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Systematic review

Blood culture contamination rates in India: a systematic review

Santosh Machado[1*], W Vishnu Vandana[2], Prashanth Purushotham[3], Ranjini C Y[4]

[1]MBBS, MD Microbiology, Assistant Professor, Department of Microbiology, Vydehi Institute of Medical Sciences and Research Centre -560066, Bengaluru, Karnataka, India.

[2]MBBS, MD Microbiology, Professor, Department of Microbiology, Vydehi Institute of Medical Sciences and Research Centre - 560066, Bengaluru, Karnataka, India.

[3]MBBS, MD Microbiology, Assistant Professor, Department of Microbiology, JIPMER-Puducherry

[4]MBBS, MD Microbiology, Professor, Department of Microbiology, Vydehi Institute of Medical Sciences and Research Centre - 560066, Bengaluru, Karnataka, India.

Corresponding Author:

Dr Santosh Machado
MBBS, MD Microbiology
Assistant Professor, Department of Microbiology
Vydehi Institute of Medical Sciences and Research Centre - 560066, Bengaluru, Karnataka, India.
Email – sanumac@gmail.com

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ABSTRACT

Background: Blood culture contamination is a quality indicator in clinical microbiology that affects antimicrobial use, patient outcomes, and healthcare costs. There is absence of consolidated national data from India, although international benchmarks recommend rates below 2–3%, this systematic review summarizes published evidence on blood culture contamination rates in India.

Methods: A systematic review was conducted as per PRISMA 2020 guidelines (OSF registration DOI: 10.17605/OSF.IO/ATKDQ) PubMed, Ovid Embase, and Google Scholar were searched without date restriction. Studies included were Observational and interventional studies conducted in India. Data were extracted, independently verified, and risk of bias was assessed using the Joanna Briggs Institute checklist for prevalence studies. Due to substantial heterogeneity in definitions and study designs, narrative synthesis was performed.

Results: Studies published between 2012 and 2024(n=12) were included, representing various regions and hospital settings, sample sizes (475 to 135,268 blood cultures), reported contamination rates (0.94% to 17%). Most observational studies reported rates (1% - 5%), while some centers exceeded the recommended <3% benchmark. Most common contaminant was Coagulase-negative staphylococci. Four interventional studies demonstrated reductions, following implementation of standardized collection bundles, staff training, dedicated phlebotomy teams, and chlorhexidine-based antisepsis. Overall methodological quality moderate, since there were many heterogeneities in operational definitions that limited comparability and precluded meta-analysis.

Conclusion: Variable Blood culture contamination rates in India exist and structured quality improvement interventions were found to be effective. Standardized definitions and harmonized reporting are needed to enable benchmarking and strengthen diagnostic stewardship nationally.

Keywords: Blood culture contamination, India, systematic review, prevalence, quality indicator; antimicrobial stewardship; diagnostic stewardship; coagulase-negative staphylococci, infection control, laboratory quality improvement

INTRODUCTION

Background

Failure of aseptic Blood culture collection is an important indicator, as it can lead to improper patient management and inappropriate antibiotic use, which results in higher healthcare costs1,2. International guidelines recommend limiting contamination rates below 2–3%3, but published data suggest significant variability across institutions and regions4.

Healthcare settings range from tertiary academic hospitals to peripheral centers, and heterogeneity exits in staffing, training, blood collection practices, and laboratory infrastructure5,6. Even when, blood culture contamination rate is a

relevant indicator, there are very few consolidated synthesis of contamination rates reported from Indian healthcare institutions despite multiple published studies, which would contribute to understanding of contamination rates and helps to identify factors influencing variability; this in turn will help us to benchmark and set up quality improvement initiatives at a national level.

The objective of this systematic review is to synthesize available evidence on blood culture contamination rates in India and evaluate determinants associated with higher contamination, thereby providing Indian evidence to inform laboratory practice and infection control strategies, in addition to describing a few interventional studies

PEO framework

- **Population**: Blood cultures performed in healthcare settings in India
- **Exposure**: Blood culture collection practices
- **Outcome**: Blood culture contamination rate.

MATERIALS AND METHODS

Protocol

This systematic review was conducted in accordance with PRISMA 2020 guidelines and was registered with open science framework (DOI: 10.17605/OSF.IO/ATKDQ).

