SVOA Paediatrics
ISSN: 2755-1660

ScienceVolks Open Access

Original Article

Microbiological Patterns and Outcomes of Catheter-Related Bloodstream Infections in Pediatric Hemodialysis: A 9-Year Retrospective Study at a National Referral Center in Mexico

Irma Esther del Moral Espinosa[1], Víctor Manuel Barajas Valencia[1], Gustavo Eduardo Aurioles Amozurrutia[2]*, Cruz Esteban Ochoa Ramirez[1], Edgar Eduardo Morales Montes[1], Rebeca Gómez Chico Velasco[1]

[1]Pediatric Nephrology Department, Hospital Infantil de México, Federico Gómez, Ciudad de México, México.

[2]Facultad Mexicana de Medicina, Universidad La Salle, Ciudad de México, México.

***Corresponding Author:** Gustavo Eduardo Aurioles Amozurrutia, Facultad Mexicana de Medicina, Universidad La Salle, Ciudad de México, México.

https://doi.org/10.58624/SVOAPD.2025.04.011

Received: May 19, 2025

Published: June 17, 2025

Citation: del Moral Espinosa IE, Valencia VMB, Amozurrutia GEA, Ochoa Ramirez CE, Morales Montes EE, Chico Velasco RG. Microbiological Patterns and Outcomes of Catheter-Related Bloodstream Infections in Pediatric Hemodialysis: A 9-Year Retrospective Study at a National Referral Center in Mexico. *SVOA Paediatrics* 2025, 4:3, 70-79. doi.org/10.58624/SVOAPD.2025.04.011

Abstract

Background: Catheter-related bloodstream infections (CRBSIs) remain a major contributor to morbidity in children receiving chronic hemodialysis, particularly in Latin American settings where surveillance data are scarce and fragmented. This study provides a comprehensive analysis of CRBSI incidence, microbiological profiles, and clinical outcomes at a national pediatric referral center in Mexico.

Methods: A retrospective study including pediatric patients (<18 years) who underwent hemodialysis via central venous catheters (CVCs) from January 2016 to May 2024 was carried out at the Hospital Infantil de México Federico Gómez. Based on CDC diagnostic criteria, confirmed CRBSI episodes were identified. Using descriptive statistics, demographic characteristics, microbiological results, therapeutic regimens, and clinical outcomes were methodically examined.

Results: Among 56 pediatric patients, a total of 89 catheter-related bloodstream infection (CRBSI) episodes were identified, resulting in an incidence of 11.6 episodes per 1,000 catheter-days. Staphylococcus aureus (39.3%), Staphylococcus epidermidis (23.6%), Klebsiella pneumoniae (9.0%), and Enterococcus faecalis (4.5%) were the most frequently isolated pathogens. The most affected groups were school-age children (37.1%) and adolescents (40.4%). The most used empirical regimen was vancomycin plus cefepime (58.4%). Catheter removal was required in 36% of episodes. No infection-related deaths were recorded. A substantial decrease in CRBSI incidence was observed from 2021 onwards.

Conclusion: The substantial decline in infection rates underscores the effectiveness of targeted preventive strategies, including standardized catheter care protocols, continuous microbiological surveillance, and context-specific therapeutic interventions. These measures have demonstrated a meaningful impact in safeguarding pediatric hemodialysis patients, a population inherently vulnerable to catheter-related complications.

Keywords: *Catheter-related bloodstream infections (CRBSIs); Pediatric hemodialysis; Infection prevention strategies; Non-tunneled central venous catheters; Microbiological profile*

1. Introduction

Catheter-related bloodstream infections (CRBSIs) are among the most frequent and serious complications in pediatric patients receiving chronic hemodialysis. These infections are associated with increased morbidity, prolonged hospitalization, vascular access loss, and elevated healthcare costs. [1–2] Children are particularly vulnerable due to their immature immune systems, repeated exposure to invasive procedures, and long-term reliance on non-tunneled central venous catheters (CVCs) as their primary vascular access. [1]

In Latin America, and specifically in Mexico, the epidemiology of CRBSIs in the pediatric dialysis population remains insufficiently documented. While some local postgraduate theses and institutional case series have addressed dialysis-related infections in pediatric patients from tertiary care hospitals,[3–4] most available data continue to focus on adult populations or isolated pediatric case reports, resulting in an important knowledge gap.

