RESEARCH PAPER

A Cross-Sectional Analysis of Blood Culture Quantities in Children Aged 1 Month to 17 Years

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Abstract: **Bloodstream infection represents a significant cause for morbidity and mortality attributable to it among paediatric patients and it is important to make an accurate diagnosis of this condition and to involve it in time. The aim of this cross-sectional study was to evaluate the diagnostic value and contamination rate of blood cultures in children aged 1 month to 17 years with various amounts of blood sent for culture. The study was carried out in a tertiary care hospital with 136 children to undergo blood culture investigations. Blood culture volume was evaluated according to the recommendations of age groups and possible factors such as age, weight and roles of healthcare workers were analysed. The results showed that sufficient blood culture quantities for pathogen detection and minimizing blood culture contamination were significant versus inadequate blood culture quantities. Between 3 and 6 months of age there was more difficulty in attaining recommended blood volumes. The ability to adhere better to the blood culture protocols was better with educational interventions and with standardized guidelines, improved collection tools, and ongoing feedback to them. The paper focuses on the benefits of optimising the use of blood cultures in the diagnosis and treatment of bloodStream infections in children.**

Keywords: Blood culture, Pediatric infections, Bloodstream infections, Diagnostic accuracy, Contamination rates

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I. INTRODUCTION

One of the most important causes of morbidity and mortality in children in any part of the world continues to be bloodstream infections (BSIs) therein infants as well as critically ill children. An early and accurate diagnosis of these infections is crucial for timely treatment and good outcome [1]. Blood culture test is regarded as the gold standard to understand the bacterial and fungal infection causing blood stream infection. Blood volume collected at sampling however, has a great influence on the diagnostic value of blood cultures. Collecting sufficient blood volumes may be a challenge in paediatric practice due to smaller blood volumes, difficulty in access as well as the fear of complications and differing ways of collection among health care workers [2]. Small volume of blood cultured is linked to a decreased detection rate for pathogens and higher risks for false negative results. Meanwhile, suboptimal sampling methods can contribute to higher rates of contamination which can result in more, and sometimes unnecessary, antibiotic usage, longer hospital stays, and higher costs of care. It has been proven that following these standards of age-specific blood volume guidance, significantly benefits culture positivity and diagnostic reliability in children [3]. Although appropriate blood collection and processing is a key element, suboptimal sampling procedures are still frequently used in a variety of clinical care settings, particularly in intensive care, wards and paediatric emergency departments. The present study aims to analyse the quantity of blood culture, a cross sectional study comprising children from 1 month to 17 years in a tertiary care hospital. To assess perceived compliance with recommended volumes of blood for blood culture and identify factors (such as patient age

and weight, and healthcare worker practices) that affect the adequacy of blood volume for culture for bloodstream infections. The study also involves interventions like providing staff education, implementing guidelines, improving sampling tools, and feedback mechanisms to improve blood culture collection practices. The study aims to enhance the diagnostic ability, decrease contamination rates, and facilitate better management of pediatric Blood Stream Infections by improving the number of blood samples collected.

II. RELATED WORKS

There have been some recent studies that have focused on the factors affecting morbidity and diagnostic outcome among children of various pediatric health conditions, infectious diseases, nutrition and healthcare factors. The results of these studies offer important clues regarding the role of accurate clinical assessment, early diagnosis and better health care practices in children. Egho et al. examined the relationship of the dietary glycemic index with obesity in preschool children from Lebanon and found that the inadequacy of the diet was a significant factor in overweight/obesity in preschool children [15]. More recently, in another study conducted by the same researchers the influence of eating habits on the health of children was further underscored and the need for preventive health care strategies for children was reaffirmed [16]. The results show the importance of conducting clinical studies in children to help learn about risk factors for diseases and treatments for them. El Moctar et al. performed a study to investigate the persistence of CL in Mauritania from 2016 to 2024 [17]. The study showed that despite the availability of vaccines, infectious diseases continue to be a major problem in the developing regions and that there was a need for the correct lab diagnostics and effective surveillance of disease. Likewise, Liang et al. assessed the factors associated with death of preschool children hospitalized with TB in China and also indicated that the poor clinical presentation and delayed diagnosis were related to death [26]. The relevance of these findings is to emphasize the need for microbiological investigation (in this case a blood culture) performed as soon as possible in pediatric patients if they are severely unwell to establish whether they have a severe infection.