Eligibility criteria

Inclusion Criteria

- Studies from India.
- Studies with blood culture contamination rate or sufficient data to calculate it.
- Observational studies.
- Interventional studies with pre- and/or post-intervention contamination rates. Baseline rates were used to estimate overall prevalence and intervention outcomes were summarized separately.
- Studies in any age group.
- English articles.
- Full-text available.

Exclusion Criteria

- Case reports or case series without denominator data.
- Studies conducted exclusively on neonatal intensive care unit (NICU), and those performed during COVID-19 Pandemic to avoid distortion of the contamination rates. Unless blood culture contamination rates were explicitly reported.
- Studies not reporting contamination rates.
- Studies conducted outside India.
- Conference abstracts without sufficient data.
- Animal studies.
- Reviews, editorials, commentaries.

Information Sources and Search Strategy

Search Strategy

Searches were done in:

- PubMed
- Ovid Embase
- Google Scholar

PubMed Search Strategy

("blood culture"[Mesh] OR "blood culture*" OR bacteremia)
AND
(contaminat*)
AND
(India[Mesh] OR India OR Indian)
The database search was conducted from inception to 20.02.2026. No study design filters applied; searches restricted to human and English articles.

Ovid Embase Search Strategy

('blood culture'/exp OR 'blood culture':ti,ab)
AND
('contamination'/exp OR contamination:ti,ab OR contaminated:ti,ab)

AND
('India'/exp OR India:ti,ab)
The database search was conducted from inception to 20.02.2026. No study design filters applied; searches restricted to human and English articles.

Google Scholar Search Strategy
"blood culture contamination" AND India
The first 200 results were screened by relevance. Further screening not done as there was decreasing yield of studies. The database search was conducted from inception to 20.02.2026. No study design filters applied; searches restricted to human and English articles.
Electronic search strategy was designed to ensure reproducibility.

Analysis
All records were imported into Rayyan for duplicate removal. Titles and abstract screening was done independently by two reviewers and was followed by full text screening done independently by four reviewers. Discrepancies were resolved by consensus discussion. Data extraction was verified by two reviewers and disagreements resolved through consensus .

Study Selection
Titles and abstracts were screened independently. Full texts were reviewed for eligibility.

Data Extraction
Data extracted included:
A standardized data extraction form captured:

- Author, year
- State/region
- Study design
- Study setting
- Study period
- Total blood cultures performed
- Number of contaminated cultures
- Contamination rate (%)
- Definition used for contamination
- Organisms classified as contaminants
- Intervention details (if applicable)

Data extraction was performed independently by two reviewers and cross verified. Discrepancies were resolved by consensus.

Risk of Bias Assessment
Risk of bias was assessed using the JBI Critical Appraisal Checklist for Prevalence Studies7. As our primary outcome of interest was a proportion(contamination rate), single tool was used maintain consistency in evaluation.

Data Synthesis
Due to substantial heterogeneity in study populations and definitions of contamination rates, Meta-analysis and pooled estimates were not done same is the reason for not doing heterogeneity tests. A structured narrative synthesis was conducted instead. Statistical calculations was done using Microsoft excel. For individual studies 95% confidence intervals were calculated using the normal approximation method for binomial proportions.

$p = x/n$
p = proportion, x = no of contaminated cultures, n = total blood cultures.
$SE = \sqrt{p(1-p)/n}$
where SE is Standard error
$95\%\ CI = p \pm 1.96 \times SE$

RESULTS
Study Selection
The database search and study selection process are summarized in Figure 1.