The Hospital Infantil de México Federico Gómez (HIMFG) serves as a national referral center for pediatric nephrology, providing specialized multidisciplinary care for children with complex kidney disorders. Over the last decade, the Nephrology Department has implemented targeted infection control measures, including the adoption of the Aseptic Non-Touch Technique (ANTT) and standardized catheter care bundles, which may have influenced infection trends. [5]

This retrospective study analyzes nine years of institutional data (2016–2024) from pediatric patients undergoing chronic hemodialysis via CVCs at HIMFG. The aim is to describe CRBSI incidence, microbiological profiles, and clinical outcomes and to evaluate the temporal impact of institutional prevention strategies. By generating region-specific evidence, we seek to inform future infection control protocols and improve care in resource-constrained pediatric dialysis settings. [1–6]

2. Methods

2.1 Study Design and Setting

This was a retrospective, single-center case series conducted at the Hospital Infantil de México Federico Gómez (HIMFG), a national pediatric referral hospital in Mexico City. Clinical records were reviewed for all patients under 18 years of age who underwent chronic hemodialysis through non-tunneled central venous catheters (CVCs) between January 2016 and May 2024. Catheter types included dual-lumen Mahurkar and Niagara devices, which were placed for temporary vascular access. Institutional infection prevention protocols such as ANTT and standardized catheter care bundles—were progressively implemented between 2019 and 2021. [1–2]

2.2 Inclusion Criteria

Eligible patients met all of the following:

- Age <18 years at the time of CRBSI.
- Diagnosis of end-stage kidney disease requiring chronic hemodialysis.
- Use of a non-tunneled CVC as the sole vascular access.
- At least one microbiologically confirmed case of CRBSI during the study period.

2.3 CRBSI Definition

CRBSI was defined according to CDC guidelines. [3] Diagnosis required clinical signs of systemic infection (e.g., fever, chills, or hypotension) in the absence of another source, accompanied by a positive blood culture drawn from the catheter. When both central and peripheral cultures were available, the same organism had to be isolated from both, with the central sample becoming positive at least two hours earlier than the peripheral sample. [4]

2.4 Data Collection

- A standardized case report form was used to collect:
- Demographics: age, sex, and developmental group classification.
- Catheter characteristics: type, insertion site, and dwell time until infection.

- Microbiological data: isolated organisms and resistance patterns.
- Clinical presentation and treatment: symptoms, empirical and definitive antimicrobial regimens, treatment duration, catheter removal, and outcomes.

2.5 Statistical Analysis

The identified data were analyzed using descriptive statistics. Categorical variables were reported as frequencies and percentages, while continuous variables were expressed as means ± standard deviation or medians with interquartile ranges, as appropriate. CRBSI incidence was calculated per 1,000 catheter-days. Yearly trends were graphed, and differences across periods were explored.

A p-value < 0.05 was considered statistically significant. Statistical review was conducted by a nephrology research fellow and cross-validated with institutional data.

3. Results

3.1 Patient Characteristics

Between January 2016 and May 2024, a total of 89 catheter-related bloodstream infection (CRBSI) episodes were documented in 56 pediatric patients undergoing chronic hemodialysis via non- tunneled central venous catheters (CVCs) at the Hospital Infantil de México Federico Gómez (HIMFG).

The cohort had a slight female predominance (53.9% female, n = 30; 46.1% male, n = 26), and patient ages ranged from 6 months to 17.9 years, with a mean age of 10.3 ± 5.2 years.

In terms of developmental stage, adolescents (12–17 years) represented the most affected group (40.4%, n = 36), followed by school-age children (6–11 years) with 37.1% (n = 33), infants (<1year) with 9.0% (n = 8), preschool-aged children (3–5 years) with 7.9% (n = 7), and toddlers (1–2 years) with 5.6% (n = 5).

