Original Article

Central line-associated bloodstream infections in children: a systematic review and meta-analysis

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Background: Central line-associated bloodstream infection (CLABSI) in pediatric patients poses significant clinical challenges, with prevention strategies heavily reliant on identifying modifiable risk factors. Despite numerous studies investigating these risk factors, heterogeneity in study designs, populations, and regional settings necessitates a systematic synthesis of evidence to guide clinical practice. This meta-analysis aims to consolidate existing data and quantify key risk factors for pediatric CLABSI.

Methods: A comprehensive search of PubMed, Embase, Cochrane Library, and Web of Science was conducted for observational studies (cohort and case-control) published up to April 1, 2024. Two independent reviewers screened studies, extracted data, and assessed quality using the MOOSE checklist for observational meta-analyses. Meta-analyses were performed using Stata 15.0 software, with pooled odds ratios (ORs) and 95% confidence intervals (CIs) calculated via random-effects models. Heterogeneity was evaluated with I^2 statistics.

Results: Seventeen studies (17 cohort studies) involving 15,221 pediatric patients were included. Significant risk factors for CLABSI were: blood transfusions (OR =5.69; 95% CI: 2.93–11.05), congenital diseases (OR =2.58; 95% CI: 1.14–5.83), central nervous system (CNS) diseases (OR =4.13; 95% CI: 1.17–9.98), total parenteral nutrition (OR =4.37; 95% CI: 1.14–16.82), multiple catheters (OR =4.16; 95% CI: 2.36–7.31), prolonged catheterization time (OR =1.19; 95% CI: 1.08–1.30). Subgroup analyses confirmed consistency across regions and study types (I^2<50% for most factors).

Conclusions: This meta-analysis identifies blood transfusions, congenital/CNS comorbidities, parenteral nutrition, and catheter-related practices as critical modifiable risk factors for pediatric CLABSI. Clinicians should prioritize early catheter removal, judicious blood product use, and intensified monitoring for high-risk patients. These findings align with existing guidelines but provide stronger evidence for pediatric-specific protocols.

Keywords: Central venous catheter (CVC); children; bloodstream infection; risk factors; meta-analysis

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Introduction

A central venous catheter (CVC) is a type of catheter implanted within a blood vessel, terminating at the heart or one of the major veins. Catheter types encompass fully implanted infusion ports, tunneled CVCs, and peripherally inserted central venous catheters (PICCs) (1). These central venous devices are crucial in the diagnosis and management of numerous pediatric conditions; however, their use is associated with the risk of central line-associated bloodstream infection (CLABSI). The occurrence of CLABSI can result in critical illnesses such as sepsis, a heightened likelihood of requiring intensive care unit (ICU) care, extended hospitalization, higher mortality rates, and significant healthcare expenditures. Additionally, CLABSI is one of the key quality monitoring indicators in hospitals (2). CLABSI is defined as laboratory-confirmed infections where a CVC has been implanted for over two calendar days prior to the event in question, with the catheter remaining *in situ* on either the event day or the preceding day, and the infection is not secondary to infections at another site (3). CLABSI is the most common healthcare-associated infection in childhood (4). Surveillance studies conducted by the International Hospitalization Infection Control Consortium from 2007 to 2012 in pediatric intensive care units (PICUs) across countries in Latin America, Asia, and Europe indicated that the incidence rate of CLABSI was 6.1 per 1,000 catheter-days (5). Currently, the factors that contribute to CLABSI remain ambiguous, indicating a need for further investigation into its risk factors. Early identification of significant risk factors and the implementation of targeted interventions are vital for enhancing clinical outcomes in children with CLABSI and minimizing the risk of severe complications. This study adopts an evidence-based methodology to explore the risk factors associated with pediatric CLABSI, supplying healthcare professionals with dependable evidence for timely identification and intervention. Techniques for central venous catheterization and adherence to aseptic practices are essential for infection control. As highlighted by Hamza *et al.*, CLABSIs are prevalent healthcare-associated infections among high-risk neonates and children, resulting in extended hospital stays, increased expenses, and elevated mortality rates (6). Evidence-based interventions, including standardized quality improvement measures, have demonstrated effectiveness in lowering CLABSI rates. We present this article in accordance with the MOOSE reporting checklist (available at https://tp.amegroups.com/article/view/10.21037/tp-2024-597/rc) (7).

Highlight box

Key findings

- The meta-analysis showed that blood transfusion [odds ratio (OR) =5.69; 95% confidence interval (CI): 2.93–11.05], congenital diseases (OR =2.58; 95% CI: 1.14–5.83), central nervous system (CNS) diseases (OR =4.13; 95% CI: 1.17–9.98), total parenteral nutrition (TPN) (OR =4.37; 95% CI: 1.14–16.82), use of multiple catheters (OR =4.16; 95% CI: 2.36–7.31) and prolonged catheterization time (OR =1.19; 95% CI: 1.08–1.30) were all important risk factors for central line-associated bloodstream infection (CLABSI) in children. The results suggest that it is necessary to optimize the indications for blood transfusion, strengthen the monitoring of special patients, reduce the number of unnecessary catheters and shorten the catheterization time as much as possible to reduce the risk of infections.

What is known and what is new?

