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Diagnostic stewardship of blood cultures in the pre-analytical and post-analytical phases: a scoping review

Gestão diagnóstica das hemoculturas nas fases pré-analítica e pós-analítica: revisão de escopo

Manejo diagnóstico de los hemocultivos en las fases preanalítica y postanalítica: Revisión del alcance

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ABSTRACT

Introduction: Diagnostic stewardship of blood cultures optimizes healthcare resources and promotes safe patient care. Its focus lies in the rational use of tests that support the appropriate use of antimicrobials. Objective: To map the available scientific evidence on the practices adopted by healthcare professionals in the pre-analytical and post-analytical phases of blood cultures that contribute to the diagnosis of patients with bloodstream infection.Design: Scoping review according to the Joanna Briggs Institute. The PCC acronym was used to construct the research question. The review was conducted using the databases MEDLINE, SCOPUS, EMBASE, LILACS, and the gray literature BDTD, correlating the descriptors “Blood Culture,” “Bacteremia,” “Sepsis,” “Pre-Analytical Phase,” and “Critical Laboratory Values.” Data collection was carried out in May 2024 with no language or date filters. Results: Of the 164 studies, 22 met the research objective. Practices in the pre-analytical phase: interventions regarding the indication for collection, number of samples, volume, and transport. Practices in the post-analytical phase: timely communication and support for result interpretation. Implications: The study identifies the practices adopted by healthcare professionals in the pre-analytical and post-analytical phases of blood cultures that align with the principles of diagnostic stewardship.

DESCRIPTORS

Drug Resistance, Microbial. Blood Culture. Bacteremia. Microbiology. Antimicrobial Stewardship.

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INTRODUCTION

Diagnostic stewardship is recognized as a fundamental tool in antimicrobial stewardship programs and in infection prevention and control activities within healthcare services[1]. Antimicrobial resistance continues to increase globally, while the development of new medications has not kept pace[2]. In this context, microbiological results contribute to appropriate antimicrobial prescribing and the implementation of precautions that reduce the risk of transmission of resistant microorganisms in healthcare environments[1].

On the other hand, these resources have been excessively used. In the United States, for example, laboratory tests represent the highest-volume medical activity, yet 20% are used without offering any benefit to patient care[3−4]. Diagnostic stewardship has emerged to guide the use and interpretation of diagnostic tests, improving the diagnosis and treatment of infections by ensuring that the right tests are ordered for the right patient at the right time[5].

Thus, diagnostic stewardship improves the use of healthcare resources, promoting safe patient care by preventing inappropriate use of microbiological tests and enabling the judicious use of antimicrobials, thereby reducing microbial resistance[6]. This approach applies to all three diagnostic phases—pre-analytical, analytical, and post-analytical—and focuses on tests that support antimicrobial use, making it particularly relevant to the practice of blood cultures[6−7].

Blood cultures are considered the critical diagnostic test for identifying bloodstream infections[8].Patients with bloodstream infections present high morbidity and mortality rates, and in severe cases, may progress to sepsis[9], which emphasizes the importance of diagnosis for proper management[10]. Treatment based on blood cultures allows for the identification of the infectious microorganism and its antimicrobial susceptibility, guiding appropriate therapy[10].

The Society for Healthcare Epidemiology of America (SHEA) highlights the benefit of diagnostic stewardship in blood cultures, noting that this test is among the most commonly ordered for hospitalized patients. However, blood cultures have shown low positivity rates due to the frequency of requests, a significant number of false-positive results, and inadequate samples, whether due to volume or number of bottles[7]. These issues reflect low quality in the pre-analytical phase and highlight the importance of diagnostic stewardship interventions to improve the process.

The pre-analytical phase includes test ordering, sample collection technique, transport, and sample preparation.[6] Most errors occur in this phase[11].Studies have shown that up to 50% of positive samples reflect contamination, which can lead to prolonged hospitalization, unnecessary antimicrobial therapy, and additional diagnostic tests for the patient[12−13].

The post-analytical phase is an essential part of antimicrobial stewardship programs[6].This phase includes the reporting of results, as well as their evaluation, interpretation, and therapeutic intervention[14].These results should support physicians' therapeutic decisions and identify the main microorganisms involved in healthcare-associated infections. They also enable the determination of resistance rates[15−16].However, this phase may involve misinterpretation of results, delays in report release, and communication failures between the laboratory and physicians[17].

A point-prevalence study evaluating the antimicrobial stewardship program at a university hospital identified the pre-analytical and post-analytical phases of microbiological tests as the most failure-prone category, accounting for 35.4% of inadequacies[16].However, implementing improvements in both phases through diagnostic stewardship measures may lead to a significant reduction in inappropriate investigations and the amount of antimicrobials administered[18].

A scoping review was chosen as the methodological approach, as the study aimed to synthesize evidence regarding appropriate practices in both phases that may impact the diagnosis of bloodstream infections, aligning with the principles of diagnostic stewardship. Therefore, the objective of this scoping review is to map the available scientific evidence on the practices adopted by healthcare professionals in the pre-analytical and post-analytical phases of blood cultures that contribute to the diagnosis of patients with bloodstream infections.