These distributions are detailed in Table 1.

Table 1. Demographic Characteristics of the Pediatric Cohort.

	<1 yr	1–2 yr	3–5 yr	6–11 yr	12–17 yr	Total
n (%)	8 (9.0)	5 (5.6)	7 (7.9)	33 (37.1)	36 (40.4)	89 (100)
Female	4	3	4	19	19	49
Male	4	2	3	14	17	40

Note: Data represent absolute frequency and relative distribution of pediatric patients undergoing hemodialysis between 2016–2024.

3.2 Incidence and Temporal Trends

The overall CRBSI incidence across the nine-year period was 11.6 episodes per 1,000 catheter- days, based on 89 microbiologically confirmed episodes and 7,663 catheter-days of follow-up.

The annual distribution of episodes was 2016 (11.2%), 2017 (19.1%), 2018 (24.7%), 2019 (9.0%), 2020 (24.7%), 2021 (0%), 2022 (0%), 2023 (5.6%), and 2024 (through May, 5.6%).

A marked reduction in CRBSI incidence was observed beginning in 2021, with no reported cases during 2021–2022 and only isolated episodes in subsequent years. This decline closely followed the phased institutional implementation of infection prevention strategies, including Aseptic Non- Touch Technique (ANTT) and standardized catheter care bundles, introduced between 2019 and 2021. [1–2]

These measures were reinforced with continuous staff education and protocol auditing, as previously described. [3]

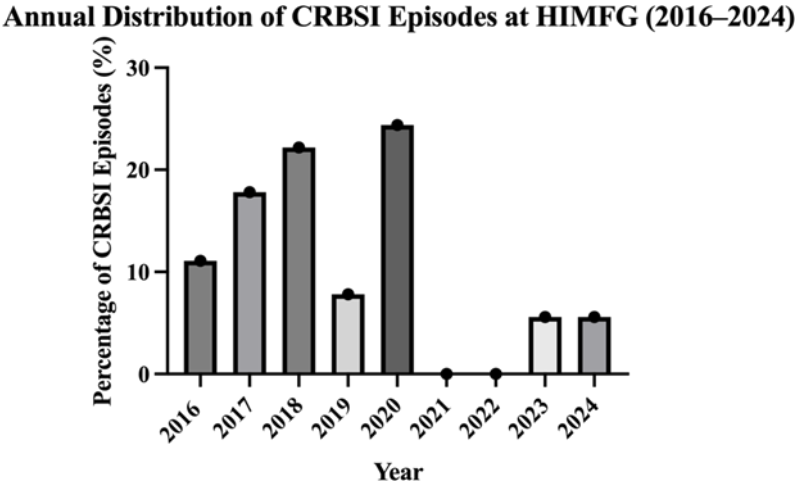

Figure 1. *Annual distribution of catheter-related bloodstream infection (CRBSI) episodes among 56 pediatric hemodialysis patients at HIMFG from 2016 to 2024. The decline observed after 2021 coincides with the implementation of targeted infection prevention strategies.*

Data from 2024 reflects only cases reported up to May.

3.3 Infection Prevention Strategies

A progressive reduction in CRBSI incidence at HIMFG correlated temporally with the implementation of multiple institutional infection prevention strategies between 2019 and 2021. These interventions were guided by evidence-based protocols and internal audits and were particularly reinforced following a quality improvement initiative reported by Guerrero-Díaz et al.[1]

The cornerstone of these efforts was the introduction of the Aseptic Non-Touch Technique (ANTT) for catheter access, adapted from central line-associated bloodstream infection (CLABSI) protocols used in intensive care settings. ANTT was introduced in late 2019 and fully adopted by early 2021, coinciding with the documented elimination of CRBSI episodes during the 2021–2022 period. [2]

Additional measures included:

I. Standardized care bundles for pediatric hemodialysis CVCs.

II. Mandatory use of maximal sterile barrier precautions during catheter insertion and manipulation.

III. Routine chlorhexidine antisepsis for skin disinfection.

IV. Daily auditing of hand hygiene practices among HD and nephrology staff.

V. Ongoing training workshops and simulation-based refresher sessions.

These strategies are summarized in Table 2.