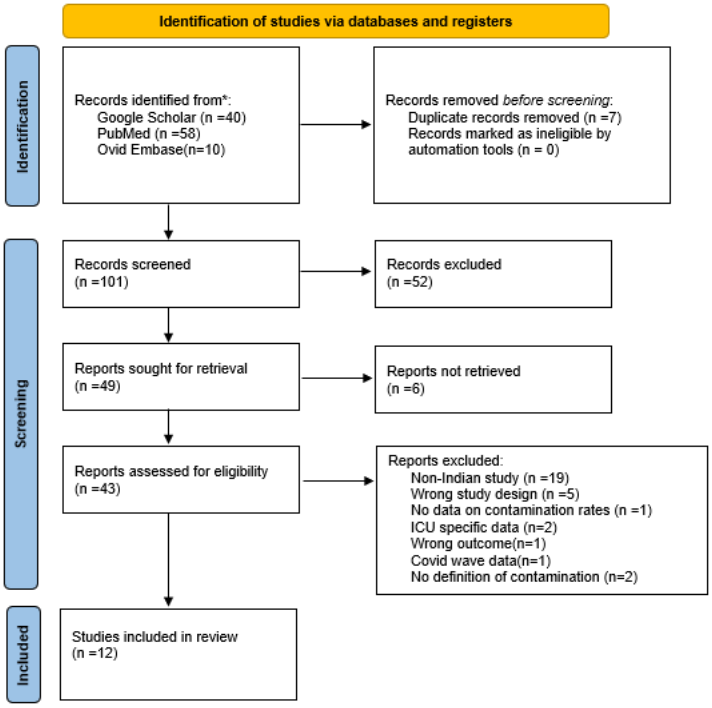

Figure :1 PRISMA 2020 flow diagram

A total of 12 studies met the inclusion criteria and were included in the final synthesis (published between 2012 and 2024); all studies were conducted in India and evaluated blood culture contamination rates in hospital-based settings. Studies conducted in NICU were excluded because of distinct patient populations and altered contamination dynamics these were used only if blood culture contamination rates were explicitly reported. Similarly, studies conducted during COVID-19 pandemic were excluded to avoid distortion in contamination rates due to altered staffing patterns and workflow.

Study Characteristics

The 12 studies included were conducted across following regions of India: Delhi, Maharashtra, Tamil Nadu, Telangana, Puducherry, Meghalaya, Andaman & Nicobar Islands, and Uttar Pradesh. One study analyzed data from a national private laboratory network encompassing multiple centers.

Studies were conducted in tertiary care hospitals, including adult intensive care units, neonatal intensive care units, emergency departments, and multispecialty teaching hospitals.Study designs included Retrospective observational studies, Prospective observational studies Interventional (quality improvement or bundle-based) studies, study duration ranged from short-term audits of two months to multi-year datasets extending up to six years. Sample sizes ranged, from 475 to over 135,000 blood cultures

Table 1 Study Characteristics

Sl no	Author	Year	State/Region	Study Design	Study Setting	Study Period
1	Tarai et al.	2012	Delhi	Retrospective	Tertiary Hospital (ICU, OPD, Wards)	Oct 2010 – June 2011
2	Surase et al.	2016	Maharashtra	Prospective	Multispecialty teaching hospital	Mar 2011 – June 2013
3	Gandra et al.	2016	National (696 centers)	Retrospective	Private laboratory network	Jan 2008 – Dec 2014
4	Tomar et al.	2017	Uttar Pradesh	Prospective	Public hospital	Aug 2014 – July 2015
5	Banik et al.	2018	Andaman & Nicobar	Retrospective	Tertiary care referral hospital	May 2015 – Feb 2017
6	Banik et al.	2020	Meghalaya	Retrospective	Tertiary care hospital	Jan 2009 – Dec 2013
7	Kumar et al.	2020	Tamil Nadu	Prospective	Tertiary hospital (ED/ICU)	Jan – Feb 2019

8	Patel et al.	2020	Maharashtra	Interventional	200-bed tertiary hospital	Dec 2017 – May 2019
9	Gunvanti et al.	2022	Telangana	Prospective	Tertiary hospital	Jan – June 2020
10	Shaji et al.	2022	Puducherry	Interventional	Tertiary teaching hospital (ED)	Nov 2019 – Oct 2020
11	Wanswett et al.	2024	Delhi	Interventional	Tertiary care hospital	Dec 2022 – May 2023
12	Tarai et al.	2024	Delhi	Interventional	Tertiary hospital (ED)	Jan – Dec 2023

Definitions of Blood Culture Contamination

Operational definition of blood culture contamination was mentioned in all the studies.

However, the definitions varied across studies and included:

- Isolation of typical skin commensals (e.g., coagulase-negative staphylococci) from a single blood culture bottle
- Growth of predefined contaminant organisms without supporting clinical evidence
- Retrospective clinical adjudication to distinguish contamination from true bacteremia
- Requirement of ≥2 positive cultures for classification as true infection

No study explicitly reported using predefined time-to-positivity thresholds as a primary criterion for contamination classification.