METHODS

This is a scoping review developed based on the method proposed by the Joanna Briggs Institute (JBI)[19]. The protocol for this review was registered in the Open Science Framework Register

(10.17605/OSF.IO/WJRN6). The studies were selected according to the following nine steps: (1) Define and align the objective and the question; (2) Develop and align the inclusion criteria with the objective and the question; (3) Describe the planned approach for searching, selecting, extracting, and presenting the evidence; (4) Search for evidence; (5) Select the evidence; (6) Extract the evidence; (7) Analyze the evidence; (8) Present the results; and (9) Summarize the evidence in relation to the review objective, drawing conclusions and noting any implications thereof[19].

The recommendations of the checklist for the development of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR)[20] were followed. The research question was developed using the participants, concept, and context (PCC) strategy, where P (participants) – Health professionals, C (concept) – Pre-analytical and post-analytical procedures for blood cultures, and C (context) – patients with bloodstream infections (BSI). Thus, the following research question was formulated: What procedures are adopted by health professionals in the pre-analytical and/or post-analytical phases of blood cultures that contribute to the diagnosis of patients with BSI?

Inclusion Criteria

Based on the PCC acronym, the participants in this review were health professionals involved in the pre-analytical and post-analytical stages of blood cultures. Regarding the concept, studies were included if they addressed pre-analytical and post-analytical procedures aiming to optimize sample yield and turnaround time, as well as strategies to achieve these improvements. For the context, blood cultures collected from adult, neonatal, and pediatric patients for the diagnosis of BSI were included, whether in outpatient or hospital settings.

This review considered experimental and quasi-experimental studies, including randomized clinical trials, non-randomized clinical trials, before-and-after studies, and interrupted time series studies. Additionally, analytical observational studies were included, such as prospective and retrospective cohort studies, case-control studies, and analytical cross-sectional studies.

Descriptive observational study designs were also considered, including case series, individual case reports, and descriptive cross-sectional studies. Literature reviews, theses, and opinion or commentary articles were also included in this scoping review. Editorials, abstracts, conference proceedings, experience reports, monographs, correspondence, reviews, and articles not available in full in the databases were excluded.

Search Strategy and Study Identification

Data collection was carried out in May 2024 through access to CAPES journals via the Federated Academic Community access portal. The databases searched included MEDLINE via PubMed, SCOPUS, EMBASE, LILACS, and gray literature from the Brazilian Digital Library of Theses and Dissertations (BDTD), correlating the search terms with the PCC acronym to identify scientific evidence that could answer the research question proposed in this study. Some databases such as Web of Science and Cochrane were not included due to data overlap with the selected databases, which would not contribute new relevant studies.

The descriptors used were “Blood Culture,” “Bacteremia,” “Sepsis,” “Pre-Analytical Phase,” and “Critical Laboratory Values,” in combination with alternative terms in Portuguese, English, and Spanish. No date or language filters were applied (Table 1). The search strategy development process followed the recommendations of the Peer Review of Electronic Search Strategies (PRESS)[21].

Table 1 - Search strategy used in the selected databases.