- CLABSI in children is a public health issue of concern. Many studies have investigated the risk factors for CLABSI in children, but these studies differ in their research times and regions.
- This meta-analysis summarizes existing studies to explore the risk factors of CLABSI in children. Specific CLABSI risk factors were identified, including blood transfusion, congenital diseases, CNS diseases, TPN, multiple catheters, catheterization time, which are new findings of the study.

What is the implication, and what should change now?

- CLABSI poses a serious threat to children's health and requires urgent prevention. This meta-analysis identified risk factors such as blood transfusion, congenital diseases, CNS diseases, TPN, multiple catheters and catheterization time, guiding clinical early identification and intervention, improving prognosis, and optimizing the allocation of medical resources.

Methods

The protocol was registered (No. CRD42024565798), detailing the research objectives, inclusion and exclusion criteria, and intended statistical methods. Throughout the study's implementation, we followed the registered protocol with slight modifications. All components of the study, including the search strategy, data extraction, and statistical analysis, were performed in accordance with the registered protocol.

Literature search

Four essential databases, including PubMed, Embase, Cochrane, and Web of Science, A systematic search was

conducted to identify observational studies (cohort and case-control designs) examining risk factors for central line-associated bloodstream infection (CLABSI) in pediatric patients, with a search period extending up to April 1, 2024. The search methodology was formulated using the PICO framework to guarantee a systematic and thorough approach. The PICO components for this investigation were delineated as follows: population (P): pediatric patients (aged 0–18 years) with CVCs. Intervention (I): CLABSI. Comparison (C): pediatric patients without CLABSI or with alternative risk factors. Outcome (O): risk factors for CLABSI and related clinical outcomes. Utilizing the PICO framework, the search strategy incorporated both controlled vocabulary (such as MeSH terms) and free text terms associated with the PICO elements: "Child, Children Pediatrics, Central Venous Catheters, Bloodstream Infection, and Risk Factors". The search terms were integrated using Boolean operators (AND, OR) to enhance both sensitivity and specificity. The detailed search strategy for each database can be found in the Appendix 1.

Inclusion and exclusion criteria

Inclusion criteria were as follows: population: patients under 18 years old. Diagnosis: patients satisfied the diagnostic criteria for CLABSI. Study design: case-control and cohort studies that were published in English. Outcome measures: this study analyzed risk factors through both univariate and multivariate analyses, prioritizing adjusted estimates from multivariate analyses when available and utilizing univariate data where necessary; secondary outcomes included catheter-associated bloodstream infection (CABSI) incidence per 1,000 catheter-days. We systematically searched studies published from each database's inception through April 1, 2024, excluding: (I) duplicate publications with overlapping cohorts; (II) conference abstracts, meta-analyses, narrative reviews, editorials, and animal studies; and (III) studies with inaccessible full texts or incomplete outcome data.

Literature screening and data extraction

Two investigators independently screened the retrieved studies. The titles and abstracts were checked to delete unrelated studies. Then, the full texts were downloaded and read to identify eligible studies. Key data were extracted employing EndNote, such as the first author, year of publication, geographical location, sample size, gender, age, and outcomes. In case of discrepancies, a third researcher would be invited to discuss the results.

Evaluation of literature quality

Two investigators independently evaluated the methodological quality of the selected studies utilizing the Newcastle-Ottawa Scale (NOS) (8). They verified each other's assessment results. The studies were classified into low (0–3), medium (4–6), or high (7–9) quality based on their NOS scores. Any dissents in the evaluation of study quality between the two researchers were addressed by seeking the opinion of a third researcher.

Statistical analysis

Data analysis was performed employing Stata 15.0 software. The pooled odds ratio (OR) and 95% confidence interval (CI) were computed. Based on the results of the heterogeneity test (Q test) and I^2 statistic, an appropriate model was selected to pool OR. If I^2>50%, a random-effects model was used; to evaluate the heterogeneity among studies, we computed the I^2 statistic, which measures the proportion of overall variability in effect estimates attributed to heterogeneity rather than to chance. Following the updated guidelines from the Cochrane Handbook for Systematic Reviews of Interventions (9), we implemented the ensuing criteria for model selection: if $I^2 \leq 50\%$, a fixed-effects model was employed, presuming that heterogeneity was minimal and the variations in effect sizes were mainly due to random error. Conversely, if I^2>50%, a random-effects model was adopted, indicating that heterogeneity was significant and the differences in effect sizes could represent genuine variability beyond random error.

This method aligns with the suggestions put forth by (10), who suggested that $I^2 \geq 50\%$ serves as a marker of substantial heterogeneity, thus necessitating the application of a random-effects model (11). Publication bias was assessed via Egger's test at a significance threshold of $\alpha = 0.05$, where a P value less than 0.05 indicated statistical significance.