Table 2. Infection Prevention Strategies Implemented at HIMFG for Pediatric Hemodialysis (2019–2024).

Infection Prevention Strategy	Description/Implementation	Associated Outcomes
Standardized HD protocol for pediatric CVCs	Institution-wide care bundle tailored for pediatric patients with central catheters	Provided a structured and consistent catheter care framework
Aseptic Non-Touch Technique (ANTT)	Adapted from CLABSI protocols and implemented for HD catheter access	Provided a structured and consistent catheter care framework
Strict hand hygiene enforcement	Regular monitoring and reinforcement of compliance among HD staff	Contributed to sustained infection control improvements
Maximal barrier precautions	Mandatory use of full sterile attire during catheter insertion and manipulation	Minimized contamination during catheter procedures
Chlorhexidine antisepsis	Required for skin disinfection during catheter insertion and maintenance	Reduced incidence of skin flora-related infections

3.4 Microbiological Profile

Among the 89 confirmed CRBSI episodes, the vast majority were caused by gram-positive organisms (70.8%), followed by gram-negative bacteria (19.1%), fungi (1.1%), and atypical organisms, including nontuberculous mycobacteria (1.1%).

The most frequently isolated pathogens were:

- *Staphylococcus aureus* (39.3%, n = 35)
- *Staphylococcus epidermidis* (23.6%, n = 21)
- *Klebsiella pneumoniae* (9.0%, n = 8)
- *Enterococcus faecalis* (4.5%, n = 4)
- *Escherichia coli* (3.4%, n = 3)

Less frequent isolates included *Streptococcus mitis*, *Pseudomonas aeruginosa*, *Stenotrophomonas spp.*, *Haemophilus influenzae*, *Candida albicans*, *Proteus mirabilis*, *Salmonella group D*, and *Mycobacterium abscessus*, each accounting for approximately 1.1% of cases. A full list of recovered organisms is provided in Supplementary Figure 2.

The predominance of *Staphylococcus spp*., particularly *S. aureus* and *S. epidermidis*, aligns with global pediatric CRBSI data and highlights the importance of strict hub asepsis and catheter manipulation protocols. [1–2]

The presence of gram-negative bacilli such as *K. pneumoniae* and *E. coli* supports the routine use of broad-spectrum empiric coverage, especially in resource-limited settings with increased environmental exposure. [3]

Rare but clinically significant isolates like *Candida albicans* and *M. abscessus* are associated with prolonged catheter dwell times and prior antimicrobial exposure, as previously reported. [4]

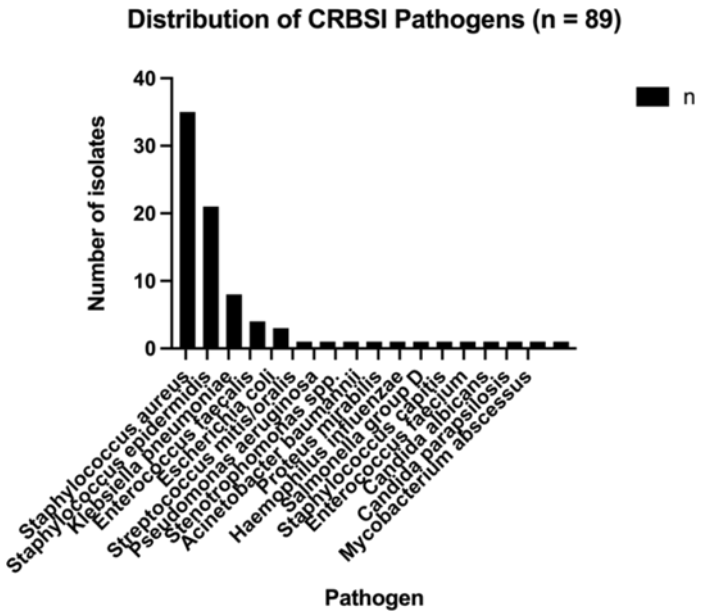

Figure 2. *Distribution of pathogens isolated from confirmed catheter-related bloodstream infections (CRBSIs) in pediatric hemodialysis patients (n = 89).*