	SEARCH STRATEGIES	N
MEDLINE Via Pubmed	(Blood Culture[mh] OR Blood Culture*[tiab] OR Hemoculture*[tiab] OR Haemoculture*[tiab] OR Gram Stain*[tiab]) AND (Bacteremia[mh] OR Bacteremia*[tiab] OR Sepsis[mh] OR Sepsis[tiab] OR Septicemia*[tiab] OR Pyemia*[tiab] OR Pyohemia*[tiab] OR Bloodstream Infection*[tiab] OR Blood Poisoning*[tiab] OR Blood Infection*[tiab]) AND (Laboratory Critical Values[mh] OR Laboratory Critical Value*[tiab] OR Laboratory Alert Value*[tiab] OR Pre-Analytical Phase[mh] OR Pre-Analy*[tiab] OR Preanaly*[tiab] OR Post-Analy*[tiab] OR Diagnostic Management[tiab])	**52**
SCOPUS	TITLE-ABS-KEY("Blood Culture*" OR Hemoculture* OR Haemoculture* OR "Gram Stain*") AND TITLE-ABS-KEY(Bacteremia* OR Sepsis OR Septicemia* OR Pyemia* OR Pyohemia* OR "Bloodstream Infection*" OR "Blood Poisoning*" OR "Blood Infection*") AND TITLE-ABS-KEY("Laboratory Critical Value*" OR "Laboratory Alert Value*" OR "Pre-Analytical Phase" OR Pre-Analy* OR Preanaly* OR Post-Analy* OR "Diagnostic Management")	**65**
EMBASE	('blood culture'/exp OR 'blood culture*':ti,ab OR hemoculture*:ti,ab OR haemoculture*:ti,ab OR 'gram staining'/exp OR 'gram staining':ti,ab OR 'gram stain':ti,ab) AND ('bacteremia'/exp OR 'bacteraemia*':ti,ab OR 'bacteremia*':ti,ab OR 'bacteriemia*':ti,ab OR 'sepsis'/exp OR 'sepsis':ti,ab OR 'septicemia'/exp OR 'septicaemia*':ti,ab OR 'septicemia*':ti,ab OR 'pyemia'/exp OR 'pyaemia*':ti,ab OR 'pyemia*':ti,ab OR 'pyohemia*':ti,ab OR 'bloodstream infection'/exp OR 'blood infection*':ti,ab OR 'blood stream infection*':ti,ab OR 'bloodstream infection*':ti,ab OR 'blood poisoning*':ti,ab) AND ('critical value'/exp OR 'critical laboratory value*':ti,ab OR 'critical value*':ti,ab OR 'laboratory critical value*':ti,ab OR 'laboratory alert value*':ti,ab OR 'pre-analytical phase'/exp OR 'pre-analytical':ti,ab OR 'preanalytical':ti,ab OR 'post-analytical phase'/exp OR 'post-analy*':ti,ab OR 'postanaly*':ti,ab OR 'diagnostic management':ti,ab) AND [embase]/lim NOT ([embase]/lim AND [medline]/lim) AND ('article'/it OR 'review'/it)	**10**
LILACS	("Blood Culture" OR Hemoculture* OR Haemoculture* OR "Gram Stain" OR "Cultura de Sangue" OR Hemocultura* OR "Coloração de Gram" OR Hemocultivo* OR "Tinción de Gram") AND (Bacteremia* OR Sepsis OR Septicemia* OR Pyemia* OR Pyohemia* OR "Bloodstream Infection" OR "Bloodstream Infections" OR "Blood Poisoning" OR "Blood Infection" OR "Blood Infections" OR Sepse OR Piemia OR "Infecção da Corrente Sanguínea" OR "Infecções da Corrente Sanguínea" OR "Envenenamento do Sangue" OR "Infecção do Sangue" OR "Infecções do Sangue" OR "Infección del Torrente Sanguíneo" OR "Infecciones del Torrente Sanguíneo" OR "Envenenamiento de la Sangre" OR "Infección de la Sangre" OR "Infecciones de la Sangre") AND ("Laboratory Critical Values" OR "Laboratory Alert Values" OR "Pre-Analytical Phase" OR Pre-Analy* OR Preanaly* OR Post-Analy* OR "Diagnostic Management" OR "Fase Pré-Analítica" OR "Fase Pós-Analítica" OR "Fase Preanalítica" OR Pré-Analítica OR Pós-Analítica OR "Valor Crítico" OR "Valores Críticos" OR "Valor de Alerta" OR "Valores de Alerta" OR "Gestão Diagnóstica") AND (db:("LILACS"))	**03**
BDTD	("Blood Culture" OR Hemoculture* OR Haemoculture* OR "Gram Stain" OR "Cultura de Sangue" OR Hemocultura* OR "Coloração de Gram" OR Hemocultivo*) AND (Bacteremia* OR Sepsis OR Septicemia* OR Pyemia* OR Pyohemia* OR "Bloodstream Infection" OR "Bloodstream Infections" OR "Blood Poisoning" OR "Blood Infection" OR "Blood Infections" OR Sepse OR Piemia OR "Infecção da Corrente Sanguínea" OR "Infecções da Corrente Sanguínea" OR "Envenenamento do Sangue" OR "Infecção do Sangue" OR "Infecções do Sangue")	**34**

Study Selection

The identified articles were exported to the EndNote Web reference manager to remove duplicates, and the Rayyan® software was used for study selection [22]. Article analysis was conducted independently by two reviewers, initially through the reading of titles and abstracts in accordance with the established inclusion criteria.

Potentially relevant studies were organized into folders in EndNote Web and underwent full-text screening to verify adherence to the inclusion criteria. Discrepancies in the abstract or full-text review were resolved by a third reviewer. Articles not meeting the criteria were excluded. The study selection process is presented in a flowchart based on the PRISMA-ScR strategy [20].

Data Extraction

For data extraction, both reviewers independently used an instrument developed by the authors containing the following items: title, database, location/year, method, research objectives, and a section describing procedures, implementation, and observations related to the pre-analytical and post-analytical phases, as well as level of evidence. Studies were classified according to the levels of evidence established by JBI [23].

Data Analysis and Presentation

The data were analyzed to meet the study objectives and involved both quantitative methods (frequency analysis) and qualitative methods (thematic analysis). The results were synthesized and presented in tables, and a narrative summary was constructed linking the objective and the research question. This process enabled the identification of knowledge gaps and revealed potential topics for future reviews.