A risk prediction nomogram to help pinpoint frailty in older Chinese adults was devised and validated by Fan et al [18]. Despite the emphasis on the elderly, the study showed the increasing applications of predictive models and statistical tools in clinical healthcare research. These types of analyses can also be used in pediatric infection research to determine additional elements related to the adequacy of blood culture samples and the diagnostic accuracy of blood culture results. Içen et al. examined executive functioning problems, food addiction, and indicators of a metabolic syndrome in obese adolescents [22]. They used cross sectional analysis of their data to explore the association of behaviors with pediatric conditions. This study emphasises the role of cross sectional research design in identifying possible association between clinical and demographic variables in the health care related studies.

Iskakova et al. contrasted the experiences of stigma with a health care context in Kazakhstan and highlighted that negative attitudes towards patients among healthcare providers not only touch on the quality of clinical services but also the overall access to health care [23]. Their study using a mixed-methods approach highlighted the need for health care provider awareness, education and communication. Staff training and adherence to procedures are also critical for the quality of blood culture practices, in addition to accurate sampling, and will affect the rate of contamination. Jean d'Amour Mutoni et al. compared Rwandan ethnic groups exposed to malaria prevalence, and analysed the specific microbiota that changed with age and location of the individuals seeking medical attention [24]. The study revealed the influence of patient characteristics on disease patterns and biological response, particularly by aging. Similarly, there is variability in the adequacy of pediatric blood cultures, depending on their age and physiology (especially young infants and children). However, Jensen and Sørensen have assessed the effect of rising temperatures on the food intake of human populations, and found moderate physiological effects in relation to environmental changes [25]. These findings present the possibility that it is external and environmental factors that have an indirect effect on health conditions and clinical outcomes. Taken together, these studies remind the reader of the importance of clinical investigations, healthcare interventions, demographic analysis, and laboratory diagnostics beneficial for the patient. There is little study, however, on the quality of blood cultures when

it comes to quantity in children older than 1 month of age up to 17 years. This study is therefore intended to fill this gap by assessing blood culture collections methods, blood culture contamination rates and the diagnostic accuracy of blood cultures in pediatric patients by a cross sectional design.

III. METHODS AND MATERIALS

Research Design

The research design of this study will be a cross sectional observation study to assess the quantity of collected blood culture specimens in children aged between 1 month to 17 years. The use of the cross-section approach is suitable, as it allows the allocation of data to the volume of blood culture requested, the contamination rate and other clinical parameters obtained during the study period to be assessed [4]. The current status of blood collection as well as compliance with blood volume recommendations for children of specific ages in day to day paediatric practice will be analysed.

Effectiveness of two intervention methods – one based on quantity – such as staff education, standardized procedures, better collection materials and feedback mechanisms, will also be assessed. All the data shall be obtained from the blood culture sample(s) taken as part of the standard treatment care of the patient.

Study Setting

The study will take place in a tertiary care teaching hospital with pediatric healthcare facilities in terms of wards, children's hospitals, Pediatric intensive care unit (PICU) and neonatal intensive care unit (NICU) and emergency department. The same blood culture bottles will be used in the entire study to capture samples and analyze the results, allowing for a standardized process [5]. All blood cultures will be analysed in the Hospital Laboratory as per the microbiological guidelines of the hospital.

The study will last for 3 months. The study will be approved by the Institutional Ethics Committee prior to the start of the study. Prior to participation, parents/legal guardians will be asked for their written informed consent.

Study Population

The study population will be all clinical children (1 month to 17 years old) who are undergoing blood culture investigations as part of their clinical evaluation for suspected blood stream infection. The study will incorporate both inpatient and Emergency Department (ED) patients.

Inclusion Criteria

The following people will be involved in the study:

- Children 1 months – 17 years of age.
- Pediatric patients who need to be blood cultured.
- Culture samples of blood obtained during the period of study.
- Patients with parents/carer and/or legal guardians who sign an informed consent form.
- Those patients who reach the wards of children and also PICU, NICU or Emergency departments.

Exclusion Criteria

The participants in the following categories will not be taken part in:

- Age of less than 1 month or more than 17 years.
- Blood culture samples of which no blood volume was measured.
- Those who had been treated for an antibiotic infection in the past 48 hours.
- Severely unstable blood collection for which is clinically contraindicated.
- Samples with known contamination that do not require a repeat sample.
- Those who have medical conditions that make it unsafe to take blood or have a vein let down.