Results

Literature search process and search results

From PubMed, Embase, Cochrane, and Web of Science, a total of 878 potential articles were identified. After duplicates were eliminated, and titles and abstracts were

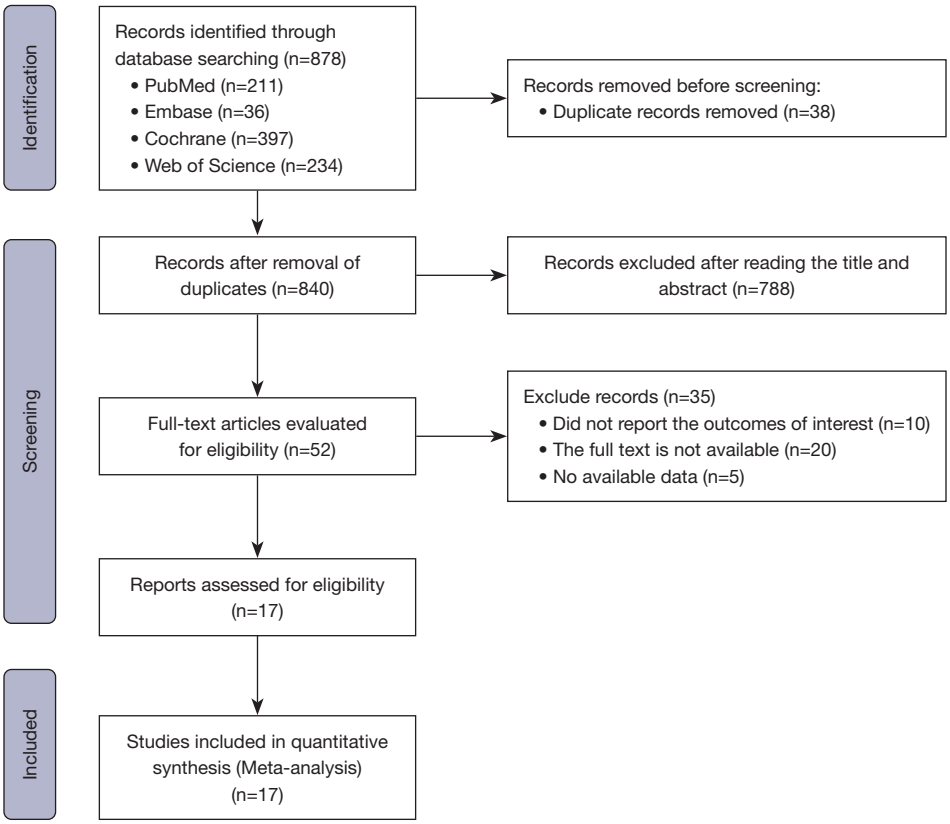

Figure 1 Literature search flow chart.

checked, 52 articles were left. Upon thorough full-text evaluation, 17 studies were deemed eligible for the meta-analysis. The detailed search process is presented in *Figure 1*. In the interest of transparency, a list of excluded studies and the reasons for their exclusion is provided (Appendix 2).

Basic characteristics of included literature

The analysis encompassed 17 studies with 15,221 participants (12-28), comprising 17 cohort studies. These studies were published between 2002 and 2024. There were 8 studies from the United States, 1 from Canada, 3 from China, 2 from Brazil, 1 from India, 1 from Greece, and 1 from South Korea. The diagnostic criteria were all based on laboratory blood culture test results, and the included participants were between 0 and 18 years old, with a median age of 18 years and a standard deviation of 6.89 years (*Table 1*). The quality of 17 studies was evaluated using the NOS, among which 15 studies were of high quality (12-17,19-25,27,28) and two studies were of moderate quality (18,26). In general, the quality of the included studies was considered to be relatively high. The detailed quality assessment results can be found in *Table 2*.

Univariate meta-analysis

Blood transfusion

Four studies examined the relationship between blood transfusions and CLABSI, involving a total of 2,721 pediatric patients. The heterogeneity analysis indicated an I^2 value of 58.4%, and thus a random-effects model was leveraged. The analysis results suggested that transfusion was a risk factor for pediatric CLABSI, with a statistically significant difference (OR = 5.69; 95% CI: 2.93–11.05), as detailed in *Figure 2*.

Congenital diseases

Five studies explored the link between congenital disorders and CLABSI, encompassing 4,190 children. Given the high heterogeneity (I^2=76%), we employed a random-

Table 1 Literature characteristics table

Study	Year of publication	Study design	Country	Sample size	Gender (M/F)	Mean age	Diagnostic criteria
Advani	2011	Cohort study	USA	1,819	1,010/809	0–13 years	Laboratory-confirmed BSIs
Carter	2016	Cohort study	Canada	5,648	–	0–18 years	Laboratory-confirmed BSIs
Yogaraj	2002	Cohort study	USA	911	526/385	<6 years	Laboratory-confirmed BSIs
Xu	2022	Cohort study	China	446	246/200	<28 days	Laboratory-confirmed BSIs
Wozniak	2018	Cohort study	USA	60	34/26	<18 years	Laboratory-confirmed BSIs
Viana Taveira	2017	Cohort study	Brazil	188	108/80	<18 years	Laboratory-confirmed BSIs
Cheng	2016	Cohort study	China	125	–	<28 days	Laboratory-confirmed BSIs
Padula	2014	Cohort study	USA	409	237/172	<18 years	Laboratory-confirmed BSIs
de Mello	2010	Cohort study	Brazil	875	–	0–18 years	Laboratory-confirmed BSIs
Elward	2006	Cohort study	USA	2,310	1,279/1,031	<18 years	Laboratory-confirmed BSIs
Zhang	2024	Cohort study	China	680	517/163	<19 days	Laboratory-confirmed BSIs
Torre	2018	Cohort study	USA	170	97/73	<18 years	Laboratory-confirmed BSIs
Sellamuthu	2023	Cohort study	India	118	62/56	2 months to 15 years	Laboratory-confirmed BSIs
Kelly	2013	Cohort study	USA	123	55/68	<18 years	Laboratory-confirmed BSIs
Miliaraki	2017	Cohort study	Greece	101	39/62	<16 years	Laboratory-confirmed BSIs
Moon	2018	Cohort study	Korea	629	278/351	<18 years	Laboratory-confirmed BSIs
Wylie	2010	Cohort study	USA	609	330/279	<12 years	Laboratory-confirmed BSIs

BSIs, bloodstream infections; F, female; M, male.

effects model for data analysis. The findings suggested that congenital disorders significantly increased the risk of CLABSI in children, with a statistically significant difference (OR =2.58; 95% CI: 1.14–5.83), as represented in *Figure 3*.