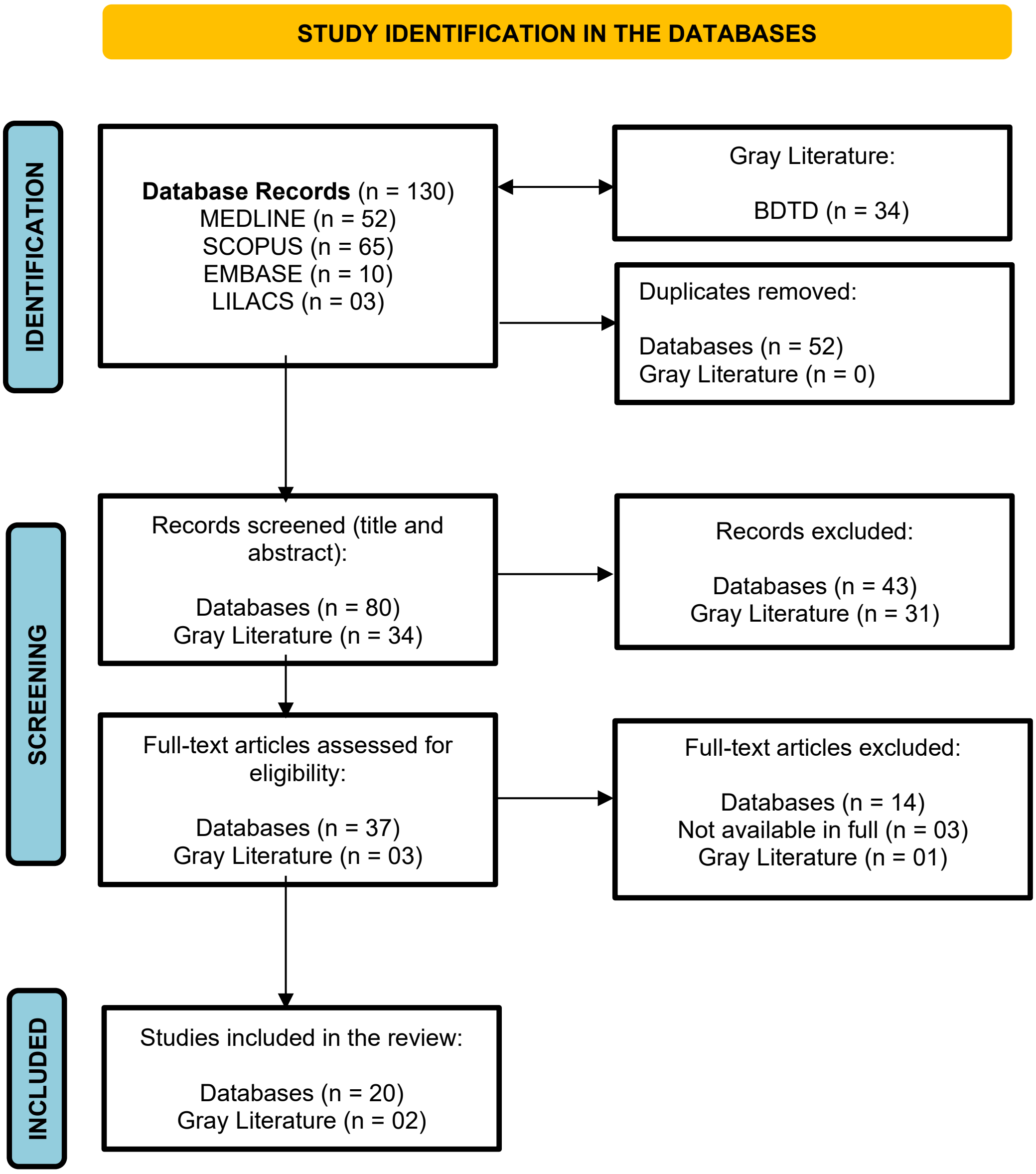
Ethical Considerations

As this is a scoping review, the study was not submitted to a Research Ethics Committee. However, Resolution No. 466/12 [24] was respected regarding the analysis and sharing of the study's results.

RESULTS

A total of 164 studies were retrieved from the databases, including 130 articles and 34 theses and dissertations. After exporting the records to the reference manager, 52 duplicates were removed. Next, two reviewers independently screened the titles and abstracts. Thirty-seven articles were selected for full-text reading, of which 20 met the inclusion criteria. In the gray literature, 34 studies were screened, and two of them answered the research question. Thus, 22 studies were included in this review (FIGURE 1).

Figure 1 – Flowchart of the study selection process in the Scoping Review (PRISMA-ScR). Rio de Janeiro, RJ, Brazil, 2024.



Source: Tricco et al. (2018)[20].

The characterization of the included studies is presented in Table 2.

Table 2 – Characteristics of the studies included in the review. Rio de Janeiro, RJ, Brazil, 2024.