Substantial heterogeneity in definitions was observed, particularly in:

- The list of organisms classified as contaminants
- The requirement (or absence) of clinical correlation
- The number of positive bottles required to define true bacteremia

This definitional variability limits direct comparability across studies

Table 2 Organisms classified as contaminants

Sl no	**Author**	**Year**	**State/Region**	**Definition of Contamination**	**Organisms Classified as Contaminants**
1	Tarai et al.	2012	Delhi	Skin contaminants isolated from <2 sets without clinical BSI signs.	CoNS, Diphtheroids, *Bacillus* spp., *Micrococcus* spp., Viridans streptococci.
2	Surase et al.	2016	Maharashtra	Isolates determined as non-pathogenic after clinical dialogue.	*Micrococcus*, *Bacillus subtilis*, *Corynebacterium* spp., *S. saprophyticus*, *S. citreus*.
3	Gandra et al.	2016	National (696 centers)	Cultures yielding CoNS (standard practice for surveillance).	CoNS.
4	Tomar et al.	2017	Uttar Pradesh	Isolation of CoNS/Candida in only one culture with negative sepsis screen.	CoNS, *Candida* spp..
5	Banik et al.	2018	Andaman & Nicobar	Isolates analyzed via clinical criteria for agent of BSI vs. contaminant.	NR
6	Banik et al.	2020	Meghalaya	Isolates meeting specific criteria for agents of contamination.	*Bacillus* spp., *Corynebacterium* spp., *Micrococcus* spp..
7	Kumar et al.	2020	Tamil Nadu	Organisms introduced during collection not responsible for BSI.	CoNS.
8	Patel et al.	2020	Maharashtra	Skin flora from a single bottle with no clinical significance.	CoNS, *Bacillus* spp., *Diphtheroids*, *B. cepacia*.
9	Gunvanti et al.	2022	Telangana	Common commensal/skin flora isolated after 24h incubation.	*S. epidermidis*, *S. hemolyticus*, *S. citreus*, Aerobic spore bearing bacilli.
10	Shaji et al.	2022	Puducherry	Growth of specific skin/environmental flora (CoNS, Micrococci, etc.).	CoNS, *Bacillus* spp., *Diphtheroids*, *Micrococcus* spp., *Aerococcus*.
11	Wanswett et al.	2024	Delhi	Commensal organisms without clinical symptoms.	CoNS, ASB, *Micrococcus* spp..
12	Tarai et al.	2024	Delhi	Commensal/environmental organisms in single culture set.	CoNS (*S. epidermidis*, *S. haemolyticus*).

Blood Culture Contamination Rates

Reported contamination rates varied widely across studies.

Overall contamination rates ranged from below 1% to greater than 15%. Most observational studies reported rates between 1% and 5%. Several studies exceeded the commonly referenced benchmark of <3%.

Variability in contamination rates was observed across:

- Study design
- Clinical setting (e.g., ICU vs hospital-wide)
- Institutional practices
- Definitions of contamination

Table 4 Confidence intervals with blood culture contamination rates

Sl no	Author	Year	State/Region	Total Blood Cultures (n)	Contaminated Cultures (x)	Contamination rate%(95%CI)
1	Tarai et al.	2012	Delhi	6,903	130	1.88(1.56-2.20)
2	Surase et al.	2016	Maharashtra	797	12	1.50(0.66-2.35)
3	Gandra et al.	2016	National (696 centers)	135,268	4,337	3.20(3.11-3.30)
4	Tomar et al.	2017	Uttar Pradesh	475	25	5.26(3.26-7.27)
5	Banik et al.	2018	Andaman & Nicobar	1,895	31	1.63(1.06-2.21)
6	Banik et al.	2020	Meghalaya	5,736	54	0.94(0.69-1.19)
7	Kumar et al.	2020	Tamil Nadu	998	48	4.80(3.48-6.14)
8	Patel et al.	2020	Maharashtra	Not reported	Not reported	(not calculated)
9	Gunvanti et al.	2022	Telangana	522	13	2.49(1.15-3.83)
10	Shaji et al.	2022	Puducherry	630	86	13.65(10.97-16.33)
11	Wanswett et al.	2024	Delhi	470	57	12.12(9.18-15.08)
12	Tarai et al.	2024	Delhi	1,306	46	3.52(2.52-4.52)

Reported contamination rates and corresponding (95% confidence intervals) are mentioned in table 4. These were calculated by using the normal approximation method for binomial proportions. Confidence intervals are narrower in large data sets and wider in smaller data sets.