Staphylococcus aureus and Staphylococcus epidermidis were the most frequently recovered organisms. Gram-negative bacilli and rare isolates such as Candida albicans and Mycobacterium abscessus were also reported.

3.5 Catheter Characteristics and Duration

The majority of CRBSI episodes occurred in patients with Mahurkar-type catheters (71.9%, n = 64), followed by Niagara catheters (6.7%, n = 6) and a single case involving a Permacath (1.1%). In 18 episodes (20.2%), the catheter type was not documented. All catheters used were non- tunneled, dual-lumen central venous devices intended for temporary hemodialysis access. [1]

Among episodes with insertion site documentation (n = 18), the most common locations were the right internal jugular vein (n = 3) and the right subclavian vein (n = 3), with other subclavian and femoral placements reported sporadically. The insertion site was not recorded in 71 episodes.

The median time from catheter placement to infection onset was 60 days, with a range from 1 to 621 days, reflecting the wide variation in catheter dwell time and outpatient follow-up.

These findings reinforce the predominant use of non-tunneled CVCs in pediatric hemodialysis and emphasize the challenges of maintaining sterility and line integrity over extended periods, particularly in resource-constrained outpatient settings. [2–3]

3.6 Treatment Approaches

The most frequently used empirical regimen was vancomycin combined with cefepime, documented in 52 episodes (58.4%). Other empirical treatments included cefepime with amikacin (7.9%) and vancomycin monotherapy (3.4%). In 11.2% of cases, the empirical regimen was not recorded. Following microbiological identification and sensitivity testing, targeted antimicrobial therapy was administered in 87.6% of episodes. The mean duration of antibiotic treatment was 8.3 days, with a range from 3 to 15 days, consistent with recommendations from pediatric infectious disease guidelines. [1–2]

Catheter removal was required in 32 of the 89 episodes (36.0%), primarily due to persistent fever, failure to respond to antibiotics, or identification of biofilm-forming organisms such as Staphylococcus aureus or Candida albicans. [3] No infection-related deaths were reported.

These findings align with current best practices for CRBSI management in children, emphasizing early empiric coverage for gram-positive and gram-negative organisms, followed by directed therapy and timely catheter removal when necessary. [2–4]

4. Discussion

This nine-year retrospective analysis of catheter-related bloodstream infections (CRBSIs) in pediatric hemodialysis patients provides valuable epidemiological and clinical insights into one of the most significant complications in this population. Our findings reflect evolving trends and underscore the impact of targeted institutional interventions on infection control outcomes.

4.1 Incidence and Temporal Trends

This nine-year retrospective analysis provides real-world insights into the burden and evolution of catheter-related bloodstream infections (CRBSIs) in a pediatric hemodialysis population. Our cohort—comprising 56 patients and 89 microbiologically confirmed episodes—yielded an incidence of 11.6 CRBSIs per 1,000 catheter-days, which is higher than reported rates in high- income countries (typically ranging from 0.5 to 5.5 episodes per 1,000 catheter-days). [1]

These discrepancies likely reflect differences in healthcare infrastructure, outpatient follow-up, infection surveillance systems, and catheter types—especially the predominant use of non- tunneled catheters in Latin American pediatric programs. [2]

A key finding was the complete absence of CRBSIs during 2021–2022 and a sustained low incidence thereafter. This temporal shift coincides with the phased institutional adoption of Aseptic Non-Touch Technique (ANTT) and a comprehensive catheter care bundle at HIMFG. [3] These protocols, introduced between 2019 and 2021, were reinforced through staff education, audit- feedback systems, and barrier precautions.

