implementation and effectiveness of ASPs in healthcare facilities, highlighting progress and identifying areas for improvement⁸. National actions to reduce infections include promoting healthcare practices, active surveillance of hospital-acquired infections, and training healthcare professionals on this scenario and the appropriate use of antimicrobials⁹.

The success of an ASP depends heavily on compliance with elements 1 and 2 of the program's guidelines. The first element emphasizes Leadership Support, which is crucial to ensuring the allocation of human, financial, and technological resources necessary for effective program implementation. Without leadership commitment, the ASP's sustainability and effectiveness are compromised¹⁰. The second element highlights the Definition of Responsibilities, ensuring that all team members have clear roles and objectives. Appointing specific leaders and defining their responsibilities is essential to coordinating ASP activities and ensuring that program goals are achieved in an organized and efficient manner¹¹.

Furthermore, the quality of relationships between the stakeholders involved in the ASP is crucial. A good relationship, based on positive behaviors, between the hospital's clinical leadership (senior management) and all professionals committed to AMR control is essential to the program's effectiveness. This relationship fosters the integration of all involved with a common goal: providing patient-centered care. Cooperation and effective communication between senior management and the clinical team foster a collaborative environment where ASP initiatives can be implemented more efficiently and with greater adherence by healthcare professional^{12,13}.

The Brazilian scenario is particularly challenging in pediatric intensive care units (PICU), where antimicrobial resistance is a critical concern. Studies show that the rate of infections by multidrug-resistant pathogens is high, exacerbated by the extensive and often inappropriate use of antimicrobials¹⁴. Implementing ASP in Brazil is crucial, but it faces significant obstacles, including a lack of human and financial resources, technological limitations, and the need for specialized training for healthcare professionals¹⁵.

Measuring and monitoring antimicrobial use in pediatrics presents specific and complex challenges, especially when compared to the adult setting. Children are not just "small adults"; they have unique physiological and immunological characteristics, in addition to a distinct nosological profile, often marked by acute respiratory infections, gastroenteritis, urinary tract infections, exanthematous diseases, and febrile conditions of viral etiology, which are frequent causes of hospitalization in this population¹⁶.

This context demands individualized and judicious therapeutic approaches, since inappropriate use of antimicrobials, whether in terms of dose, duration, spectrum, or route of administration, can have significant impacts on the development of bacterial resistance and pediatric patient safety. Furthermore, the scarcity of robust data and the limited availability of effective monitoring systems hinder the accurate assessment of antimicrobial use and the true prevalence of microbial resistance in hospitalized pediatric patients^{14,16}.

Therefore, strengthening ASP programs in PICUs is crucial to mitigating AMR in Brazil. These programs not only improve medication use but also promote patient safety and quality of care, contributing to a more resilient and sustainable healthcare system^{17,18}. The objective of this study was to assess Leadership Support and Definition of Responsibilities for antimicrobial stewardship programs in pediatric intensive care units in Brazil.

METHOD

This is a cross-sectional, multicenter study carried out in Brazilian hospitals.

As the largest country in South America and the fifth largest in the world, Brazil has over 210 million inhabitants and a territorial extension of approximately 8.5 million km². Composed of 5,570 municipalities and 27 federative units (26 states and the Federal District), it is divided into five macro-regions (North, Northeast, Midwest, Southeast and South), based on natural, social, cultural, political, and economic criteria¹⁹. According to the Brazilian Health Regulatory Agency (ANVISA), in 2022, there were 662 hospitals with Pediatric ICUs (PICUs) in Brazil, with the Southeast region having 346 (52.26%), followed by the Northeast with 110 (16.62%) and South with 83 (12.54%).

The sample consisted of data from a segment of the 2nd national ASP survey in Brazil, coordinated by ANVISA/Ministry of Health. The study focused on the PICU, with an invitation sent by email to all hospitals in the three healthcare spheres (federal, state and regional). Recruitment was conducted through ANVISA's communication channels, and participants voluntarily filled out an electronic form (Google Forms®).

Data collection was conducted between October 2022 and January 2023 by filling out an electronic form sent to the PICUs in Brazil. The questionnaire made it possible to analyze the level of adherence to six essential elements recommended for structuring an effective ASP: (Component 1) Leadership Support; (Component 2) Definition of Responsibilities; (Component 3) Education; (Component 4) Monitoring of antimicrobial use; (Component 5) Evidence-based interventions for the rational use of antimicrobials; and (Component 6) Monitoring of process and outcome indicators²⁰.

The data collection instrument assessed program implementation, classifying each component as inadequate, basic, intermediate, or advanced, based on the score obtained. Responses, which varied in points, included some questions with multiple answers, where all options selected within the same component were counted²⁰. The survey, organized into sections, addressed the identification of the health service profile and the existence or absence of the ASP. The questionnaire contained 46 dichotomous questions (YES or NO) and 15 questions with multiple answer options, all mandatory depending on the ASP implementation.

A specific analysis was conducted only for hospitals with implemented ASP, focusing on components 1 (Leadership Support) and 2 (Definition of Responsibilities). Component 1 assessed the availability of human, financial, and technological resources, while component 2 examined the appointment of ASP team members and the definition of their leaders and roles (11). A sub-analysis was conducted regarding the existence of a team responsible for implementing the ASP in the hospital. Hospital characteristics such as location, service profile, hospital size, and the size of the PICU were also considered. Hospitals were classified as private (managed by private, charitable, or philanthropic entities) or public (managed by municipal, state, or federal government entities)²¹. Categorization was performed according to the number of hospital beds (up to 100, 101/199, and ≥200 beds), Brazilian regions, and the number of PICU beds (up to 20 and >20 beds)²¹.

All analyses were conducted using the Statistical Package for the Social Sciences (SPSS®), version 23 (IBM, Armonk, NY). The comparison of continuous scores for components 1 (Leadership Support) and 2 (Definition of Responsibilities) between the service profile and hospital size and PICU size was performed using two approaches: the first with parametric tests using the Bootstrapping procedure with 5,000 resamplings and the bias-corrected and accelerated method (BCa); and the second with non-parametric tests due to non-normal distribution of variables.

The comparison between the type of institution used Student's t-test for independent samples and Mann-Whitney's U test, while the comparisons between the number of available beds used one-way analysis of variance (ANOVA) and the Kruskal-Wallis test²².

Finally, comparisons of the relative frequencies of 'yes' responses between the type of institution and the number of available beds were performed using the a posteriori z-test in the chi-square analysis, adjusting p-values using the Bonferroni method, according to the number of comparisons between groups. p-values ≤ 0.05 were considered statistically significant²².

The research protocol respected the ethical aspects related to research with human beings, according to National Health Council Resolution No. 466 dated December 12th, 2012, and was approved by the Research Ethics Committee.

RESULTS

Of the 393 (59.36%) participating PICUs in Brazil, 219 that reported having implemented ASP were included in the final study sample and had their data analyzed. Of these, the overall level of adherence to components 1 (Leadership Support) and 2 (Definition of Responsibilities) differed between states, but the overall average for both was classified as basic (Figure 1).