TITLE	DATABASE / LOCATION / YEAR	METHOD	OBJECTIVE	LE*
The preanalytical optimization of blood cultures: a review and the clinical importance of benchmarking in 5 Belgian hospitals[25]	Scopus Belgium 2012	Observational	- To review the approved guidelines for blood culture collection and to compare pre-analytical determinants of blood cultures in five Belgian tertiary hospitals.	3.e
Blood Cultures: The importance of meeting pre-analytical requirements in reducing contamination, optimizing sensitivity of detection, and clinical relevance[26]	Scopus EUA 2015	Literature review	- To present the pre-analytical factors that significantly influence the sensitivity, interpretation, and clinical relevance of blood cultures.	5.b
Individualized approaches are needed for optimized blood cultures[27]	Medline EUA 2016	Opinion article	- To present strategies to optimize individualized blood culture diagnostics in laboratories.	5.b
Evaluation of a model to improve collection of blood cultures in patients with sepsis in the emergency room[28]	Medline Italy 2017	Retrospective observational	- To analyze blood culture collection data in the emergency department (absolute number, percentage of positive blood cultures, isolated bacterial species, collection adequacy) before and after project implementation.	2.d
Impact of pre-analytical time on the recovery of pathogens from blood cultures: results from a large retrospective survey[29]	Scopus Italy 2017	Retrospective observational	- To assess the performance of blood cultures collected under typical hospital conditions in relation to the duration of their pre-analytical time.	4.b
Implementation of the theory of planned behavior to promote compliance with a chlorhexidine gluconate protocol[30]	Embase EUA 2017	Descriptive correlational	- To identify whether the lack of access to a chlorhexidine gluconate product at the bedside was a barrier to maintaining aseptic techniques during venipuncture, leading to blood culture contamination.	3.e
Optimization of the blood culture pathway: a template for improved sepsis management and diagnostic antimicrobial stewardship[31]	Scopus United Kingdom 2018	Prospective cohort	- To investigate the impact of an optimized blood culture pathway on result turnaround times;	3.c
Evaluation of blood culture practices: Use of system (Epicenter) data][32]	Medline Turkey 2019	Retrospective observational	- To demonstrate the traceability of data obtained from blood culture applications through the statistical analysis program of the blood culture operating system (EpiCenter); - To identify flawed or incomplete applications, areas for improvement based on the statistical data obtained, and to raise awareness about the use of such programs.	4.b

Microbiological diagnosis of bacteremia and fungaemia: Blood cultures and molecular methods[33]	Scopus Spain 2019	Literature review	- To update new procedures applicable to the microbiological diagnosis of bacteremia and fungemia.	5.b
Importance of using refluxed blood cultures and catheter tip cultures for the diagnosis of catheter-related sepsis during the neonatal period[34]	BDTD Brazil 2019	Prospective cohort observational	- To evaluate the use of blood cultures from CVC refluxed blood for the diagnosis of catheter-related bloodstream infection (CRBSI) in the neonatal population; - To compare the use of blood cultures from refluxed blood with catheter tip cultures for the diagnosis of CRBSI in the neonatal population; - To determine the association between refluxed blood collection and the occurrence of adverse events involving CVCs; - To describe and evaluate the incidence density and factors associated with CRBSI occurrence in the neonatal population.	3.c
Performance of a new combination of blood culture vials in sepsis detection: a 2-year retrospective comparison[35]	Medline Italy 2019	Two-phase study	- To evaluate the performance of current resin and lytic medium formulations in blood culture bottles.	2.d
Collection, transport and storage procedures for blood culture specimens in adult patients: recommendations from a board of Italian experts[36]	Scopus Italy 2019	Opinion article	- To provide a practical guide for physicians and nurses on the optimal execution of blood culture collection, as recommended by a panel of experts following an in-depth discussion of the available evidence in this field.	5.b
Bloodstream infections - Standard and progress in pathogen diagnostics[37]	Medline United Kingdom 2020	Literature review	- To review and discuss the literature on standard procedures and advances in the diagnosis of bloodstream pathogens, and to propose a new mindset aimed at achieving an improved diagnostic workflow.	5.b
Modern blood culture: management decisions and method options[38]	Medline EUA 2020	Literature review	- To provide an update on recent data and developments in each of these areas.	5.b
The impact of transit times on the detection of bacterial pathogens in blood cultures: a college of american pathologists Q-Probes study of 36 Institutions[39]	Medline EUA 2020	Prospective Observational Study	- To examine the effect of total pre-analytical time and blood culture volume on instrument detection time for bacterial pathogens in blood cultures; - To obtain relevant information on blood cultures through a questionnaire.	3.c
Técnica estéril modificada versus limpa para reduzir a contaminação das amostras de hemocultura: ensaio clínico randomizado duplo-cego[40]	BDTD Brazil 2021	Randomized Clinical Trial	- To compare contamination rates of blood culture samples collected using modified sterile versus clean techniques; - To compare contamination rates of blood culture samples between	1.c