Central nervous system (CNS) diseases

Three studies reported the association between CNS diseases and CLABSI, involving 1,200 pediatric patients. Given high heterogeneity (I^2=63.4%), a random-effects model was employed. The analysis results suggested that CNS diseases were a risk factor for pediatric CLABSI, with a statistically significant difference (OR =4.13; 95% CI: 1.17–9.98), as shown in *Figure 4*.

Total parenteral nutrition (TPN)

Four studies reported on the association between TPN and CLABSI, including 3,231 pediatric patients. Due to high heterogeneity (I^2=88%), the random-effects model was selected for the analysis. The analysis indicated that TPN was a risk factor for CLABSI in children, with a statistically significant difference (OR =4.37; 95% CI: 1.14–16.82), as depicted in *Figure 5*.

Multivariate meta-analysis

Multiple catheters

Three studies examined the relationship between multiple catheters and CLABSI, encompassing 1,204 pediatric patients. Owing to low heterogeneity (I^2=14.4%), a fixed-effects model was leveraged. The findings suggested that the presence of multiple catheters was a risk factor for CLABSI in children, with a statistically significant difference (OR =4.16; 95% CI: 2.36–7.31), as depicted in *Figure 6*.

Prolonged catheterization time

Eight studies explored the link between catheterization duration and CLABSI, encompassing 5,786 pediatric subjects. Given high heterogeneity (I^2=95%), a random-effects model was leveraged for analysis. The findings demonstrated that prolonged catheterization was a risk factor for CLABSI in children, with a statistically significant difference (OR =1.19;

Table 2 NOS score

Study	Representativeness of the exposed group	Selection of non-exposed groups	Determination of exposure factors	Identification of outcome indicators not yet to be observed at study entry	Comparability of exposed and unexposed groups considered in design and statistical analysis	Design and statistical analysis	Adequacy of the study's evaluation of the outcome	Adequacy of follow-up in exposed and unexposed groups	Total scores
Advani 2011	*	*	*	*	**	*	*	*	9
Carter 2016	*	*	*	*	**	*	*	*	9
Yogaraj 2002	*	*	*	*	**	*	*	–	8
Xu 2022	*	*	*	*	**	–	–	*	7
Viana Taveira 2017	*	*	*	*	*	*	–	*	7
Cheng 2016	*	*	*	*	*	*		*	7
Padula 2014	*	*	*	*	**	*	*	*	9
de Mello 2010	*	*	*	*	**	*	*	*	9
Elward 2006	*	*	*	*	**	*	*	*	8
Zhang 2024	*	*	*	*	*	*	*	*	8
Torre 2018	*	*	*	*	**	*	*	*	9
Sellamuthu 2023	*	*	*	*	**	*	*	*	9
Wozniak 2018	*	*	*	*	*	*	–	*	7
Miliaraki 2017	*	*	*	*	*	*	–	–	6
Moon 2018	*	*	*	*	**	*	*	–	8
Kelly 2013	*	*	*	*	*	*	*	–	7
Wylie 2010	*	*	*	*	*	*	*	*	8

*, 1 point (criterion met); **, 2 points (criterion met); –, 0 points (criterion not met). NOS, Newcastle-Ottawa Scale.

95% CI: 1.08–1.30), detailed in *Figure* 7.

Other meta-analysis results

The differences in age, gender, pulmonary disease, chemotherapy, antibiotics, surgery, hematological tumors, and length of hospital stay were not statistically significant, as shown in Appendix 3.

Publication bias assessment results

In this research, we utilized Egger's test to evaluate publication bias for all identified risk factors. The findings revealed a significant publication bias concerning catheterization duration in the multivariate analysis (Egger's test, P=0.04), whereas no substantial bias was observed for other risk factors in both univariate and multivariate analyses (all P values >0.05, Appendix 4). To address the influence of publication bias, we performed sensitivity analyses to assess the impact on the results. Despite the detection of bias, the relationship between catheterization duration and bloodstream infections persisted as statistically significant.

Sensitivity analysis

In this research, sensitivity analyses indicated variability in CNS diseases, probably as a result of differences in patient populations, disease severity, and medical treatments, as emphasized by Xu *et al.* [2022] (26). Other risk factors, including catheter dwell time and the use of multiple catheters, displayed low sensitivity and consistent results across studies, reinforcing their validity as independent risk factors for CLABSI and CRBSI. Future multicenter studies with large sample sizes are essential for further investigating the intricate relationship between CNS diseases and bloodstream infections, concentrating on disease subtypes and confounding factors such as immune status to enhance risk identification