Sample Size Determination

The sample size was calculated using below formula:

$n=4pq/l^2$

Where:

- p=18.6 (estimated prevalence)
- q=100−p=81.4
- l=7 (precision error)

The calculation is as follows:

$n=4\times18.6\times81.4/7^2$

After adding a 10% non-response rate:

123.6+12.3=135.9

The final sample size will therefore be rounded to 136 participants.

Sampling Technique

The sampling method is a consecutive sampling method which will be adopted throughout the study period. Only pediatric patients who meet the inclusion criteria above will be included, and sample size will be the number of eligible patients obtained. This sampling method is appropriate as continuous

recruitment of patients for blood culture investigations is allowed within the timeframe.

Data Collection Procedure

Data collection will be done in collaboration with the pediatric healthcare personnel, microbiologist and laboratory technicians. Sterile precautions for blood sampling are to be taken and the method to be followed is as laid down in the institutions [6].

The intervention plan that was followed during the study are:

- Establishment of age based guidelines for blood volumes based on evidence.
- Educational events and practical training of health care workers.
- Implement use of 3 ml syringes and enhance collection accuracy.
- Communication of guidelines using posters, meetings and web based tools.
- Ongoing information on volume of blood cultures estimated and actually collected.

Prior to inoculation, the blood culture bottles will be weighed on calibrated laboratory scales. Blood inculation will be done with the bottles being reweighed after inoculation to assess the amount of blood obtained. Then blood volume will be determined by using blood density conversion techniques [7].

The following information will be documented on the patient and laboratory:

- Age
- Gender
- Weight
- Gestational age (for neonates where applicable)
- Hospital department
- Role of sample collector (nurse or doctor)
- Blood volume collected
- Blood culture result
- Presence of contamination
- Identified pathogen

Table 1: Variables Included in the Study

Variable Category	Variables Measured
Demographic Variables	Age, gender, weight
Clinical Variables	Department, diagnosis, antibiotic history
Sample Collection Variables	Blood volume collected, collector role
Laboratory Variables	Culture positivity, contamination, isolated organism
Outcome Variables	Adequacy of blood volume, diagnostic accuracy

Blood Culture Volume Assessment

The blood culture adequacy will be assessed according to the recommended blood volumes for children. Samples will be classified as ‘adequate’ or ‘inadequate’ based on guidelines for age. The adequacy assessment will aid in determining if enough blood was taken to get the best possible pathogen detection [8].

The presence of common skin flora organisms will be considered contamination in the absence of clinical signs of bloodstream infection. A comparison of the prevalence of contamination from good and bad blood culture specimens will be performed.

Data Analysis

The data will be collected in Microsoft Excel and will be analyzed in SPSS software 25. Patient characteristics and the blood culture results will be summarized using descriptive statistics including the number of patients, frequency, percentage, mean and standard deviation [9].

Chi square tests and independent t-tests will be used to analyze the relationships between blood volume adequacy and variables (age, weight, sample collector role) when applicable. A p of <0.05 will be deemed statistical significance.

Table 2: Statistical Analysis Plan

Study Objective	Variables	Statistical Test
Assess adequacy of blood volume	Adequate vs inadequate samples	Percentage and frequency

Compare contamination rates	Blood volume and contamination	Chi-square test
Analyze patient characteristics	Age, weight, blood volume	Independent t-test
Evaluate role of sample collector	Nurse vs doctor collection	Chi-square test
Assess culture positivity	Adequate volume and pathogen detection	Chi-square test

Ethical Considerations

The study will be approved by an Institutional Ethics Committee before the start of the study. This will be voluntary and with informed written consent of parents/legal guardians. To ensure confidentiality of the patient information during the study, the information will be coded with a unique identification code, and access to the study information will be restricted [10]. The study is of limited risk since the collection of the blood cultures is already a routine clinical practice. The participants will be able to withdraw from the research at any time without any impact on medical treatment. All of the information collected will be utilized solely on a research basis and for academic reporting.