Their effectiveness is consistent with reports from other pediatric units implementing ANTT and aligns with international recommendations. [4–5]

4.2 Microbiological Profile

Our microbiological analysis revealed that over 70% of CRBSI episodes were caused by gram- positive organisms, with Staphylococcus aureus (39.3%) and Staphylococcus epidermidis (23.6%) as the dominant pathogens. These findings are consistent with global pediatric hemodialysis cohorts, where skin flora organisms remain the principal source of infection due to hub contamination and suboptimal line access techniques. [1–2]

The presence of gram-negative organisms, including Klebsiella pneumoniae (9.0%) and Escherichia coli (3.4%), underscores the importance of broad-spectrum empirical regimens, especially in high-density urban centers or where environmental sanitation is suboptimal. [3] Such coverage is routinely recommended by the Infectious Diseases Society of America (IDSA) and Cochrane reviews on pediatric CRBSI management. [2–4]

Although rare, the isolation of fungal (*Candida albicans*) and nontuberculous mycobacteria (*Mycobacterium abscessus*) is clinically significant. These pathogens are often linked to prolonged catheter dwell times, prior antibiotic exposure, and biofilm formation. Their detection in our cohort reinforces the need for early catheter removal and aggressive therapy in refractory or relapsing infections. [5]

These microbiological trends justify our institution's empirical use of vancomycin plus cefepime, a combination offering coverage against methicillin-resistant staphylococci and gram-negative bacilli, including Pseudomonas spp., as recommended by IDSA.[2]

4.3 Age Distribution

CRBSIs were most frequently observed in adolescents (40.4%) and school-age children (37.1%), a pattern that may reflect differences in behavioral factors, catheter manipulation, and autonomy of care. Adolescents, in particular, may struggle with adherence to aseptic practices during home handling or outpatient visits, especially in the absence of consistent caregiver supervision. [1]

School-aged children, while more closely monitored, are often physically active and mobile, increasing the risk of inadvertent line disruption or contamination during routine activities. In contrast, infants (<1 year)—who accounted for 9.0% of infections—face unique anatomical and immunological vulnerabilities, such as immature immune responses, thinner skin, and challenges maintaining catheter dressing integrity. [2]

These developmental differences suggest that infection prevention strategies should be tailored not only to technical care protocols but also to age-appropriate education and caregiver engagement, particularly for older children managing dialysis in the outpatient setting. [3]

4.4 Treatment Approaches

The predominance of Staphylococcus aureus and other gram-positive organisms, along with the presence of gram negative pathogens such as Klebsiella pneumoniae and Escherichia coli, supports the use of empiric broad-spectrum regimens in pediatric CRBSIs. In our cohort, the most frequently used combination vancomycin plus cefepime was administered in 58.4% of episodes, offering reliable coverage against methicillin-resistant *Staphylococcus aureus* (MRSA) and *Pseudomonas spp.*[1]

This approach is consistent with IDSA 2018 guidelines and the Cochrane meta-analysis by Ong et al., which highlight the importance of early empirical therapy targeting both gram-positive and gram-negative organisms in children with suspected catheter infections. [1–2] Empirical regimens were adjusted following microbiological identification in 87.6% of episodes in our study.

The mean treatment duration was 8.3 days, aligning with published pediatric standards and reflecting the effectiveness of early therapy and infection control interventions. [2–3]

In 36% of cases, catheter removal was necessary due to persistent symptoms or infection by biofilm-forming organisms (*S. aureus, Candida spp.*). Timely removal remains a cornerstone in managing catheter-related infections, particularly when clinical improvement is not achieved within 48–72 hours of appropriate antimicrobial therapy. [3]

4.5 Recurrent Infections

Recurrent CRBSIs were documented in 34.1% of patients in our cohort, underscoring the persistent challenge of infection control in chronically catheterized pediatric populations. Multiple episodes in the same patient may result from biofilm persistence, inadequate eradication of microorganisms, or ongoing lapses in outpatient catheter care. [1–2]