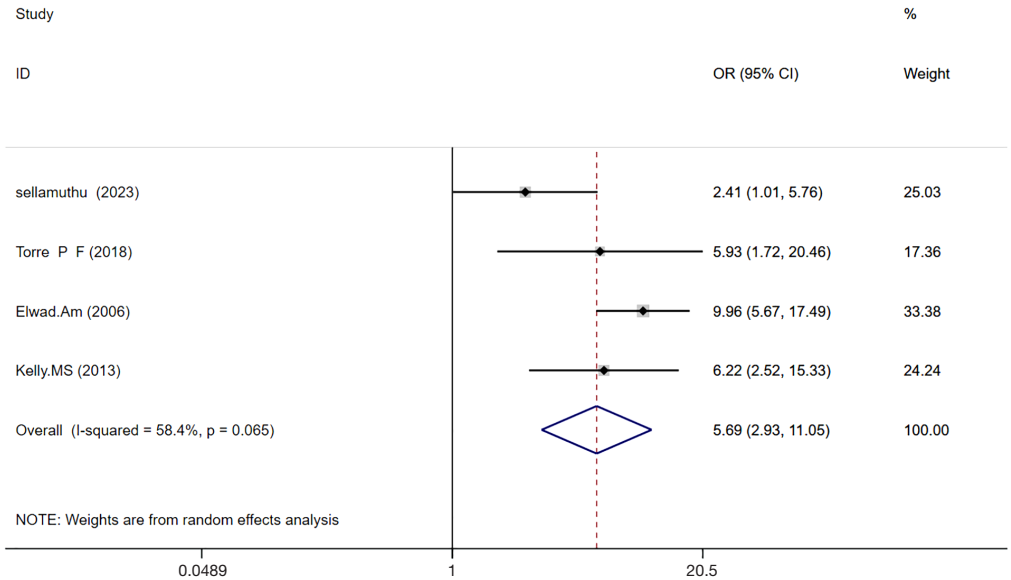

Figure 2 Forest plot of univariate meta-analysis for blood transfusion. CI, confidence interval; OR, odds ratio.

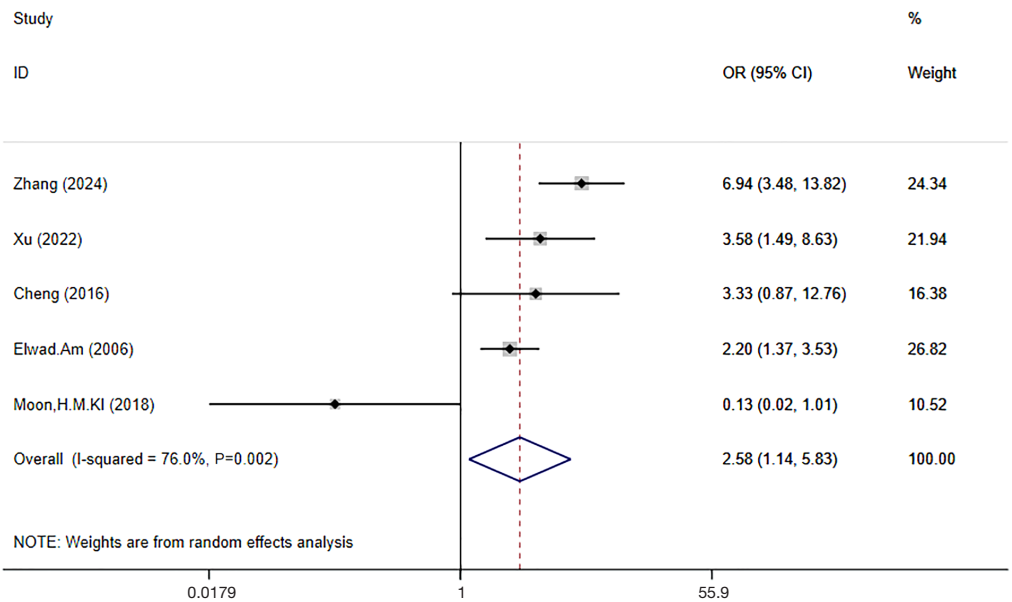

Figure 3 Forest plot of univariate meta-analysis for congenital diseases. CI, confidence interval; OR, odds ratio.

and clinical management strategies (Appendix 5).

Discussion

This research serves as the inaugural meta-analysis aimed at thoroughly examining the risk factors linked to CLABSI in pediatric patients. Through both univariate and multivariate analyses, we identified multiple significant risk factors, including transfusions, congenital disorders, CNS conditions, TPN, the presence of multiple catheters, and extended catheterization duration. These factors exhibited a strong correlation with an elevated risk of CLABSI in the pediatric population. Appropriate preventive measures need to be taken (Appendix 6). On the other hand, variables such