Results of Interventional Studies

Four studies evaluated interventions aimed at reducing blood culture contamination, interventions included, standardized blood culture collection bundles, dedicated phlebotomy teams, structured staff education and training programs, standardized antisepsis protocols (including chlorhexidine-based preparation), use of collection checklists and procedural standardization. All interventional studies reported a reduction in contamination rates following implementation, with magnitude of reduction varied across studies, with absolute reductions ranging from approximately 1% to over 10%. Baseline contamination rates differed, but improvement was seen across all studies.

Table 5 Results of Interventional studies

Sl no	Author	Year	State/Region	Study Design	Intervention Details	Pre-Intervention Rate (%)	Post-Intervention Rate (%)
1	Patel et al.	2020	Maharashtra	Interventional	BCC Bundle (Hand hygiene, skin antisepsis, order of draw).	17.00%	4.10%
2	Shaji et al.	2022	Puducherry	Interventional	Standard protocol + Multimodal educational training.	13.70%	4.2% (regular); 3.2% (phleb)
3	Wanswett et al.	2024	Delhi	Interventional	Comprehensive training in aseptic collection.	12.10%	8.60%
4	Tarai et al.	2024	Delhi	Interventional	Standardized trays, 2-step prep, 2% CHG.	3.50%	2.00%

Synthesis of Results
Quantitative meta-analysis was considered inappropriate due to substantial heterogeneity in study design, contamination definitions, organism classification, and intervention types, hence, was not undertaken.

A structured narrative synthesis demonstrated the following points. There is a wide variability in reported contamination rates across Indian healthcare settings, consistent predominance of coagulase-negative staphylococci as the principal contaminant organism, uniform direction of effect in interventional studies, with reduction in contamination rates following implementation of standardized collection strategies, methodological heterogeneity, particularly in operational definitions of contamination, which limits comparability and pooling of estimates.

Risk of Bias Assessment
Of the 12 included prevalence studies, sampling frames were appropriate to the clinical population of interest; however, all studies relied on convenience laboratory-based sampling, which introduces a moderate selection bias. Measurement validity was generally acceptable, though contamination definitions varied and were inconsistently standardized in three studies. Sample size adequacy was not formally given in most studies, and smaller single-center studies may be underpowered. Statistical reporting was descriptively appropriate; Confidence intervals were uniformly absent in the original studies, but were calculated in this review. Overall methodological quality was moderate, with four studies judged at low risk of bias and 8 requiring cautious interpretation due largely due to sampling and sample size limitations.

Table 6 Summary of Risk of Bias Assessment

Study	Sampling Bias (Q1+Q2)	Coverage Bias (Q5+Q9)	Measurement Bias (Q6+Q7)	Analytical Adequacy (Q3+Q8)
Tarai 2012	Moderate	Low	Low	Low
Surase 2016	Moderate	Low	Low	Moderate
Gandra 2016	Moderate	Low	Low	Low
Tomar 2017	Moderate	Low	Low	Moderate
Banik 2018	Moderate	Low	Moderate	Low
Banik 2020	Moderate	Low	Moderate	Low
Kumar 2020	Moderate	Low	Low	Moderate
Patel 2020	Moderate	Moderate	Low	Moderate
Gunvanti 2022	Moderate	Low	Low	Moderate
Shaji 2022	Moderate	Low	Low	Low
Wanswett 2024	Moderate	Low	Low	Moderate
Tarai 2024	Moderate	Low	Low	Low

DISCUSSION
We conducted a systematic review summarizing available evidence on blood culture contamination rates in Indian healthcare settings to estimate reported prevalence and determinants of variability. The method used was PRISMA 2020–compliant8 and included observational and interventional hospital-based studies that reported contamination rates or sufficient data for calculation. We decided to do a structured narrative synthesis rather than Meta-analysis due to substantial heterogeneity in definitions, study designs, and reporting practices. We didn't reclassify the data as we did not have the original datasets of the studies, whic reflects real-world practices but limits comparability across studies.