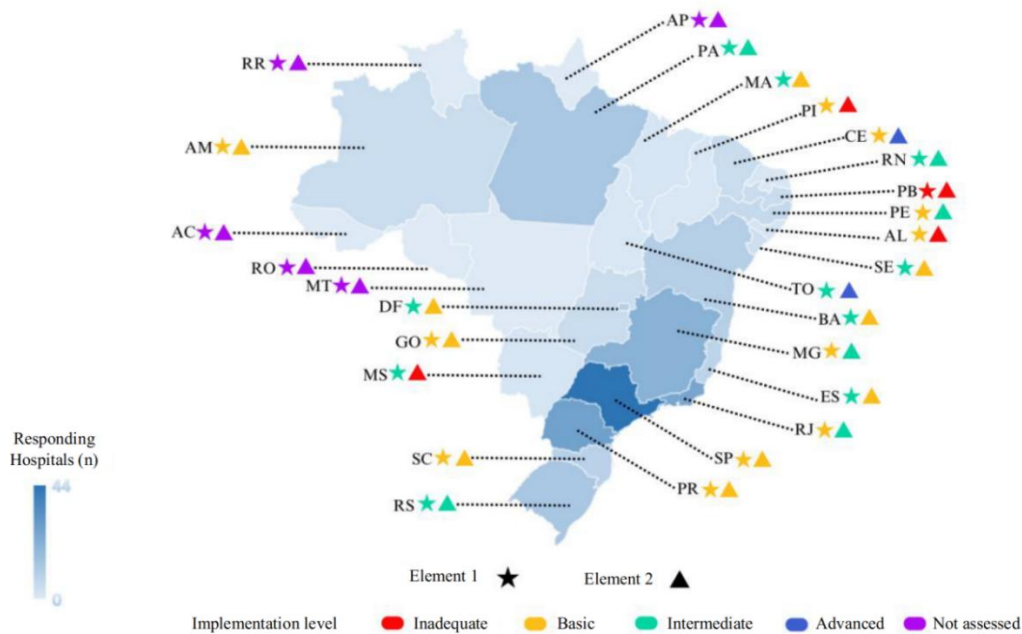
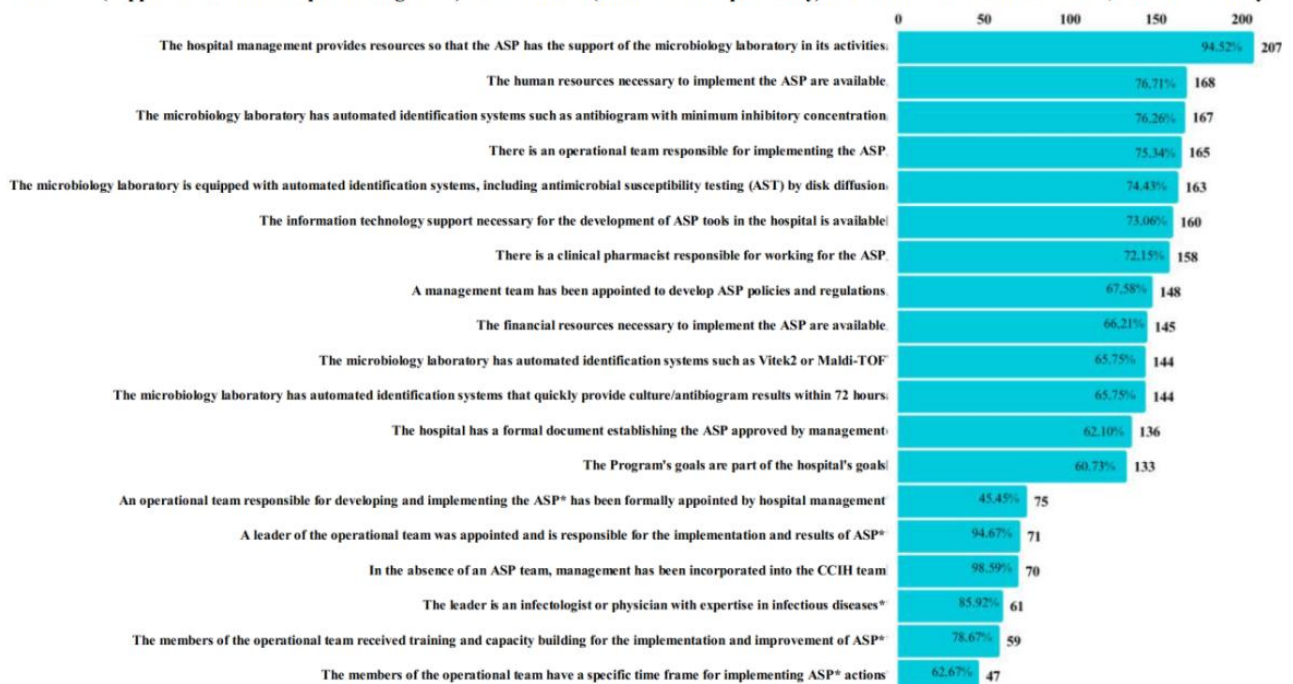


Figure 1: Number of hospitals that responded to the survey on the ASP in PICU implemented by state and adherence level to the Leadership Support and Definition of Responsibilities components (n=219). Brazil, 2023.

Component 1 scored 117.85 (± 39.65) and level 2 scored 84.79 (± 47.02). In level 1, the classifications “basic” with 78 institutions (35.62%) and “advanced” with 64 (29.22%) stood out, followed by “intermediate” with 61 (27.85%) and “inadequate” with 16 (7.31%). Level 2 also obtained the same classifications: “basic” with 88 (40.18%) and “advanced” with 49 (22.38%) of the institutions, followed by “intermediate” with 43 (19.63%) and “inadequate” with 39 (17.81%).

Figure 2 describes the findings related to the existence of a formal document approved by the institution's board of directors for the ASP.

Element 1 (Support from senior hospital management) and Element 2 (Definition of responsibility) in the ASP at 219 Brazilian PICUs, in the 2023 survey



*Subdivision of the survey in the question: There is an operational team responsible for implementing the ASP

Figure 2: Number of hospitals that responded to the survey on the ASP in PICU implementation and the level of adherence to the Leadership Support and Definition of Responsibilities components (n=219). Brazil, 2023.

Regarding Component 1 (Leadership Support), 62.1% of hospitals have a formal document approved by the board of directors for the ASP, 60.73% have integrated the program's goals with the hospital's strategic goals, and 76.71% have the necessary human resources. Furthermore, 94.52% of hospitals have laboratory support, and 73.06% have technological support.

Regarding Component 2 (Definition of Responsibilities), 67.58% defined a management team for the ASP, 75.34% have an operational team, and 94.67% have a leader responsible for the program, with 85.92% of these leaders being infectologists. In addition, 72.15% of hospitals have clinical pharmacists in the ASP. Table 1 presents data related to the nature of the institutions.

Table 1: Characterization of the operational team in the responses of components 1 (Leadership Support) and 2 (Definition of Responsibilities), according to the nature of the hospitals with the team responsible for implementing the ASP, according to the nature of the institution (n=165). Brazil, 2023.

| Characterization of the operational team responsible for implementing the ASP | Profile | | |
|---|-----------------|----------------|----------|
| | Private n(%) | Public n(%) | p-value* |
| The hospital has a formal document establishing the ASP approved by the management | 85 (73.3) | 31 (26.7) | 0.02 |
| The ASP goals are part of the hospital's goals | 81 (77.1) | 24 (22.9) | 0.01 |
| The financial resources necessary to implement the ASP are available | 86 (72.9) | 32 (27.1) | |
| The human resources necessary to implement the ASP are available | 99 (74.4) | 34 (25.6) | 0.088 |
| The hospital management provides resources so that the ASP has the support of the microbiology laboratory in its activities | 119 (75.8) | 38 (24.2) | |
| The information technology support necessary for the development of ASP tools in the hospital is available | 94 (76.4) | 29 (23.6) | |
| A management team has been appointed to develop ASP policies and regulations | 97 (73.5) | 35 (26.5) | |
| In the absence of an ASP team, management has been incorporated into the CCIH team | 25 (75.8) | 8 (24.2) | 0.071 |
| An operational team responsible for developing and implementing the ASP* has been formally appointed by hospital management | 33 (70.2) | 14 (29.8) | |
| The members of the operational team have a specific time frame for implementing ASP* actions | 33 (70.2) | 14 (29.8) | |
| The members of the operational team received training and capacity building for the implementation and improvement of ASP* | 44 (74.6) | 15 (25.4) | |
| A leader of the operational team was appointed and is responsible for the implementation and results of ASP* | 55 (77.5) | 16 (22.5) | |
| The leader is an infectologist or physician with expertise in infectious diseases* | 47 (77.0) | 14 (23.0) | |
| There is a clinical pharmacist responsible for working for the ASP | 98 (77.2) | 29 (22.8) | |

It is observed that 70.05% of the responding institutions are private (n=160), while 59 are public (26.94%). Data distribution according to the Federation states is described in Tables 2, 3, 4, 5 and 6.