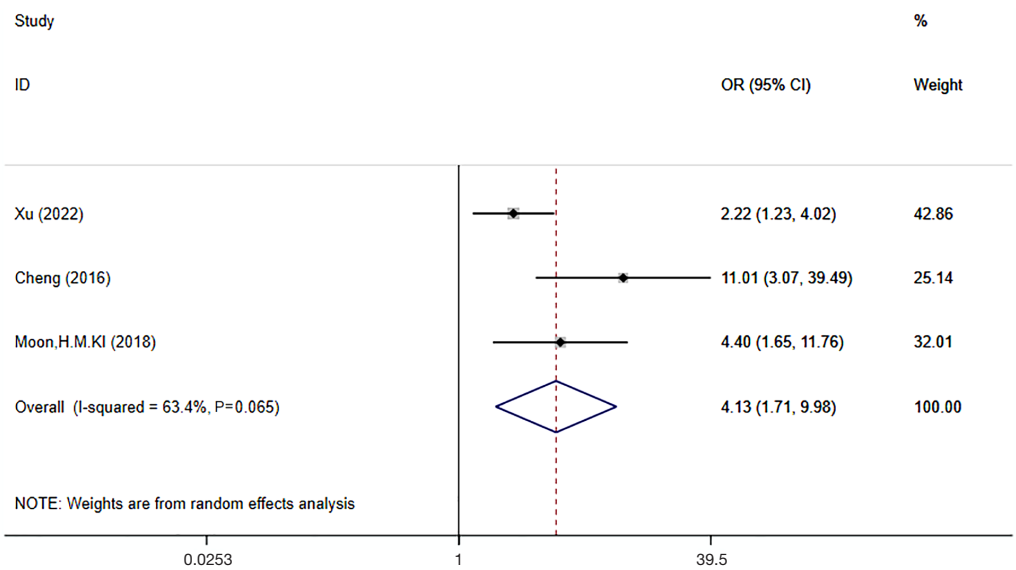

Figure 4 Forest plot of univariate meta-analysis for central nervous system diseases. CI, confidence interval; OR, odds ratio.

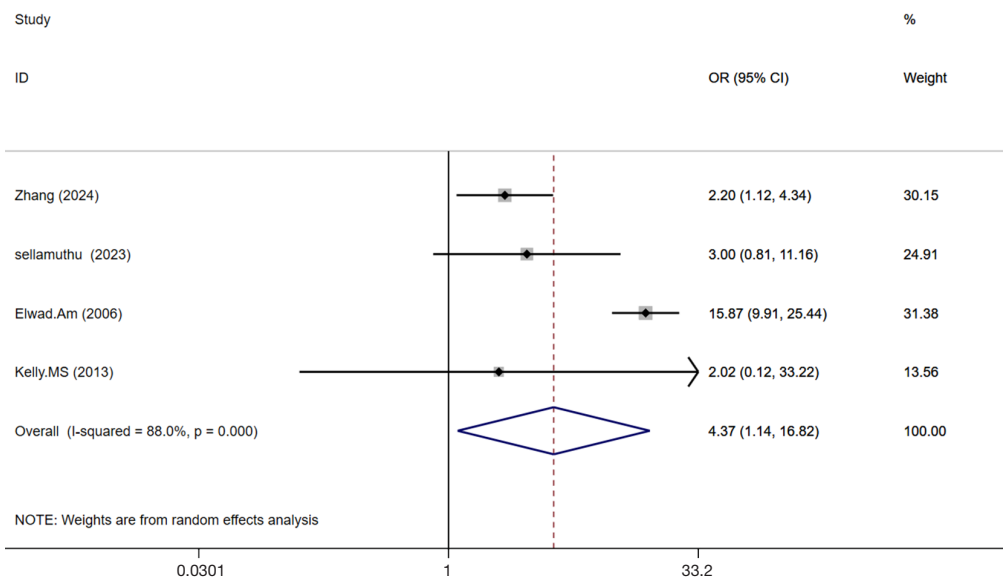

Figure 5 Forest plot of univariate meta-analysis for total parenteral nutrition. CI, confidence interval; OR, odds ratio.

as age, birth weight, and gender did not reveal a statistically significant connection with CLABSI risk in the univariate analysis. Although these factors may affect other clinical outcomes, they do not seem to serve as primary contributors to CLABSI within this group. The research conducted by Scarselli *et al.* offers valuable insights when considering the association between various disease categories in children and bloodstream infections. Their findings demonstrate that the incidence of CLABSI in children with medical complexity (CMC) who are admitted to PICUs is markedly greater than in those without underlying conditions. This underscores the significance of efforts aimed at preventing CLABSI within this particular patient demographic (29). These findings underscore the necessity for additional research to investigate the potential interactions between these factors and other variables that might influence

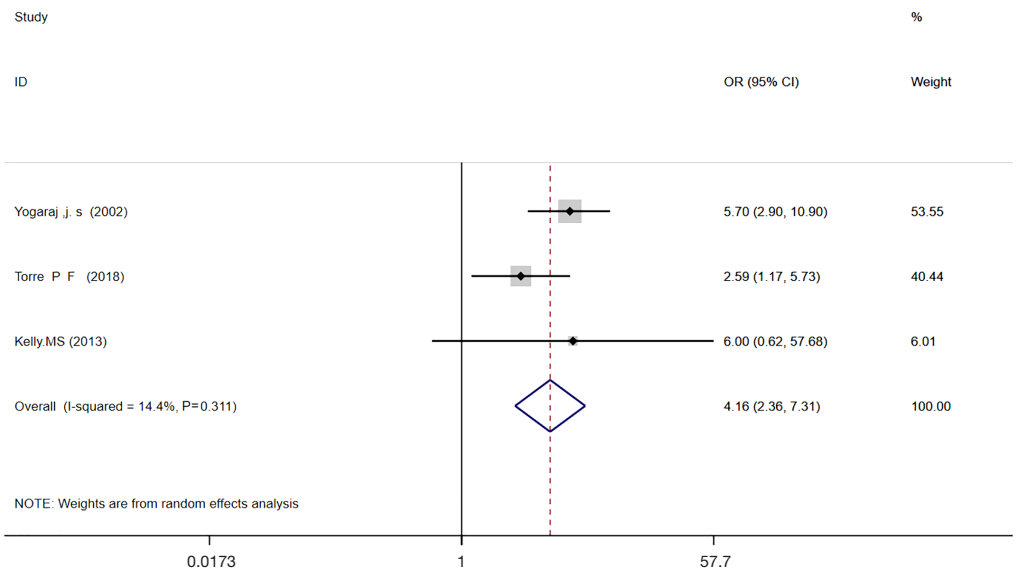

Figure 6 Forest plot of multivariate meta-analysis for multiple catheters. CI, confidence interval; OR, odds ratio.