Staphylococcus epidermidis, Enterococcus spp., and atypical organisms such as *Mycobacterium abscessus* are known to form biofilms that resist conventional antibiotic regimens and require catheter removal for definitive resolution. [3]

Our findings echo those from Schaefer and Schmitt, who reported that recurrent CRBSIs are associated with increased hospitalization, catheter-related complications, and longer cumulative dwell times. [4]

To address this issue, potential strategies include:

- Antimicrobial lock therapy, particularly in patients with a history of recurrence.[5]
- Structured outpatient protocols for line care and follow-up.
- Early transition to arteriovenous fistula, when feasible, to minimize long-term catheter dependence.

4.6 Clinical Implications and Future Directions

This study demonstrates that structured, multidisciplinary infection prevention strategies can lead to sustained reductions in CRBSI incidence, even in resource-limited pediatric settings. The elimination of cases during 2021–2022 and persistently low incidence in subsequent years support the effectiveness of ANTT, staff education, and standardized catheter care protocols. [1–2]

Our microbiological findings support broad empiric antimicrobial coverage that includes both gram-positive and gram-negative organisms, with early de-escalation based on culture data. The relatively high rate of catheter removal (36%) and recurrent infections (34%) also highlight the need for individualized risk stratification, close outpatient monitoring, and potential incorporation of lock protocols or earlier AVF referral. [3]

Future efforts should include:

- Development of national pediatric dialysis infection registries.
- Implementation of standardized CRBSI surveillance protocols across institutions.
- Multicenter studies assessing the impact of preventive strategies on long-term outcomes.
- By strengthening clinical infrastructure and adopting evidence-based practices, pediatric nephrology centers in Latin America can bridge the quality gap in catheter-related infection management.

5. Limitations

This study has several limitations inherent to its retrospective design, including the incomplete documentation of key variables such as catheter insertion site and exact duration of catheter use in some cases. Although the study spans nine years, data collection depended on the accuracy and availability of medical records, which may introduce information bias.

Second, this is a single-center analysis conducted at a national pediatric referral hospital, which may limit the generalizability of findings to other institutions with different patient profiles, resource availability, or infection prevention protocols.

Third, the study did not systematically assess socioeconomic variables, caregiver adherence, or home catheter care practices, all of which can significantly influence infection risk and recurrence.

Finally, changes in institutional surveillance protocols over the study period may have influenced CRBSI reporting rates, despite efforts to standardize definitions based on CDC criteria.

Despite these limitations, the study provides a robust, data-driven view of CRBSIs in pediatric hemodialysis over an extended period and offers actionable insights for infection prevention strategies in similar settings.

6. Conclusion

This nine-year retrospective study demonstrates that catheter-related bloodstream infections (CRBSIs) remain a significant clinical challenge in pediatric hemodialysis, especially in settings where non-tunneled catheters are used as long-term access. Despite this, our findings show that substantial and sustained reductions in infection rates are achievable through the implementation of structured, evidence-based prevention strategies.

The complete absence of CRBSIs during 2021–2022 and the persistently low incidence thereafter support the effectiveness of institutional interventions such as Aseptic Non-Touch Technique (ANTT), standardized catheter care bundles, and continuous staff training. These strategies, when properly implemented, can protect a highly vulnerable population without requiring high-cost technologies.

Our microbiological data reinforce the importance of broad-spectrum empiric antibiotic coverage and emphasize the need for timely catheter removal in refractory cases. The high rate of recurrent infections highlights the importance of long-term surveillance, risk stratification, and consideration of alternative vascular access options, such as arteriovenous fistulas in suitable candidates.

Ultimately, this study contributes valuable region-specific data to the pediatric nephrology literature and supports the development of national CRBSI surveillance frameworks. Future multicenter studies are needed to validate these findings, explore modifiable risk factors, and guide best practices in pediatric dialysis care.