Table 2: Characterization of the operational team in the responses of components 1 (Leadership Support) and 2 (Definition of Responsibilities), of the hospitals that had a team responsible for implementing the ASP in the states of the Southern Region (n=165). Brazil, 2023.

| Characterization of the operational team responsible for implementing the ASP | PR n (%) | RS n (%) | SC n (%) |
|---|-------------|-------------|-------------|
| | | | |
| The hospital has a formal document establishing the ASP approved by the management | 6 (5.2) | 9 (7.8) | 5 (4.3) |
| The ASP goals are part of the hospital's goals | 10 (9.5) | 7 (6.7) | 3 (2.9) |
| The financial resources necessary to implement the ASP are available | 10 (8.5) | 8 (6.8) | 6 (5.1) |
| The human resources necessary to implement the ASP are available | 17 (12.8) | 11 (8.3) | 4 (3.0) |
| The hospital management provides resources so that the ASP has the support of the microbiology laboratory in its activities | 19 (11.5) | 12 (7.3) | 7 (4.2) |
| The information technology support necessary for the development of ASP tools in the hospital is available | 17 (13.8) | 8 (6.5) | 7 (5.7) |
| A management team has been appointed to develop ASP policies and regulations | 14 (10.6) | 12 (9.1) | 6 (4.5) |
| In the absence of an ASP team, management has been incorporated into the CCIH team | 5 (15.2) | 0 (0.0) | 1 (3.0) |
| An operational team responsible for developing and implementing the ASP* has been formally appointed by hospital management | 6 (8.0) | 4 (5.3) | 1 (1.3) |
| The members of the operational team have a specific time frame for implementing ASP* actions | 3 (6.5) | 3 (6.4) | 1 (2.1) |
| The members of the operational team received training and capacity building for the implementation and improvement of ASP* | 6 (10.2) | 2 (3.4) | 1 (1.7) |
| A leader of the operational team was appointed and is responsible for the implementation and results of ASP* | 6 (8.5) | 4 (5.6) | 1 (1.4) |
| The leader is an infectologist or physician with expertise in infectious diseases* | 5 (8.2) | 3 (4.9) | 1 (1.6) |
| There is a clinical pharmacist responsible for working for the ASP | 16 (12.6) | 10 (7.9) | 6 (4.7) |

Notes: PR – Paraná; SC – Santa Catarina; RS – Rio Grande do Sul; *Subdivision of the survey question: There is an operational team responsible for implementing ASP.

Table 3: Characterization of the operational team in the responses of components 1 (Leadership Support) and 2 (Definition of Responsibilities), of the hospitals that had a team responsible for implementing the ASP in the states of the Southeast Region. Brazil, 2023.

| Characterization of the operational team responsible for implementing the ASP | ES n (%) | MG n (%) | RJ n (%) | SP n (%) |
|---|-------------|-------------|-------------|-------------|
| The hospital has a formal document establishing the ASP approved by the management | 4 (3.4) | 15 (12.9) | 15 (12.9) | 27 (23.3) |
| The ASP goals are part of the hospital's goals | 6 (5.7) | 11 (10.5) | 18 (17.1) | 16 (15.2) |
| The financial resources necessary to implement the ASP are available | 7 (5.9) | 13 (11.0) | 16 (16.6) | 25 (21.2) |
| The human resources necessary to implement the ASP are available | 6 (4.5) | 12 (9.0) | 20 (15.0) | 25 (18.8) |
| The hospital management provides resources so that the ASP has the support of the microbiology laboratory in its activities | 7 (4.2) | 17 (10.3) | 20 (13.3) | 32 (20.6) |
| The information technology support necessary for the development of ASP tools in the hospital is available | 6 (4.9) | 11 (8.9) | 12 (9.8) | 24 (19.5) |
| A management team has been appointed to develop ASP policies and regulations | 5 (3.8) | 15 (11.4) | 18 (13.6) | 23 (17.4) |
| In the absence of an ASP team, management has been incorporated into the CCIH team | 2 (6.1) | 2 (6.1) | 4 (12.1) | 11 (33.3) |
| An operational team responsible for developing and implementing the ASP* has been formally appointed by hospital management | 3 (4.0) | 10 (13.3) | 10 (13.3) | 16 (21.3) |
| The members of the operational team have a specific time frame for implementing ASP* actions | 2 (4.3) | 4 (8.5) | 4 (8.5) | 11 (23.4) |
| The members of the operational team received training and capacity building for the implementation and improvement of ASP* | 2 (3.4) | 9 (15.3) | 6 (10.2) | 11 (18.6) |
| A leader of the operational team was appointed and is responsible for the implementation and results of ASP* | 2 (2.8) | 9 (12.7) | 9 (12.7) | 15 (21.1) |
| The leader is an infectologist or physician with expertise in infectious diseases* | 2 (3.3) | 7 (11.5) | 8 (13.1) | 15 (24.6) |
| There is a clinical pharmacist responsible for working for the ASP | 6 (4.7) | 12 (9.4) | 20 (15.7) | 22 (17.3) |

Notes: ES – Espírito Santo; MG – Minas Gerais; RJ – Rio de Janeiro; SP – São Paulo; *Subdivision of the survey in the question: There is an operational team responsible for implementing the ASP.

Table 4: Characterization of the operational team in the responses of components 1 (Leadership Support) and 2 (Definition of Responsibilities), of the hospitals that had a team responsible for implementing the ASP in the states of the Midwest Region. Brazil, 2023.

| Characterization of the operational team responsible for implementing the ASP | DF n (%) | GO n (%) | MS n (%) | MT# n (%) |
|---|-------------|-------------|-------------|--------------|
| The hospital has a formal document establishing the ASP approved by the management | 6(5.2) | 0(0.0) | 1(0.9) | 0(0.0) |
| The ASP goals are part of the hospital's goals | 5(4.8) | 1(1.0) | 0(0.0) | 0(0.0) |
| The financial resources necessary to implement the ASP are available | 5(4.2) | 1(0.8) | 2(1.7) | 0(0.0) |
| The human resources necessary to implement the ASP are available | 5(3.8) | 1(0.8) | 1(0.8) | 0(0.0) |
| The hospital management provides resources so that the ASP has the support of the microbiology laboratory in its activities | 5(3.6) | 2(1.2) | 2(1.2) | 0(0.0) |
| The information technology support necessary for the development of ASP tools in the hospital is available | 6(4.9) | 2(1.6) | 2(1.6) | 0(0.0) |
| A management team has been appointed to develop ASP policies and regulations | 6(4.5) | 0(0.0) | 1(0.8) | 0(0.0) |
| In the absence of an ASP team, management has been incorporated into the CCIH team | 0(0.0) | 2(6.1) | 1(3.0) | 0(0.0) |
| An operational team responsible for developing and implementing the ASP* has been formally appointed by hospital management | 3(4.0) | 1(1.3) | 0(0.0) | 0(0.0) |
| The members of the operational team have a specific time frame for implementing ASP* actions | 3(6.4) | 0(0.0) | 0(0.0) | 0(0.0) |
| The members of the operational team received training and capacity building for the implementation and improvement of ASP* | 2(3.4) | 1(1.7) | 0(0.0) | 0(0.0) |
| A leader of the operational team was appointed and is responsible for the implementation and results of ASP* | 3(4.2) | 1(1.4) | 0(0.0) | 0(0.0) |
| The leader is an infectologist or physician with expertise in infectious diseases* | 3(4.3) | 1(1.6) | 0(0.0) | 0(0.0) |
| There is a clinical pharmacist responsible for working for the ASP | 6(4.7) | 1(0.8) | 0(0.0) | 0(0.0) |