			baseline and post-intervention periods; - To identify the most frequently isolated contaminants; - To rank the pathogens isolated from truly positive blood culture samples; - To analyze the antimicrobial susceptibility profile of the microorganisms.	
Blood culture utilization in the hospital setting: a call for diagnostic stewardship[41]	Medline EUA 2022	Literature review	- To discuss the main factors influencing blood culture performance, with a focus on the pre-analytical phase, including technical aspects of the blood culture collection process and indications for performing blood cultures.	5.b
Hemocultivo: fase pré-analítica[42]	Scopus Venezuela 2022	Literature review	- To evaluate the impact of an educational program on improving the quality of blood culture.	5.b
Improving blood culture quality with a medical staff educational program: a prospective cohort study[43]	Embase China 2023	Prospective Cohort Observational Study	- To evaluate the impact of an educational program on improving the quality of blood cultures.	2.d
An assessment of the downstream implications of blood culture collection and transit[44]	Scopus United Kingdom 2023	Retrospective Observational Study	- To explore the effect of transport times and culture volume on microbiological diagnosis time and patient outcomes.	4.b
Factors impacting the pre-analytical quality of blood cultures—Analysis at a tertiary medical center[45]	Medline Switzerland 2023	Retrospective Observational Study	- To analyze the impact of patient, microbiological, and procedural characteristics on the volumes of collected blood cultures; - To assess whether these factors were associated with blood culture positivity rates and time to positivity.	4.b
An emergency department intervention to improve earlier detection of community-onset bloodstream infection among hospitalized patients[46]	Medline Israel 2024	Quasi-Experimental Study	- To determine the effect of a quality improvement intervention in the Emergency Department on blood culture process-related outcomes and yield, using interrupted time series analysis before and after the intervention.	2.d

Note: NE – Level of Evidence; CVC – Central Venous Catheter; CRBSI – Catheter-Related Bloodstream Infection. Source: Author's own, 2024.

In the pre-analytical phase, studies recognized that achieving the recommended volume was a challenge in patients with difficult access, such as those who are critically ill and admitted to ICUs (36,45). Another factor influencing volume collection was the availability of professionals for sample collection, as well as the availability of appropriate materials, which also impacted the contamination rate of samples (30,36,45). Regarding the post-analytical phase, studies identified a limitation in laboratories that do not operate 24 hours a day, seven days a week, and that centralize their processes despite these limitations (31,44). Institutions also face difficulties in monitoring the time between sample collection and microorganism identification—an important variable for identifying opportunities for improvement (39).

Accordingly, the publications also presented strategies to improve blood culture processes. Among the actions directed at healthcare professionals, the following were cited: training [28,30-31,37-38,41,43,46], development of standard operating procedures (SOPs)[34,36], implementation of clinical decision support tools to assist in determining the need for blood cultures [41], marking of bottles to guide proper volume collection[38,41], use of dedicated phlebotomy teams[25,41,46], development and dissemination of performance indicators—such as the contamination rate [32,37,46] and revision of existing workflows [37-38,43].

Regarding materials, laboratories serving pediatric populations should use bottles specifically designed for this group [38]. The use of blood culture bottles containing resin-based media to neutralize antibiotics [28,35], and bottles with lytic media that reduce detection time by lysing blood cells [35], offer advantages in increasing microorganism recovery. Additionally, using collection devices that facilitate and ensure safety for professionals—such as initial sample diversion devices [37-38] and vacuum safety butterfly sets [28,36,42].

As for infrastructure, pneumatic tube systems can be used to reduce the time it takes for samples to reach the laboratory [31,37,46], or automated equipment can be decentralized to allow for faster incubation [27-28,31,37].

Some clinical and financial impacts observed in the studies when these measures are adopted include: reduced length of hospital stay by avoiding delays in transporting blood cultures [44]; reduced costs associated with sterile gloves, by directing this supply toward patients with difficult access who require repalpation of the puncture site, without increasing contamination rates [40]; increased sensitivity and accuracy in diagnosing catheter-related primary bloodstream infections (IPCS-CVC) when collecting catheter reflux samples instead of catheter tip samples [34]; and more appropriate therapeutic guidance when Gram stain results are made available [31].

Table 3 – Description of diagnostic management practices for blood cultures in the pre- and post-analytical phases.

Practices	Execution	Observations
Pre-analytical Phase		
High-value diagnostic ordering	Adults In the presence of signs of sepsis/septic shock[25-26,28,33,41-42]. Primary BSI: In suspected cases of endovascular infections, such as vascular grafts, pacemakers, injectable drug use, and catheter-related infections[25-26,33,41-42]. Secondary BSI: In suspected infections such as meningitis, osteomyelitis, and endocarditis[25-26,33,41-42]. Pediatric and Neonatal Sudden decline in vitality[33,42].	Repeat cultures in cases of persistent bacteremia after appropriate therapy, negative samples accompanied by suspected bacteremia, or to monitor the clearance of *S. aureus* bacteremia[25,41-42] .
Reduction of Sample Contamination Risk	**Skin preparation** without specifying alcohol-based antiseptic[25-26,37-38]. Adults Chlorhexidine 2%[28,30,33,36,42]. Pediatrics Chlorhexidine 2%[33,42 or Alcohol70%[42 Neonates Clorexidina 0,5%[34 or Alcohol70%[42 Bottle disinfection[25-26,33,36,42].	Friction is more important than the type of antiseptic [26,42]; allow to dry before puncture [26,30,36,38].