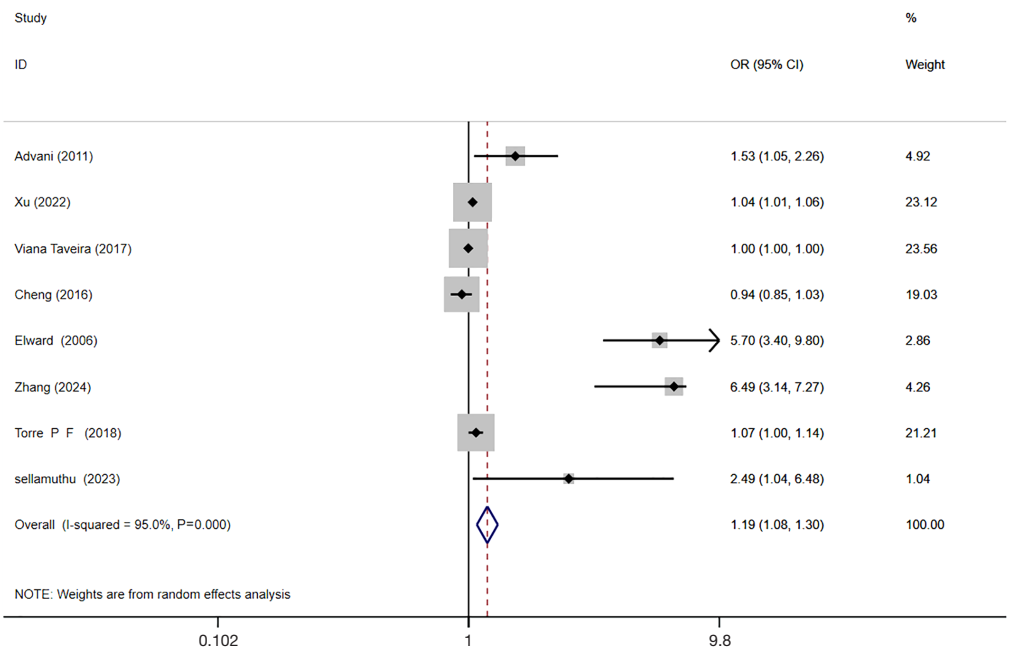

Figure 7 Forest plot of multivariate meta-analysis for catheterization duration. CI, confidence interval; OR, odds ratio.

the risk of CLABSI, ultimately shaping more focused prevention and intervention strategies. The study has determined that the likelihood of developing CLABSI significantly rises in patients receiving transfusions. Blood transfusions, which include red blood cells (RBCs), platelets, and fresh frozen plasma, are often administered to critically ill children, especially in PICUs. The rate of bloodstream infections in recipients of transfusions is considerably higher compared to those who are not transfused, and the risk of developing CLABSI during hospitalization intensifies with the frequency of transfusions. This phenomenon may be linked to the presence of blood

inflammatory mediators and the difficulties related to the management of transfusion safety. Hence, ensuring the safety of transfusions via CVCs is essential. Strategies such as employing leukocyte-reduced RBCs and flushing the catheter post-transfusion have been advised to reduce infection risks (23). In a study conducted by Wylie *et al.*, an examination of risk factors for CLABSI in pediatric ICUs indicated a significant association between blood transfusion and an elevated risk of infection. The study's results revealed that receiving a blood transfusion (OR =2.55; 95% CI: 1.21–5.36; P=0.014) served as an independent predictor for CLABSI (25). This finding emphasizes the critical need for rigorous management of transfusion decisions and the establishment of preventive strategies against transfusion-related infections within clinical settings, especially in the ICU environment. However, the association between leukocyte-depleted RBC transfusions and nosocomial infections is still intricate (30). The study by He *et al.* also indicated that RBC transfusion is associated with an increased risk of ICU-acquired infections in 2022 (31). The utilization of CVCs, along with the simultaneous administration of various antimicrobial agents, has been recognized as a pivotal risk factor for nosocomial infections. These observations establish a theoretical foundation for employing leukocyte-depleted RBC transfusions as a feasible approach to mitigate catheter-related infections; however, additional investigations are necessary to validate their effectiveness in particular clinical scenarios. Congenital disorders demonstrate a multifaceted association with catheter-related bloodstream infections (CRBSIs). This study analyzed different congenital conditions to evaluate their influence on the risk of CLABSI. Included disorders encompass congenital heart disease, congenital metabolic disorders (e.g., phenylketonuria and congenital hypothyroidism), and congenital immunodeficiency conditions (e.g., severe combined immunodeficiency). These ailments may affect CLABSI susceptibility by impacting immune response or metabolic functions. Future studies should delve deeper into how various subtypes of congenital diseases influence CLABSI risk to facilitate the formulation of more precise prevention and management strategies. While some research, such as that conducted by Martynov *et al.*, indicates that enhanced medical care and preventive measures can diminish infection risks in pediatric patients suffering from severe primary immunodeficiency diseases (PIDs) (32), other studies, like those by Dunseath *et al.*, indicate elevated infection rates in conditions such as Hurler syndrome, attributed to complications such as transplantation-associated thrombotic microangiopathy (TA-TMA) (33). Moon *et al.* (19) identified congenital disorders as potentially protective against CRBSI, which may relate to the frequent administration of antibiotics and rigorous monitoring. Nevertheless, this protective role is contentious, given that immune deficiencies inherent in congenital diseases could heighten infection risks. Further inquiry is required to clarify these mechanisms. Collectively, these findings imply that congenital diseases, irrespective of their specific type, may predispose individuals to CRBSI, likely stemming from immune dysfunction, metabolic irregularities, and the necessity for invasive interventions. Additional research is crucial to elucidate the mechanisms at play and to devise targeted preventive measures. The presence of multiple catheters is notably correlated with an augmented risk of bloodstream infections among children. In a retrospective cohort study by Ardura *et al.*, involving pediatric and adolescent patients with malignancies, hematologic disorders, and hematopoietic cell transplantation (HCT) recipients, it was found that the presence of multiple CVCs independently compounded the risk of CLABSI (34). Similarly, Cabrera *et al.* demonstrated that the employment of multiple catheters in neonatal intensive care units (NICUs) was significantly linked to CLABSI (P<0.001) (35). These findings underscore the necessity of optimizing catheter management and enforcing rigorous preventive strategies to lower infection risks in pediatric cohorts.