Notes: DF – Distrito Federal; GO – Goiás; MS – Mato Grosso do Sul; MT – Mato Grosso; #States that did not participate in the survey; *Subdivision of the survey in the question: There is an operational team responsible for implementing the ASP.

Table 5: Characterization of the operational team in the responses of components 1 (Leadership Support) and 2 (Definition of Responsibilities), of the hospitals that had a team responsible for implementing the ASP in the states of the Northeast Region. Brazil, 2023.

| Characterization of the operational team responsible for implementing the ASP | AL n(%) | BA n(%) | CE n(%) | MA n(%) | PB n(%) | PE n(%) | PI n(%) | RN n(%) | SE n(%) |
|---|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| The hospital has a formal document establishing the ASP approved by the management | 0(0.0) | 7(6.0) | 4(3.4) | 7(6.0) | 0(0.0) | 4(3.4) | 0(0.0) | 1(0.9) | 2(1.7) |
| The ASP goals are part of the hospital's goals | 0(0.0) | 7(6.7) | 5(4.8) | 7(6.7) | 0(0.0) | 2(1.9) | 0(0.0) | 1(1.0) | 2(1.9) |
| The financial resources necessary to implement the ASP are available | 0(0.0) | 8(6.8) | 2(1.7) | 7(5.9) | 0(0.0) | 4(3.4) | 0(0.0) | 0(0.0) | 1(0.8) |
| The human resources necessary to implement the ASP are available | 1(0.8) | 8(6.0) | 4(3.0) | 8(6.0) | 0(0.0) | 3(2.3) | 0(0.0) | 1(0.8) | 2(1.5) |
| The hospital management provides resources so that the ASP has the support of the microbiology laboratory in its activities | 1(0.6) | 7(4.8) | 5(3.0) | 9(5.5) | 1(0.6) | 5(3.6) | 0(0.0) | 1(0.6) | 2(1.2) |
| The information technology support necessary for the development of ASP tools in the hospital is available | 1(0.8) | 6(4.9) | 3(2.4) | 9(7.3) | 0(0.0) | 5(4.1) | 0(0.0) | 1(0.8) | 0(0.0) |
| A management team has been appointed to develop ASP policies and regulations | 1(0.8) | 6(4.5) | 5(3.8) | 8(6.1) | 1(0.8) | 4(3.0) | 0(0.0) | 1(0.8) | 2(1.5) |
| In the absence of an ASP team, management has been incorporated into the CCIH team | 0(0.0) | 2(6.1) | 0(0.0) | 1(3.0) | 0(0.0) | 2(6.1) | 0(0.0) | 0(0.0) | 0(0.0) |
| An operational team responsible for developing and implementing the ASP* has been formally appointed by hospital management | 0(0.0) | 4(5.3) | 4(5.3) | 7(9.3) | 0(0.0) | 3(4.0) | 0(0.0) | 0(0.0) | 1(1.3) |
| The members of the operational team have a specific time frame for implementing ASP* actions | 0(0.0) | 2(4.3) | 2(4.3) | 7(14.9) | 0(0.0) | 2(4.3) | 0(0.0) | 0(0.0) | 1(2.1) |
| The members of the operational team received training and capacity building for the implementation and improvement of ASP* | 0(0.0) | 4(6.8) | 4(6.8) | 6(10.2) | 0(0.0) | 2(3.4) | 0(0.0) | 0(0.0) | 1(1.7) |
| A leader of the operational team was appointed and is responsible for the implementation and results of ASP* | 0(0.0) | 4(5.6) | 4(5.6) | 7(9.9) | 0(0.0) | 3(4.2) | 0(0.0) | 0(0.0) | 1(1.4) |
| The leader is an infectologist or physician with expertise in infectious diseases* | 0(0.0) | 4(6.6) | 1(1.6) | 6(9.8) | 0(0.0) | 3(4.9) | 0(0.0) | 0(0.0) | 1(1.6) |
| There is a clinical pharmacist responsible for working for the ASP | 0(0.0) | 6(4.7) | 5(3.9) | 8(6.3) | 0(0.0) | 3(2.4) | 0(0.0) | 1(0.8) | 1(0.8) |

Notes: AL – Alagoas; BA – Bahia; CE – Ceará; MA – Maranhão; PB – Paraíba; PE – Pernambuco; PI – Piauí; RN – Rio Grande do Norte; SE – Sergipe.

*Subdivision of the survey in the question: There is an operational team responsible for implementing the ASP.

Table 6: Characterization of the operational team in the responses of components 1 (Leadership Support) and 2 (Definition of Responsibilities), of the hospitals that had a team responsible for implementing the ASP in the states of the Northern Region. Brazil, 2023.

| Characterization of the operational team responsible for implementing the ASP | AC# n(%) | AM n(%) | AP# n(%) | RO# n(%) | RR# n(%) | TO n(%) |
|---|-------------|------------|-------------|-------------|-------------|------------|
| The hospital has a formal document establishing the ASP approved by the management | 0(0.0) | 1(0.9) | 0(0.0) | 0(0.0) | 0(0.0) | 1(0.9) |
| The ASP goals are part of the hospital's goals | 0(0.0) | 2(1.9) | 0(0.0) | 0(0.0) | 0(0.0) | 1(1.0) |
| The financial resources necessary to implement the ASP are available | 0(0.0) | 1(0.8) | 0(0.0) | 0(0.0) | 0(0.0) | 1(0.8) |
| The human resources necessary to implement the ASP are available | 0(0.0) | 2(1.5) | 0(0.0) | 0(0.0) | 0(0.0) | 1(0.8) |
| The hospital management provides resources so that the ASP has the support of the microbiology laboratory in its activities | 0(0.0) | 2(1.2) | 0(0.0) | 0(0.0) | 0(0.0) | 1(0.6) |
| The information technology support necessary for the development of ASP tools in the hospital is available | 0(0.0) | 2(1.6) | 0(0.0) | 0(0.0) | 0(0.0) | 1(0.8) |
| A management team has been appointed to develop ASP policies and regulations | 0(0.0) | 2(1.5) | 0(0.0) | 0(0.0) | 0(0.0) | 1(0.8) |
| In the absence of an ASP team, management has been incorporated into the CCIH team | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) |
| An operational team responsible for developing and implementing the ASP* has been formally appointed by hospital management | 0(0.0) | 1(1.3) | 0(0.0) | 0(0.0) | 0(0.0) | 1(1.3) |
| The members of the operational team have a specific time frame for implementing ASP* actions | 0(0.0) | 1(2.1) | 0(0.0) | 0(0.0) | 0(0.0) | 1(2.1) |
| The members of the operational team received training and capacity building for the implementation and improvement of ASP* | 0(0.0) | 1(1.7) | 0(0.0) | 0(0.0) | 0(0.0) | 1(1.7) |
| A leader of the operational team was appointed and is responsible for the implementation and results of ASP* | 0(0.0) | 1(1.4) | 0(0.0) | 0(0.0) | 0(0.0) | 1(1.4) |
| The leader is an infectologist or physician with expertise in infectious diseases* | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 1(1.6) |
| There is a clinical pharmacist responsible for working for the ASP | 0(0.0) | 2(1.6) | 0(0.0) | 0(0.0) | 0(0.0) | 1(0.8) |

Notes: AC – Acre; AM – Amazonas; AP – Amapá; RO – Rondônia; RR – Roraima; TO – Tocantins; *States that did not participate in the survey;

*Subdivision of the survey in the question: There is an operational team responsible for implementing the ASP.