IV. RESULTS AND ANALYSIS

In this cross-sectional study 136 paediatric patients aged from one month to 17 years were included to assess the volume of blood cultures collected, and the relationship between amount and end result. This study evaluated compliance with the age-specific blood culture volume guidelines, blood culture contamination rates, blood culture positivity and the impact of patient or health care worker characteristics upon blood culture adequacy [11]. The results highlight the need for sufficient blood volume for diagnosis of BSI in children.

Figure 1: “Pediatric Blood Culture Collection Procedure”

Demographic Characteristics of Participants

Children of various paediatric departments attended the study, such as paediatric wards, emergency units and intensive care units. These participants were stratified into several age strata to assess age-related factors of blood culture adequacy and outcome of diagnosis.

Table 1: Demographic Characteristics of Study Participants (n = 136)

Variable	Category	Frequency (n)	Percentage (%)
Age Group	1 month–1 year	38	27.9
	1–5 years	42	30.9
	6–10 years	31	22.8
	11–17 years	25	18.4
Gender	Male	74	54.4
	Female	62	45.6
Hospital Unit	Pediatric Ward	58	42.6

	Emergency Department	44	32.4
	PICU/NICU	34	25.0

Most of the participants were aged from 1-5 years (30.9%) with a close follow-up of 1 month to 1 year infants (27.9%). Of the population 54.4 % were males and 45.6 % were females. The majority of blood cultures (42.6%) were taken from children's wards, thus indicating that BSI is common amongst children requiring hospital admission in this setting [12].

Patients included from intensive care units and emergency departments enabled the study to include the sickest children who are likely to need rapid blood culture investigations. The younger children and infants were more difficult in the collection of blood due to several reasons including smaller veins, lesser blood volume and increased blood collection difficulty.

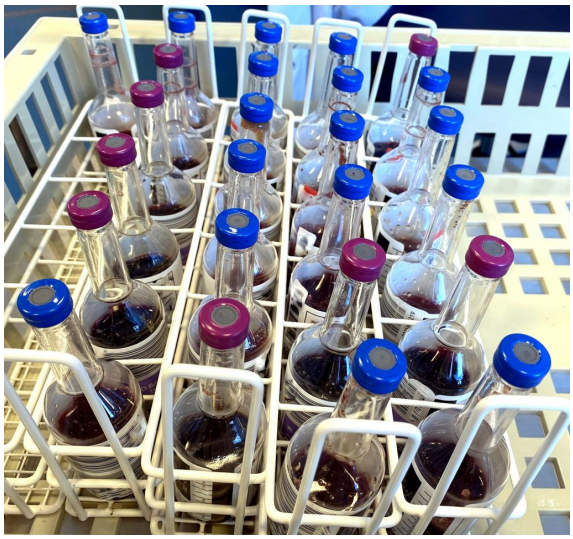

Figure 2: “Blood Culture Bottles and Laboratory Processing”

Blood Culture Volume Adequacy

Volume of a blood culture is an important component of maximising pathogen recovery and minimising false-negative results. The study included blood collection assessment to (whether) it is in line with pediatric age group recommendations.

Table 2: Blood Culture Volume Adequacy According to Age Group

Age Group	Adequate Samples n (%)	Inadequate Samples n (%)	Total
1 month–1 year	20 (52.6)	18 (47.4)	38
1–5 years	29 (69.0)	13 (31.0)	42
6–10 years	24 (77.4)	7 (22.6)	31
11–17 years	22 (88.0)	3 (12.0)	25
Total	95 (69.9)	41 (30.1)	136

Of 136 blood culture specimens collected, 95 (69.9%) had the recommended amount of blood, and 41 (30.1%) were classified as inadequate. There was a gradual increase in the percentage of good samples as age went up. Adequate blood volume was collected in only 52.6% of the infants, and 88.0% of adolescents (11–17 years).

These observations indicate that younger age groups are still more likely to have difficulties in drawing blood and to have inadequate samples because of technical and/or blood withdrawal issues in small children. Generally, older children (aged more than 5 years) tolerated the procedure more easily and to achieve recommended sample volumes was more effective [13].

Collecting blood samples according to the guidelines by age and the education of personnel seemed to increase the quality of blood collection in most departments. But the continued lack of good samples in infants underscores the need for new phlebotomy techniques and training specifically for pediatrics.