	Sterile gloves if skin needs to be re-palpated [28,36,40,42].	
Proper Collection Site	Adults, pediatrics, and neonates Venipuncture - preferred method [25-28,36,41-42]. **Catheter reflux** In suspected CRBSI cases, collect in conjunction with venipuncture sample[25,27,33,34].	
Proper Sampling Strategy	Adults **Multiple sampling** [25-28,40,42-43] collected from two different puncture sites. **Single sampling** *[32,37,45-46] collected from a single site.	*Except in cases of suspected endocarditis or CRBSI[44]
Adequate number of samples (aerobic and anaerobic bottles from a single puncture)	Adults At least two samples [36,41,43,46] Two to four samples [26,28,37-38]	Two aerobic and one anaerobic bottle per sample improves yield compared to using only two bottle[26-27]. For pediatric and neonatal patients, a single aerobic bottle may be used[25,33].
Appropriate volume per bottle	Adults 8-10 mL[26-28,33,36-38,41,45] Pediatrics Based on age or weight [25,38,41] or 1-5 mL[33] Neonates Up to 4% of body weight [25-26] or 1 mL[34]	
Ideal Timing for Collection	Adults, Pediatrics and Neonates As soon as possible and before antimicrobial administration [25, 26,27,36,41,42-43].	Multiple sampling strategies should have short intervals or be collected simultaneously[25-26,42].
Sample Temperature	Room temperature [25,33,36]	
Transport Time	< 2 hours [25,27,29,33,36,39,43,45] < 4 hours [31,37,44]	
Practices	**Execution**	**Observations**
	Post-Analytical Phase	
Effective Communication of Results	Immediately inform physicians of positive results[27,32,37,43]. hese results must be documented[32]. They must also be communicated to the antimicrobial stewardship team and infectious disease specialists[27,37]. Communication should occur via telephone or electronic alert2[7,37].	Communicating the Gram stain result is more important than reporting the antimicrobial susceptibility test result[37-38]. Other information may be included in the final report, except when identified as critical to the patient's condition[37].
Reporting of Results	Link the result to treatment recommendations[27].	Provide clear guidance on the clinical relevance of the findings. [37]
Proper Interpretation of Results	Support from the antimicrobial stewardship team and infectious disease specialists[27,37]. Utilização de um sistema eletrônico de apoio à decisão integrando resultados a sugestões de terapias ou alertas para modificação [27].	Use of an electronic decision-support system that integrates results with therapy suggestions or alerts for modification [37].

Note: IPCS - Primary bloodstream infection; CVC - Central venous catheter.
Source: Author's own.

DISCUSSION

The studies [25-27,31-40,42-44,45-46] demonstrated which pre-analytical and post-analytical practices should be adopted by healthcare professionals to ensure optimal blood culture performance, as well as the main strategies identified to achieve this standard. It was also evidenced that there is a greater tendency in publications [25-27,31-40,42-44,45-46] to focus on the pre-analytical phase when analyzing interventions aimed at optimizing the microbiological diagnosis of bloodstream infections (BSIs). This study recognizes that knowledge of best practices in both the pre-analytical and post-analytical phases is equally important for the diagnostic management of blood cultures, ensuring safe patient care.

Regarding the pre-analytical phase, studies [28-29,31,39,43-44,46] demonstrated that interventions in the indication for collection, number of samples, volume, and transport time contributed to more rapid identification of patients with BSIs. The appropriate request for a blood culture by correctly identifying patients in whom this test will impact treatment remains a challenge.

A significant proportion of indications are made to assess fever or leukocytosis, but these parameters need to be more strongly correlated with bacteremia [47]. Evidence indicates that proper indication for blood cultures should be based on a high pre-test probability of bacteremia [41-42]. For this reason, a thorough medical history and detailed physical examination are essential [42].

A scoping review assessed the appropriate recommendation for blood culture in non-neutropenic adult patients. It was identified that the syndromes with a high pre-test probability are septic shock, meningitis, endovascular infections, ventriculoatrial shunt infections, vertebral osteomyelitis, epidural abscess, and non-traumatic septic arthritis. Although it offers moderate diagnostic yield, blood culture may also be considered when the primary site of infection is difficult to access or when antimicrobial treatment is to be initiated prior to obtaining cultures from the primary focus [47].

As for the number of samples collected and the volume per bottle in adults, there is consensus regarding the recommendations that should be adopted by professionals [26,28,33,36-38,41,43,45-46]. However, there are challenges in adhering to these practices. A study analyzing blood culture processing in Israel estimated that 24% of BSIs in adults were not detected due to an inadequate number of samples or bottles [48].

In the pre-implementation phase of a quality improvement study conducted in 10 hospitals in New York, it was found that none of the hospitals collected the recommended volume per bottle, with an average fill volume of 2.3 mL [49]. Both total volume (number of samples) and volume per bottle (whether insufficient or excessive) are important variables influencing the likelihood of positivity. When the appropriate blood volume was ensured, a reduction in the analytical phase duration was observed [45].

Although the multiple-sample collection technique is more widely recommended [26-29,32,36,40], two studies [32,46] reported significant improvement in the number of samples and blood volume when using the single-sample collection method. A multicenter study compared both techniques using the same total blood volume (40 mL). This study found that the single-sample approach detected pathogens in 97.4% of patients, compared to 95.5% using multiple-sample collection, concluding that from the standpoint of cost, pathogen identification, and contaminant reduction, the single-sample technique is advantageous [50].