The Southeast region has the largest number of hospitals with 98 units (44.75%), followed by the South with 49 (22.37%) and the Northeast with 36 (16.44%). In terms of capacity, most hospitals have 200 or more beds (n=112; 51.14%), with the Southeast region standing out, comprising 49 hospitals in this category (50%). Furthermore,

the Midwest region has the highest proportion of private hospitals (82.40%) and the South has the highest proportion of hospitals with more than 200 beds (55.10%). Regarding ICU sizes, 198 have up to 20 PICU beds (90.41%).

Tables 7 and 8 show the data related to the characteristics of the operational team in the responses of components 1 (Leadership Support) and 2 (Definition of Responsibilities), according to the total number of beds and PICU of the hospitals studied.

Table 7: Characterization of the operational team in the responses of components 1 (Leadership Support) and 2 (Definition of Responsibilities), according to the total number of beds in hospitals with a team responsible for implementing the ASP (n=165). Brazil, 2023.

| Characterization of the operational team responsible for implementing the ASP | Hospital Beds (n - %) | | |
|---|-----------------------|-----------|-----------|
| | Up to 100 | 101-199 | >200 |
| The hospital has a formal document establishing the ASP approved by the management | 16 (13.8) | 34 (29.3) | 66 (56.9) |
| The ASP goals are part of the hospital's goals | 7 (25.0) | 7 (25.0) | 14 (50.0) |
| The financial resources necessary to implement the ASP are available | 18 (15.3) | 35 (29.7) | 65 (55.1) |
| The human resources necessary to implement the ASP are available | 21 (15.8) | 37 (27.8) | 75 (56.4) |
| The hospital management provides resources so that the ASP has the support of the microbiology laboratory in its activities | 26 (16.6) | 47 (29.9) | 84 (53.5) |
| The information technology support necessary for the development of ASP tools in the hospital is available | 18 (14.6) | 41 (33.3) | 64 (52.0) |
| A management team has been appointed to develop ASP policies and regulations | 19 (14.4) | 36 (27.3) | 77 (58.3) |
| In the absence of an ASP team, management has been incorporated into the CCIH team | 10 (30.3) | 12 (36.4) | 11 (33.3) |
| An operational team responsible for developing and implementing the ASP* has been formally appointed by hospital management | 10 (13.3) | 25 (33.3) | 40 (53.3) |
| The members of the operational team have a specific time frame for implementing ASP* actions | 5 (10.6) | 15 (31.9) | 27 (57.4) |
| The members of the operational team received training and capacity building for the implementation and improvement of ASP* | 8 (13.6) | 20 (33.9) | 31 (52.5) |
| A leader of the operational team was appointed and is responsible for the implementation and results of ASP* | 9 (12.7) | 23 (32.4) | 39 (54.9) |
| The leader is an infectologist or physician with expertise in infectious diseases* | 9 (14.8) | 18 (29.5) | 34 (55.7) |
| There is a clinical pharmacist responsible for working for the ASP | 19 (15.0) | 37 (29.1) | 71 (51.9) |

Table 8: Characterization of the operational team in the responses of components 1 (Leadership Support) and 2 (Definition of Responsibilities), according to the number of PICU beds of hospitals with a team responsible for implementing the ASP (n=165). Brazil, 2023.

| Characterization of the operational team responsible for implementing the ASP | PICU Beds (n - %) | | |
|---|-------------------|-----------|---------|
| | Up to 20 | Over 20 | p-value |
| The hospital has a formal document establishing the ASP approved by the management | 105 (90.5) | 11 (9.5) | 0.02 |
| The ASP goals are part of the hospital's goals | 95 (90.5) | 10 (9.5) | 0.01 |
| The financial resources necessary to implement the ASP are available | 104 (88.1) | 14 (11.9) | |
| The human resources necessary to implement the ASP are available | 118 (88.7) | 15 (11.3) | 0.056 |
| The hospital management provides resources so that the ASP has the support of the microbiology laboratory in its activities | 143 (91.1) | 14 (8.9) | |
| The information technology support necessary for the development of ASP tools in the hospital is available | 108 (87.8) | 15 (12.2) | |
| A management team has been appointed to develop ASP policies and regulations | 119 (90.2) | 13 (9.8) | 0.017 |
| In the absence of an ASP team, management has been incorporated into the CCIH team | 30 (90.9) | 3 (9.1) | 0.017 |
| An operational team responsible for developing and implementing the ASP* has been formally appointed by hospital management | 67 (89.3) | 8 (10.7) | |
| The members of the operational team have a specific time frame for implementing ASP* actions | 39 (83.0) | 8 (17.0) | |
| The members of the operational team received training and capacity building for the implementation and improvement of ASP* | 51 (86.4) | 8 (13.6) | |
| A leader of the operational team was appointed and is responsible for the implementation and results of ASP* | 63 (88.7) | 8 (11.3) | |
| The leader is an infectologist or physician with expertise in infectious diseases* | 53 (86.9) | 8 (13.1) | |
| There is a clinical pharmacist responsible for working for the ASP | 114 (89.8) | 13 (10.2) | |

Notes: *Subdivision of the survey in the question: Is there an operational team responsible for implementing the ASP.

A total of 165 (75.34%) services were identified as having an operational team working in primary care. In terms of the hospitals' profile, most of those with such teams are private. The distribution of hospitals varies in

terms of capacity, ranging from small (up to 100 beds) to large (over 200 beds), with the majority having over 200 beds.

Regarding PICU beds, most hospitals have up to 20 pediatric ICU beds, with a smaller proportion having more than 20 beds. However, when analyzed individually, the group with more than 20 PICU beds stands out with a higher proportion of YES responses (66.06%) in most scenarios analyzed. Table 1 also presents the comparisons between hospitals with PICUs up to 20 beds and more than 20 beds for components 1 and 2, with $p < 0.05$. Furthermore, variables were identified concerning nature with p values not less than 0.05, but which draw attention, such as: the existence of human resources to implement the ASP in the hospital ($p = 0.088$) and the management of the ASP incorporated into the Hospital Infection Control Committee ($p = 0.071$), indicating relevant aspects that deserve consideration in the health services analyzed.

DISCUSSION

An analysis of the ASP implementation levels in Brazilian states reveals significant variation, which can be correlated with the regions' GDP and population density. International studies highlight that regions with higher GDP and population density tend to have better infrastructure and resources for implementing AMR programs^{23,24}. States such as São Paulo, Rio de Janeiro, and Minas Gerais have higher GDP and higher population density, providing better resources and support for ASP implementation. However, São Paulo is only at the basic level for both elements, indicating that, despite the available resources, there is still room for improvement in implementation, despite having a larger number of participants. On the other hand, states such as Acre, Amapá, Mato Grosso, Rondônia, and Roraima face additional challenges due to the lower availability of financial and technological resources, reflected in the inadequate level of implementation due to non-participation in the survey or non-adherence to the ASP.