The association between catheter dwell time and bloodstream infections is well-documented in various studies. Srinivasan *et al.* identified catheter dwell time as a major risk factor for CLABSI in hospitalized children, reporting an OR of 1.24 (95% CI: 1.12–1.37) for each organ system requiring ICU-level care (36). This observation is consistent with findings from Johnson *et al.* (37), who noted that extended catheter placement considerably elevates infection risk, with infection rates significantly increasing for catheters left indwelling beyond a specific duration (P<0.05). To address this risk, healthcare institutions should evaluate the optimal duration for catheter use and consider timely removal or replacement. Moreover, these findings underscore the vital importance of effective catheter management in controlling CLABSI, particularly in pediatric populations with intricate medical needs. In our discourse on the connection between CVCs utilized for TPN and bloodstream infections, numerous studies have provided essential scientific evidence.highlighted that central venous CRBSIs are relatively prevalent among

patients on TPN, with infection rates substantially affected by catheter type and dwell time (38). Furthermore, when discussing the correlation between bloodstream infections and the infusion of TNA, the study by Fuchs *et al.* provides compelling evidence. The study conducted a pilot intervention to reduce CLABSIs in children receiving home parenteral nutrition (HPN) from extremely low-income settings. The results demonstrated that through a series of interventions, including home visits, the use of prophylactic ethanol lock solutions, and regular multidisciplinary team debriefings, the CLABSI rate significantly decreased from 9.62 episodes per 1,000 catheter-days to 0.79 episodes per 1,000 catheter-days, and the CVC replacement rate decreased from 2.5 replacements per 1,000 catheter-days to 1.2 replacements per 1,000 catheter-days (39,40). This finding not only proves the feasibility of implementing such interventions in resource-limited environments but also offers a new strategy for reducing the incidence of CLABSI. Furthermore, the study emphasizes the importance of assessing and improving the patient's home environment and nursing techniques during the provision of HPN to prevent CLABSI (39). This study indicates that CNS diseases also pose risk factors for CLABSI. We incorporated various CNS disorders, such as cerebral palsy, congenital hydrocephalus, neonatal hypoxic-ischemic encephalopathy, and intraventricular hemorrhage, to evaluate their influence on CLABSI risk. These conditions may elevate infection risk by impacting neurological or immune functions while necessitating more invasive procedures. Future studies should investigate how different subtypes of CNS diseases affect CLABSI risk to enhance prevention and management approaches. CNS diseases are intricately associated with bloodstream infections, particularly CLABSI. Lengthy hospital admissions and catheter use in CNS patients augment CLABSI risk, particularly in younger individuals (33). The presence of multidrug-resistant *Acinetobacter baumannii* further intensifies mortality, particularly observed in cases of meningitis with high fatality rates. Meticulous catheter management and prompt intervention are essential to mitigate infection risks (41). This study acknowledges several limitations. First, the incorporated studies are confined to cohort and case-control designs, which may introduce potential biases and limit the research depth. Second, these studies do not differentiate between various catheter types or insertion locations, which could impact the outcomes. Third, the analysis does not categorize OR, relative risk, or hazard ratios, which may introduce bias, despite minimal group differences. Fourth, the sample size is restricted, and no subgroup analysis has been conducted. Thus, future high-quality, multicenter, large-sample prospective studies are necessary to validate and broaden the understanding of CLABSI-related risk factors.

Conclusions

According to the available evidence, factors such as the use of multiple catheters, TPN, blood transfusions, congenital conditions, extended durations of catheterization, and CNS disorders may significantly increase the risk of CLABSI in pediatric patients. In clinical settings, these risk factors should be combined to formulate early preventive measures, enhance diagnostic precision, and apply effective strategies to lower the incidence of CLABSI among children.

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Footnote

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