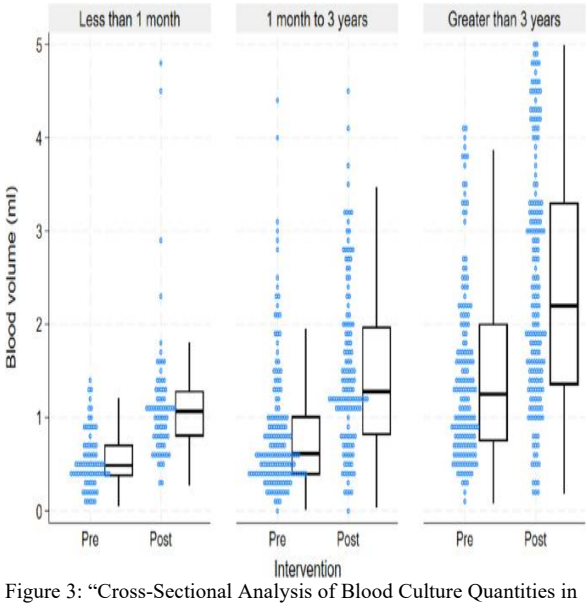

Figure 3: "Cross-Sectional Analysis of Blood Culture Quantities in Children"

Blood Culture Positivity and Diagnostic Yield

A blood volume adequacy assessment was made in the study that correlated with the percentage of culture positivity. Pathogen recovery and diagnostic accuracy was thought to be enhanced if adequate blood volumes were obtained.

Table 3: Association Between Blood Volume Adequacy and Blood Culture Results

Blood Culture Volume	Positive Cultures n (%)	Negative Cultures n (%)	Total
Adequate Volume	34 (35.8)	61 (64.2)	95
Inadequate Volume	7 (17.1)	34 (82.9)	41
Total	41 (30.1)	95 (69.9)	136

For the proportion of samples that were collected and adequate for testing, culture growth was detected in 35.8% of samples but in 17.1% of inadequate samples. Significant difference(s) confirm the good correlation between adequate blood volume and the detection of bloodstream infections.

Increase in blood volume means there's a greater chance of isolating microorganisms circulating in low levels, especially in the paediatric population with sepsis episodes and intermittent or low levels of bacteremia. As such, suboptimal sample collection might miss clinically meaningful and/or significant infections, which decreases the likelihood of prompt treatment and will ultimately impact patient outcomes [14].

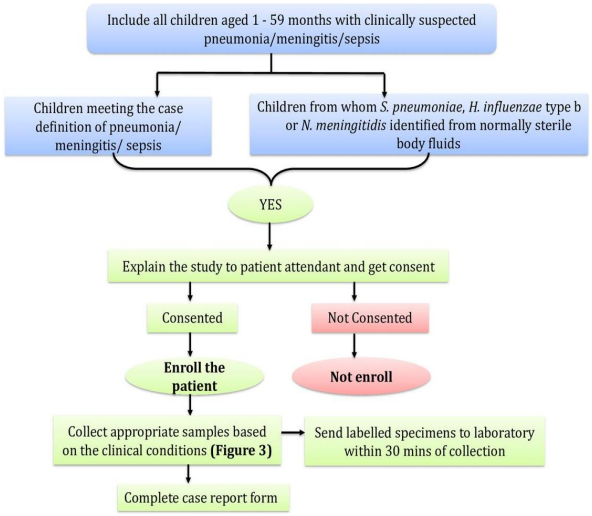

Figure 4: "Pediatric Infection Diagnosis and Clinical Monitoring"

It was found that the higher the volume of blood inoculated into a culture bottle, the more likely it is to be detected by the BLOX cleansweep device, confirming previous studies that the amount of blood inoculated is directly proportional to its sensitivity in a blood culture. The better compliance with blood volume guidelines will thus reinforce the diagnostic values and optimize antimicrobial therapy.

Analysis of Blood Culture Contamination

The main problem in blood culture diagnostics is contamination, which could unnecessarily result in antibiotic treatment, prolonged hospital stay, and cost of hospitalization. In the current study contamination rate was assessed with respect to blood culture adequacy.

Table 4: Blood Culture Contamination According to Sample Adequacy

Sample Category	Contaminated Samples n (%)	Non-Contaminated Samples n (%)	Total
Adequate Samples	6 (6.3)	89 (93.7)	95
Inadequate	10 (24.4)	31 (75.6)	41

Samples			
Total	16 (11.8)	120 (88.2)	136

Overall 11,8% of all blood culture samples were contaminated. There was a much higher contamination rate from inadequate blood volume samples (24.4%) than from adequately collected samples (6.3%).