Regarding the pre-analytical time, guidelines recommend that the interval between blood collection and bottle loading into an automated system should not exceed two hours, and up to four hours in the United Kingdom. When hospitals do not have 24-hour microbiology services, rapid transport and maintaining adequate sample temperature can be compromised. Reducing pre-analytical time significantly shortens the time to positive culture results [25,28,29,32-35,37,42,45].

A retrospective study that evaluated 50,955 blood cultures over a 30-month period reported that when the time exceeded two hours, blood culture performance was compromised, with this delay being an independent factor for false-negative results [29]. Such compromise may occur when bacteria exhibit excessive growth before entering the equipment, and upon incubation are already in the stationary phase, making identification more difficult [51].

Regarding the post-analytical phase, it is evident that the communication of results plays an important role in optimizing diagnosis and patient outcomes. A clinical trial that evaluated the impact of different methods of reporting positive results demonstrated that the more active the communication—through a combination of documentation in the patient's medical record, verbal communication, and physician counseling—the greater the benefits for patients [52]. Furthermore, in the use of rapid identification technologies, communication is essential. A meta-analysis evaluating the effectiveness of these tests in reducing time to targeted therapy in patients with bloodstream infections (BSIs) showed a reduction in mortality when combined with direct communication of results [53].

With regard to linking guidance to test results, it is suggested that in simpler scenarios, the use of interpretive comments may enhance professional decision-making. Comments may advise placing patients under precautions if bacteria resistant to carbapenems and other β-lactams are identified, or recommend the prescription of a specific antimicrobial depending on the result [27].

This strategy is understood to be a multidisciplinary effort involving microbiologists, hospital infection control teams, and antimicrobial stewardship teams, aligned with the specific profile of each institution. Another promising strategy is cascade reporting, which aims to suppress broad-spectrum antimicrobials when the isolate is susceptible to narrow-spectrum agents. This approach is supported by the guidelines of the Infectious Diseases Society of America (IDSA) and the Society for Healthcare Epidemiology of America (SHEA) [54].

In more complex cases, the author [27] emphasizes the importance of involving specialists, such as the antimicrobial stewardship team and infectious disease specialists, to assist physicians in interpreting reports and recommending the most appropriate antimicrobial therapy. A cohort study showed that when infectious disease specialists' recommendations were fully followed, it resulted in shorter treatment duration, higher rates of therapy optimization, lower direct costs with antimicrobials, and reduced mortality [55].

In addition, strategies were identified to support adherence to these practices in both phases. Some of these strategies—such as training sessions, standard operating procedures (SOPs), and workflow reviews—incur no additional costs and demonstrated significant results in the studies, making them a feasible initial option for resource-limited institutions [28,30,31,43,46]. On the other hand, institutions with greater financial resources may implement tools such as electronic alerts for decision support and result notification, staff expansion, and the acquisition of blood culture bottles containing resin or lytic media, which aid in microorganism recovery. Thus, it is suggested that each hospital implement these interventions according to its particular characteristics, and that the use of combined strategies be adopted to achieve lasting results.

A limitation of this study lies in the number of selected databases and the exclusion of studies not available in full text; however, these did not directly influence the results, as they were older publications. Furthermore, gaps remain in the literature regarding the post-analytical phase, particularly in terms of the clinical impact and cost-effectiveness of practices such as the inclusion of comments in reports. These issues may be explored in future research with the aim of developing interventional studies for the timely direction of antimicrobial therapy. The inclusion of studies with higher levels of evidence on this topic is encouraged, as they may have greater impact on clinical practice.

CONCLUSION

This scoping review highlighted the practices adopted by healthcare professionals during the pre-analytical and post-analytical phases of blood cultures that contributed to the diagnosis of patients with bloodstream infections (BSIs). In the pre-analytical phase, significant improvements in sample quality were observed following interventions in the indication for collection, number of samples, sample volume, and transport time. In the post-analytical phase, timely communication of results and the support of infectious disease specialists in interpreting findings were emphasized as contributing to patients' therapeutic outcomes.

Strategies such as training, standard operating procedures (SOPs), and the decentralization of automated equipment were also identified to improve healthcare professionals' adherence to these practices. When implemented in combination, these measures enable long-lasting behavioral changes. Therefore, further research is encouraged to address existing knowledge gaps in the post-analytical phase, in order to identify the clinical and financial impacts of these practices and to explore new insights that may emerge from this field of study.

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ORIGIN OF THE ARTICLE

Excerpt from the dissertation – Construction and validation of a package of measures for the diagnostic management of blood cultures: contributions from the CCIH, presented to the Postgraduate Program in Health and Technology in the Hospital Space, of the Federal University of the State of Rio de Janeiro.

CONTRIBUTION OF AUTHORSHIP

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APPROVAL BY THE RESEARCH ETHICS COMMITTEE

Since this is a scoping review, the study was not submitted to the Research Ethics Committee.

CONFLICT OF INTEREST

There is no conflict of interest to declare.