Acknowledgments

We extend our sincere gratitude to the Pediatric Nephrology Department of the Hospital Infantil de México Federico Gómez for their support throughout the development of this study. We also thank the Department of Epidemiology and the Medical Archives Unit for their assistance in data retrieval and validation. Special recognition is due to the nursing staff of the Hemodialysis Unit, whose commitment to patient care and adherence to infection prevention protocols were fundamental to the success of this work.

Conflict of Interest

The authors declare no conflicts of interest related to the content of this article.

Author Contributions

- Irma Esther del Moral Espinosa: Institutional coordination, infection control guidance, quality assurance.
- Víctor Manuel Barajas Valencia: Clinical oversight, data verification, editorial review, and approval.
- Gustavo Eduardo Aurioles Amozurrutia: Conceptualization, methodology, data collection, statistical analysis, writing—original draft, and project coordination.
- Cruz Esteban Ochoa Ramirez: Initial conceptual groundwork through thesis research and preliminary data compilation; no direct participation in manuscript preparation.
- Edgar Eduardo Morales Montes: Clinical supervision, data validation, critical manuscript revision.
- Rebeca Gómez Chico Velasco: Conceptual oversight, supervision of study design, manuscript refinement.

Funding

This research received no external or institutional funding.

References

1. Ruebner RL, Gruhler De Souza H, Richardson T, et al. Epidemiology and risk factors for hemodialysis access-associated bloodstream infections in children. Am J Kidney Dis. 2022;80(2):185–194.
2. Centers for Disease Control and Prevention (CDC). Guidelines for the Prevention of Intravascular Catheter-Related Infections. MMWR Recomm Rep. 2011;60(RR-10):1–38.
3. Blair N, Patil P, Nguyen D, Paudyal-Nepal B, Iorember F. Antibiotic lock solutions as adjunct therapy for catheter-related blood stream infections in pediatric hemodialysis patients. Front Pediatr. 2024 Apr 11;12:1379895. doi: 10.3389/fped.2024.1379895. PMID: 38665376; PMCID: PMC11043483.
4. Mermel LA, Allon M, Bouza E, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2018 update by the Infectious Diseases Society of America. Clin Infect Dis. 2018;67(1):e1–e45.
5. Weldetensae MK, Weledegebriel MG, Nigusse AT, Berhe E, Gebrearegay H. Catheter-Related Blood Stream Infections and Associated Factors Among Hemodialysis Patients in a Tertiary Care Hospital. Infect Drug Resist. 2023 May 22;16:3145-3156. doi: 10.2147/IDR.S409400. PMID: 37249964; PMCID: PMC10216862.
6. Guerrero-Díaz AC, Rosa-Zamboni D, Martin-Martin MA, et al. Reducing CLABSI through a quality strategy for the implementation of the aseptic non-touch technique in a pediatric ward. Reducción de infecciones relacionadas con catéteres venosos centrales por medio de una estrategia de calidad para la implementación de la técnica aséptica «no tocar» en una sala de pediatría. *Bol Med Hosp Infant Mex*. 2024;81(3):182-190. doi:10.24875/BMHIM.23000134
7. Araya CE, Fennell RS, Neiberger RE, Dharnidharka VR. Hemodialysis catheter-related bacteremia in children: increasing antibiotic resistance and changing bacteriological profile. *Am J Kidney Dis*. 2007;50(1):119-123. doi:10.1053/j.ajkd.2007.04.005
8. Ferris M, Gibson K, Plattner B, et al. Hemodialysis outcomes in a global sample of children and young adult hemodialysis patients: the PICCOLO MONDO cohort. *Clin Kidney J*. 2016;9(2):295-302. doi:10.1093/ckj/sfv157
9. World Health Organization (WHO). Global report on antimicrobial resistance surveillance 2023.Geneva: WHO; 2023. Available from: https://www.who.int/publications/i/item/9789240070893
10. Erbay A, Ergönül O, Stoddard GJ, Samore MH. Recurrent catheter-related bloodstream infections: Risk factors and outcome. *Int J Infect Dis*. 2006;10(5):396-400. doi:10.1016/j.ijid.2005.08.002