This finding indicates either poor aseptic technique or repeated manipulation of needles and/or difficulty with venipuncture. Healthcare workers may have to overcome additional difficulties collecting adequate amounts of blood from smaller children, increasing the potential of contamination with skin flora organisms [27].

Diagnostic error can be minimized by following the standard procedure of sample collection and by training the other staff members because of the lower contamination rate within the adequate samples. Improved contamination control may have been brought about by educational interventions in the study, such as advice on applying the aseptic precautions, and blood collecting methods. There is a clinical significance in the reduction of contamination because of the clinical and financial implications of unnecessary antibiotic therapy, laboratory testing and utility costs associated with a false positive blood culture. Better ways of collecting blood have thus clinical and economic advantages.

Role of Healthcare Workers in Blood Culture Adequacy

In addition, the study investigated the effect of roles of sample collectors on adequacy of the volumization of blood cultures. Both the nurses and doctors were used to collect blood samples in the different pediatric units.

Table 5: Blood Volume Adequacy According to Sample Collector Role

Sample Collector	Adequate Samples n (%)	Inadequate Samples n (%)	Total
Nurses	58 (74.4)	20 (25.6)	78
Doctors	37 (63.8)	21 (36.2)	58
Total	95 (69.9)	41 (30.1)	136

There was a greater percentage of samples where the recommended volume of blood was collected by nurses (74.4%) than by doctors (63.8%). A reason for this difference is that there is a higher level of knowledge about routine paediatric blood collection procedures among the staff nurses [28].

Nurses often have difficulty with taking blood from children and frequently undertake this task in the children's wards, in intensive care units and in other critical situations. Blood collection, on the other hand, can be less common than in a non-emergency situation, and facilitated by doctors.

The results highlight the critical need for ongoing education of all stakeholders collecting blood cultures. Pediatric blood sampling practices can be standardized with educational interventions to increase competency, confidence and consistency.

Overall Interpretation of Findings

The results of this study overall are in accord with the important role of blood culture volume adequacy on the diagnostic yields in paediatric BSI. Higher percentage for detection of pathogens and lower percentage of contamination was achieved in adequate blood samples than in inadequate blood samples.

Moreover younger children (especially infants) had higher risk for inadequate blood volumes due to physiological and technical difficulties of blood volume collection. Based on these results, it is necessary to develop age-specific strategies to ensure accuracy of sampling in younger age groups. Educational activities, standard procedures, equipment and feedback had a good impact on the use of blood cultures throughout the study [29]. Raising risk awareness about the importance of proper blood taking among healthcare workers was probably to enhance adherence to proper standards in the blood collection [30].

It was further clearly shown that contamination rates can be minimised by appropriate aseptic technique and following the evidence based guidelines for the collection of blood. Reduced contamination rates lead to more reliable microbiological results and help in the appropriate use of antibiotics.

V. CONCLUSION

As a cross-sectional study, the authors have identified a key potential intervention to enhance diagnosis of

BSI in childhood and have shown the critical importance of correct BSI collection. Results showed that the detection of pathogens was significantly improved by using appropriate amounts of blood culture, with a lower contamination rate and false negatives. However, poor samples correlated with both decreased diagnostic accuracy and increased contamination rates were likely to contribute to delayed treatment and to unnecessary antibiotic use. The study also found that lower age group children, especially the infants, had more trouble in obtaining suggested blood culture volumes due to technical difficulties that occurred during sample collection. Further, the role of health-care workers was identified as an influencing factor in adequate blood culture collection, and the importance of ongoing education, and uniform and consistent collecting methods are underscored. Enactment of evidence-based guidance, education, advancements in blood collection supplies, and feedback to enhance adherence to guidance on blood cultures contributed positively to better adherence. The study highlights that despite the challenges, implementing best practices in blood culture can contribute to better early identification and management of BSIs in children, leading to improved patient outcomes and decreasing healthcare burden. This result is supportive in developing and incorporating structured tools for blood culture and continuous staff in-service in pediatric care facilities. Further multicenter studies with larger children and longer follow-up are suggested to characterize blood culture quantity changes in children in order to assess the sustainability and overall clinical outcomes of these changes.

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