The findings on ASP implementation in PICU in Brazilian hospitals strongly correlate with recent international literature, highlighting both the progress and the challenges faced^{25,26}. The support of senior hospital management, highlighted in Figure 2 with 94.52% of hospitals providing resources for the ASP, is essential for the success of the implementation^{27,28}. This finding is corroborated by studies that emphasize the importance of institutional support and leadership for the effectiveness of ASP^{23,24,27}. The availability of adequate human and financial resources for ASP implementation is another crucial factor (76.71% and 66.21%, respectively). These results are consistent with findings from other research indicating that resource availability is a significant barrier in Latin American and Caribbean countries²⁴. Lack of funding and qualified personnel limits the effective implementation of these programs, as also observed in low- and middle-income countries²⁸.

Furthermore, Information Technology (IT) support, present in 73.06% of Brazilian hospitals, reflects a global trend toward integrating technological tools into the ASP. A study demonstrated that the use of methodologies such as Lean Six Sigma, which rely heavily on data and technology, can optimize processes and reduce antimicrobial use without compromising clinical outcomes²⁵. This alignment highlights the importance of IT in the continuous monitoring and assessment of programs. The presence of teams responsible for implementing ASP (75.34%) stands out, a strategy widely recognized in the literature as fundamental to the success of AMR programs. Other studies reinforce that the formation of multidisciplinary teams is vital to addressing AMR in a coordinated and effective manner^{29,30}. The integration of clinical pharmacists, mentioned in 72.15% of Brazilian hospitals, is a recommended practice and has been successfully implemented in several regions of the world, including the Middle East²⁵.

Despite notable progress in implementing ASP in Brazilian PICUs, some weaknesses have been revealed that deserve attention. A critical aspect is that only 66.21% of hospitals have the necessary financial resources to implement ASP. This financial limitation is a common challenge, especially in low- and middle-income countries. A review highlights that lack of adequate funding is a significant barrier in Latin America and the Caribbean, directly affecting the ability to maintain sustainable and effective programs²⁴. Furthermore, several studies indicate that resource scarcity is a critical obstacle preventing the advancement of robust AMR programs in many parts of the world, especially in resource-limited settings³¹⁻³⁴.

Another vulnerability identified is that only 67.58% of hospitals designated a manager responsible for developing ASP policies and regulations. Appointing dedicated leaders is essential to ensure the effective implementation and oversight of AMR programs. According to studies, institutional leadership is crucial to the success of programs, as it facilitates the coordination of multidisciplinary efforts and the implementation of evidence-based strategies. The absence of clear leadership can result in fragmented and less effective efforts in the fight against antimicrobial resistance^{23,26-28,34}. This study also indicates that only 60.73% of the hospitals have

ASP goals aligned with their strategic goals. This strategic alignment is crucial to ensuring that AMR programs receive the necessary support from all levels of hospital administration. Studies show that integrating ASP goals with the hospital's overall strategy improves guideline adherence and intervention success. A lack of alignment can lead to inappropriate prioritization of ASP activities, resulting in reduced effectiveness and impact on reducing inappropriate antimicrobial use²³⁻²⁷.

An analysis of the operational team responsible for implementing the ASP in 165 Brazilian hospitals reveals several strengths and weaknesses, as corroborated by international literature. It is important to note the differences and similarities in the factors assessed, both in terms of the nature of the hospitals (private vs. public) and their bed capacity. Private hospitals are more likely to have a formal document establishing the ASP and are more likely to integrate the ASP goals into the hospital's strategic goals, suggesting greater availability of formal structures and dedicated resources. Hospitals with larger bed capacities (>200) are significantly more likely to have a formal document and integrate ASP goals, reflecting greater administrative and resource capacity. Most hospitals with up to 20 PICU beds have a formal document and integrate ASP goals, indicating an operational need to standardize processes and ensure quality of care^{24,26,28}.

Although some differences observed between private and public hospitals are not statistically significant ($p>0.05$), some aspects suggest that institutional nature may influence policy implementation and the integration of ASP goals. Therefore, although there was no robust statistical significance across all variables analyzed, the trend noticed indicates a need to consider the hospitals' profile when formulating and implementing these policies. Observed in 85 (73.30%) of the hospitals with p -value=0.02, the existence of a formal document establishing the ASP suggests an association between program formalization and its effective implementation. A study emphasizes that formal documentation is essential for the success of ASPs, as it eases resource mobilization and ensures health professionals' commitment²³. This institutional support is corroborated by results from other countries that demonstrate the importance of formalizing policies for program effectiveness^{28,31,32}.

The presence of teams responsible for implementing ASP in 105 (90.50%) of the hospitals with up to 20 beds is a crucial factor for the effectiveness of the programs, with p -value=0.020. This result is consistent with the literature, which highlights the importance of dedicated multidisciplinary teams in managing antimicrobial resistance. Studies indicate that well-structured teams with clear responsibilities are more effective in implementing ASP, especially in low- and middle-income settings^{23,28}. The alignment of ASP goals with the hospital's strategic goals, observed in 81 (77.10%) of the private hospitals, presents p -value=0.01, indicating significant statistical significance.

The combined analysis of these results provides a comprehensive understanding of the factors that affected ASP implementation in Brazil, from internal hospital conditions to regional disparities. While the operational teams' characterization reveals the strengths and weaknesses within hospitals, the implementation in the states highlights the need for specific policies to overcome regional challenges and ensure effective implementation nationwide.

This survey offers valuable contributions to antimicrobial stewardship by providing a comprehensive assessment of ASP in PICUs in Brazil. Despite the existence of pediatric ASP in the country, its activities vary significantly, necessitating initiatives toward standardization. Understanding the impact of antimicrobial resistance (AMR) and identifying key weaknesses and strengths in prevention are essential to inform policy and institutional decisions tailored to each location and care setting. This is particularly important for reducing the use of broad-spectrum antibiotics. Incorporating ASP strategies is believed to promote the judicious use of antimicrobials, reducing infant morbidity and mortality and associated costs. This approach is expected to increase multidisciplinary team adherence to the program in clinical practice and improve safety regarding AMR in PICUs.

Study limitations

The study had some limitations due to the hospitals' voluntary participation. Most participating hospitals had ASPs, which may not adequately represent all hospitals with PICUs in Brazil. Responses to the survey varied across regions, which may compromise data representativeness when compared to each other. The specific characteristics of hospitals in terms of type of care and number of beds in different regions were not identified. The multiple-choice questions may not have covered all possible options, and it was not possible to add free-text responses. In addition, the lack of previous research in this context limited the discussion and comparison of the results obtained.

CONCLUSION

This study shows that the effectiveness of implementing ASPs in PICU in Brazil depends directly on effective support from institutional leadership and a clear Definition of Operational Responsibilities. The national analysis shows that, although relevant initiatives are underway, adherence to Components 1 (Leadership Support) and 2 (Definition of Responsibilities) remains uneven across states, being more consistent in regions with greater infrastructure and hospital management capacity.

Component 1, which reflects leadership commitment, is a critical pillar: where there is active and engaged leadership, there is more significant progress in ASP implementation. Component 2, which addresses the definition of roles and responsibilities, remains a weak point in many institutions, especially in states with less socioeconomic development, where inadequate levels of program structure persist.

The lack of committed technical leadership and formal accountability structures limits an ASP transformative potential in PICUs. Therefore, the program's existence on paper is not enough: genuine leadership engagement and institutionalized responsibilities are essential to ensure its effectiveness. Institutions that already have organized teams and clear leadership demonstrate that change is possible, provided there is strategic direction.

Therefore, to advance in tackling antimicrobial resistance in PICUs, it is essential that Brazil adopts structural measures, prioritizes training and retention of committed leaders and implements mechanisms that ensure definition and accountability of the teams involved. Only with this commitment will it be possible to consolidate ASPs as a robust and effective institutional policy, contributing to patient safety and strengthening public health in all territories.

REFERENCES

1. Pallares CJ, Porras J, La Cadena E, García-Betancur JC, Restrepo-Arbeláez N, Cobo Viveros SM, et al. Antimicrobial stewardship programs in seven Latin American countries: facing the challenges. *BMC Infect Dis*. 2023 Jul 11 [cited 2025 Jun 3]; 23(1):463. DOI: <https://doi.org/10.1186/s12879-023-08398-3>.
2. GBD 2019 Antimicrobial Resistance in the Americas Collaborators. The burden of antimicrobial resistance in the Americas in 2019: a cross-country systematic analysis. *Lancet Reg Health Am*. 2023 [cited 2024 Dec 17]; 25:100561. DOI: <https://doi.org/10.1016/j.lana.2023.100561>.
3. Murray CJL, Ikuta KS, Sharara F, Swetschinski L, Aguilar GR, Gray A, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *Lancet*. 2022 [cited 2024 Dec 17]; 399(10325):629–55. DOI: [https://doi.org/10.1016/S0140-6736\(21\)02724-0](https://doi.org/10.1016/S0140-6736(21)02724-0).
4. World Health Organization, Food and Agriculture Organization of the United Nations, United Nations Environment Program, World Organization for Animal Health. Implementing the global action plan on antimicrobial resistance: first quadripartite biennial report. Geneva: WHO; 2024 [cited 2025 Jun 3]. Available from: <https://www.who.int/publications/i/item/9789240074668>.
5. Pan American Health Organization. Antimicrobial resistance in the Americas: Magnitude and response. [Internet]. 2019 [cited 2024 Dec 17]; Available from: <https://iris.paho.org/handle/10665.2/51655>.
6. Agência Nacional de Vigilância Sanitária (Br). Programa Nacional de Prevenção e Controle de Infecções Relacionadas à Assistência à Saúde: PNPCIRAS 2021–2025. Brasília: Anvisa; 2021 [cited 2025 Jun 3]. Available from: https://www.gov.br/anvisa/pt-br/centraisdeconteudo/publicacoes/servicosdesaude/publicacoes/pnpciras_2021_2025.pdf.
7. Agência Nacional de Vigilância Sanitária (Br). Plano Nacional para a Prevenção e o Controle da Resistência aos Antimicrobianos nos Serviços de Saúde – PAN Serviços de Saúde 2023–2027. Brasília: Anvisa; 2023 [cited 2025 Jun 3]. Available from: <https://www.gov.br/anvisa/pt-br/assuntos/servicosdesaude/prevencao-e-controle-de-infeccao-e-resistencia-microbiana/pnpciras-e-pan-servicos-de-saude/pan-servicos-de-saude-2023-2027-final-15-12-2023.pdf>.
8. Agência Nacional de Vigilância Sanitária (Br). Relatório de Atividades dos Programas de Gerenciamento de Antimicrobianos no Brasil. Brasília: Anvisa; 2022. [cited 2024 Dec 17]; Available from: <https://www.gov.br/anvisa/pt-br>.
9. Agência Nacional de Vigilância Sanitária (Br). Nota Técnica GVIMS/GGTES/DIRE3/ANVISA nº 01/2025: Orientações para vigilância das Infecções Relacionadas à Assistência à Saúde (IRAS) e resistência aos antimicrobianos em serviços de saúde. [Internet]. Brasília: Anvisa; 2025 [cited 2025 Jun 3]. Available from: <https://www.gov.br/anvisa/pt-br/centraisdeconteudo/publicacoes/servicosdesaude/notas-tecnicas/notas-tecnicas-vigentes/nota-tecnica-gvims-ggtes-dire3-anvisa-no-01-2025/view>.
10. Harun MGD, Sumon SA, Hasan I, Akther FM, Islam MS, Anwar MMU. Barriers, facilitators, perceptions and impact of interventions in implementing antimicrobial stewardship programs in hospitals of low-middle and middle countries: a scoping review. *Antimicrob Resist Infect Control*. 2024 [cited 2024 Dec 17]; 13(1):8. <https://doi.org/10.1186/s13756-024-01369-6>.
11. Agência Nacional de Vigilância Sanitária (Br). Diretriz Nacional para Elaboração de Programa de Gerenciamento do Uso de Antimicrobianos em Serviços de Saúde. Revisão 2023. Brasília: Anvisa; 2024 [cited 2024 Dec 17]; Available from: <https://www.gov.br/anvisa/pt-br/centraisdeconteudo/publicacoes/servicosdesaude/publicacoes/DiretrizGerenciamentoAntimicrobianosANVISA2023FINAL.pdf>.
12. Zay Ya K, Win PTN, Bielicki J, Lambiris M, Fink G. Association Between Antimicrobial Stewardship Programs and Antibiotic Use Globally: A Systematic Review and Meta-Analysis. *JAMA Netw Open*. 2023 [cited 2024 Dec 17]; 6(2):e2253806. DOI: <https://doi.org/10.1001/jamanetworkopen.2022.53806>.

13. Linde-Ozola Z, Classen AY, Giske CG, Göpel S, Eliakim-Raz N, Semret M, et al. Quality, availability and suitability of antimicrobial stewardship guidance: a multinational qualitative study. *JAC Antimicrob Resist.* 2024 [cited 2024 Dec 17]; 6(2):dlae039. DOI: <https://doi.org/10.1093/jacamr/dlae039>.
14. Yock-Corrales A, Naranjo-Zuñiga G. Regional perspective of antimicrobial stewardship programs in Latin American Pediatric Emergency Departments. *Antibiotics (Basel).* 2023 [cited 2024 Dec 17]; 12(5):916. DOI: <https://doi.org/10.3390/antibiotics12050916>.
15. Fernandes TB, Ramos SF, Leitzke LRF, Júnior RGA, Araújo JM, Souza Júnior AS, et al. Use of antimicrobials in pediatric wards of five Brazilian hospitals. *BMC Pediatr.* 2024 [cited 2024 Dec 17]; 24(1):177. DOI: <https://doi.org/10.1186/s12887-024-04655-9>.
16. Gidey K, Aregawi SG, Hailu BY, Asgedom SW, Niriayo YL. Antimicrobial use-related problems among hospitalized pediatric patients: a prospective observational study. *Infect Drug Resist.* 2024 [cited 2024 Dec 17]; 17:119-30. DOI: <https://doi.org/10.2147/idr.s433677>.
17. Chorafa E, Komatsioulis V, Iosifidis E, Kourti M, Sdougka M, Roilides E. Antimicrobial stewardship programs in PICU settings: a systematic review. *Pediatr Crit Care Med.* 2023 [cited 2024 Dec 17]; 24(1):e20-7. DOI: <https://doi.org/10.1097/pcc.0000000000003069>.
18. Krummenauer EC, Ziembowicz H, Gonçalves MRS, Costa MMM, Assis MP, Dias VMCH, et al. A nationwide survey of antimicrobial stewardship in pediatric intensive care unit: implementation notes from the Brazilian underground. *Antimicrob Steward Healthc Epidemiol.* 2023 [cited 2024 Dec 17]; 3(1):e250. <https://doi.org/10.1017/ash.2023.530>.
19. Instituto Brasileiro de Geografia e Estatística (Br). IBGE Cidades. Brasília: IBGE; 2024 [cited 2024 Dec 17]. Available from: <https://cidades.ibge.gov.br/>.
20. Menezes RM, Carneiro M, Gonçalves MRS, Costa MMM, Krummenauer EC, Reuter CP, et al. Desenvolvimento e validação de questionário para autoavaliação dos programas de gerenciamento de antimicrobianos em unidade de terapia intensiva adulto. *Revista Científica Multidisciplinar Núcleo do Conhecimento* 2022 [cited 2024 Dec 17]; 5:175-215. Available from: <https://www.nucleodoconhecimento.com.br/saude/questionario-para-autoavaliacao>.
21. Cherubin NA, Santos NA. Administração Hospitalar. Fundamentos. São Paulo: CEDAS, 1997.
22. Field A. Descobrimos a estatística usando o SPSS. 5ª ed. Porto Alegre: Penso, 2020.
23. Setiawan E, Abdul-Aziz MH, Roberts JA, Cotta MO. Hospital-based antimicrobial stewardship programs used in low- and middle-income countries: a scoping review. *Microb Drug Resist.* 2022 [cited 2024 Dec 17]; 28(5):566-84. DOI: <https://doi.org/10.1089/mdr.2021.0363>.
24. Restrepo-Arbeláez N, García-Betancur JC, Pallares CJ, Villegas MV. Antimicrobial stewardship programs in latin america and the caribbean: a story of perseverance, challenges, and goals. *Antibiotics.* 2023 [cited 2024 Dec 17]; 12(8):1342. DOI: <https://doi.org/10.3390/antibiotics12081342>.
25. Sallam M, Snugg J. Improving antimicrobial stewardship program using the lean six sigma methodology: a descriptive study from mediclinic welcare hospital in Dubai, the UAE. *Healthcare.* 2023 [cited 2024 Dec 17]; 11(23):3048. DOI: <https://doi.org/10.3390/healthcare11233048>.
26. Chukwu EE, Abuh D, Idigbe IE, Osuolale KA, Chuka-Ebene V, Awoderu O, et al. Implementation of antimicrobial stewardship programs: A study of prescribers' perspective of facilitators and barriers. *PLoS ONE.* 2024 [cited 2024 Dec 17]; 19(1): e0297472. DOI: <https://doi.org/10.1371/journal.pone.0297472>.
27. Mateus C. Implementation of antimicrobial stewardship programs: a study of prescribers' perspective of facilitators and barriers. *PLoS ONE.* 2023 [cited 2024 Dec 17]; 18(1):e0235567. DOI: <https://doi.org/10.1371/journal.pone.0235567>.
28. Pauwels I, Versporten A, Ashiru-Oredope D, Costa SF, Maldonado H, Porto APM, et al. Implementation of hospital antimicrobial stewardship programmes in low- and middle-income countries: a qualitative study from a multi-professional perspective in the Global-PPS network. *Antimicrob Resist Infect Control.* 2025 [cited 2025 Jun 3]; 14(1):26. DOI: <https://doi.org/10.1186/s13756-025-01541-6>.
29. Jordan I, Benavent E, Bordejé ML, Calvo C, Cambra FJ, Esteban E, et al. antimicrobial stewardship improvement in pediatric intensive care units in Spain—what have we learned? *Children.* 2022 [cited 2024 Dec 17]; 9(6):902. DOI: <https://doi.org/10.3390/children9060902>.
30. Hassan SK, Dahmash EZ, Madi T, Tarawneh O, Jomhawi T, Alkhob W, et al. Four years after the implementation of antimicrobial stewardship program in Jordan: evaluation of program's core elements. *Front Public Health.* 2023 [cited 2024 Dec 17]; 11:1078596. DOI: <https://doi.org/10.3389/fpubh.2023.1078596>.
31. Hadi HA, Eltayeb F, Al Balushi S, Daghfal J, Ahmed F, Mateus C. Evaluation of hospital antimicrobial stewardship programs: implementation, process, impact, and outcomes, review of systematic reviews. *Antibiotics (Basel).* 2024 [cited 2024 Dec 17]; 13(3):253. DOI: <https://doi.org/10.3390/antibiotics13030253>.
32. Collignon P, Athukorala P, Senanayake S, Khan F. Socio-economic, governance, and health indicators shaping antimicrobial resistance: a global analysis. *Lancet Infect Dis.* 2018 [cited 2024 Dec 17]; 18(10):1167-74. DOI: [https://doi.org/10.1016/S2542-5196\(18\)30186-4](https://doi.org/10.1016/S2542-5196(18)30186-4).
33. Tadesse BT, Ashley EA, Ongareello S, Havumaki J, Wijegoonewardena M, González IJ, et al. Antimicrobial resistance in Africa: a systematic review. *BMC Infect Dis.* 2017 [cited 2024 Dec 17]; 17(1):616. DOI: <https://doi.org/10.1186/s12879-017-2713-1>.
34. Ayukekbong JA, Ntemgwa M, Atabe AN. The threat of antimicrobial resistance in developing countries: causes and control strategies. *Antimicrob Resist Infect Control.* 2017 [cited 2024 Dec 17]; 6:47. DOI: <https://doi.org/10.1186/s13756-017-0208-x>.

Author contributions:

Conceptualization, E.C.K.; M.P.A., M.R.S.G., M.M.M.C., R.M.M., J.D.P.R. and M.C.; methodology, E.C.K., M.P.A., M.R.S.G., M.M.M.C., R.M.M., J.D.P.R. and M.C.; software, E.C.K., M.P.A. and M.R.S.G.; validation, E.C.K., M.P.A., M.R.S.G., M.M.M.C., R.M.M., J.D.P.R. and M.C.; formal analysis, E.C.K., M.P.A., M.R.S.G., J.D.P.R. and M.C.; investigation, E.C.K., M.P.A. and M.R.S.G.; resources, M.R.S.G., M.M.M.C., J.D.P.R. and M.C.; data curation, E.C.K., M.P.A., M.R.S.G., J.D.P.R. and M.C.; manuscript writing, E.C.K., M.P.A., M.R.S.G., J.D.P.R. and M.C.; review and



Research Article
Artigo de Pesquisa
Artículo de Investigación

Krummenauer EC, Assis MP, Gonçalves MRS, Costa MMM, Menezes RM, Renner JDP, Carneiro M
Antimicrobial stewardship programs in Brazil

DOI: <https://doi.org/10.12957/reuerj.2025.89530>

editing, E.C.K., M.P.A., M.R.S.G., M.M.M.C., R.M.M., J.D.P.R. and M.C.; visualization, E.C.K., M.P.A., M.R.S.G., M.M.M.C., R.M.M., J.D.P.R. and M.C.; supervision, M.R.S.G., M.M.M.C., J.D.P.R. and M.C.; project administration, M.R.S.G., M.M.M.C., J.D.P.R. and M.C.; financing acquisition, E.C.K., M.R.S.G., M.M.M.C., J.D.P.R. and M.C. All authors read and agreed with the published version of the manuscript.

Use of artificial intelligence tools

The authors declare that no artificial intelligence tools were used in the composition of the manuscript “*Antimicrobial stewardship programs: Progress and challenges in Brazilian pediatric intensive care units*”.