Key Findings
This review demonstrated substantial variability across the Indian healthcare settings, with some institutions were generally within threshold others exceeded it3,9. There was significant heterogeneity across settings, which reflected variation in clinical practices, institutional protocols and definitions, which could be due to differences in staffing patterns, training levels, adherence to aseptic techniques. All settings had issue of contamination, including large laboratory networks.

Similar microbiological pattern was seen across studies, showing Coagulase-negative staphylococci as a common contaminant. This pattern concurs with global evidence that contamination, in principle arises from inadequate skin antisepsis and procedural lapses during venipuncture (Hall and Lyman, 2006)4. Notably, no included study incorporated time-to-positivity thresholds as a principal discriminator between contamination and true bacteremia, and the requirement for multiple positive sets varied considerably.

Definitional heterogeneity was an important source of variability. These included approaches based on clinical adjudication following clinician–microbiologist dialogue18, fewer than two positive sets in the absence of clinical evidence of bloodstream infection15 and Coagulase-negative staphylococci as contaminants within surveillance definitions14. Such

differences in operational criteria may have contributed to the wide range of reported rates and limited comparability across institutions. Without standardized definitions, benchmarking and national-level synthesis are challenging.

Reduction of contamination rates were consistent across studies following the usage of interventions like, blood culture collection bundle19, standard protocol and dedicated phlebotomists17, comprehensive training20, Standardized trays and two step chlorhexidine-based preparation16.

Consistent reduction suggests this is a modifiable indicator, even when the baseline levels are near or below the recommended levels. This is indicative of possible efficacy of bundled interventions and structured training even when causal inference cannot be made.

This aligns with international evidence demonstrating that dedicated phlebotomy teams and standardized protocols can sustainably reduce contamination (Bekeris et al., 2005; Self et al., 2019)21,22.

Similar to the definitions, variability in baseline rates, definitions, and intervention components limit causal inference and generalizability with interventional studies.

In the context of antimicrobial resistance burden of India, reduction of false-positive blood cultures directly impacts stewardship implications by minimizing antimicrobial exposure and downstream healthcare costs (Laxminarayan et al., 2013)23.

Quality of the Evidence

Risk of bias assessment using the JBI checklist suggested overall moderate methodological quality7. Sampling frames were appropriate to hospital-based populations; however, all studies used laboratory-based convenience sampling, which may introduce potential selection bias. Sample size justification was rarely provided, particularly in smaller single-center studies such as Tomar et al. (2017) and Kumar et al. (2020), which may affect precision10,11. Measurement validity was generally acceptable, but heterogeneity in contamination definitions introduces indirectness and potential misclassification bias, as seen in Banik et al. (2018) and Banik et al. (2020). Statistical reporting was descriptive, and confidence intervals were uniformly absent, which limits the assessment of imprecision. Overall, confidence in the direction of findings; particularly regarding intervention effectiveness is moderate, but precision in estimating national prevalence remained limited.

Limitations

This review is limited by following issues; Heterogeneity in definitions, organism classification, and study design limitations resulted in absence of quantitative pooling. Studies being single-center and hospital-based, this limited generalizability to peripheral or primary care centers. Incomplete reporting of denominators in one interventional study. Non-calculation of confidence intervals across original studies limited precision. Publication bias could not be ruled out, especially for interventional studies that demonstrated improvement. Time-to-positivity data not being reported and limited clinical adjudication criteria restrict assessment of misclassification bias.

Even with these limitations, this review gives the one of the first comprehensive summary of blood culture contamination rates in India, which show , consistent microbiological patterns, and benefits of structured quality improvement strategies. Standard definitions of reporting, integration of contamination monitoring into routine laboratory indicators, and wider implementation of evidence-based collection bundles may substantially reduce contamination and support stewardship efforts nationally

CONCLUSION

We reviewed the available evidence on blood culture contamination rates in India. While some institutions exceeded, some were within internationally recommended benchmarks (Weinstein et al., 1997; CLSI, 2022)3,9, indicating ongoing quality challenges.

Due to multiple in operational definitions and organism classification, meta-analysis and pooled estimates were not done. Most common contaminant was Coagulase-negative staphylococci. Interventional studies showed reductions in contamination after implementing protocols, showing structured quality improvement initiatives can be effective.

Methodological quality was largely acceptable and the overall level of evidence was moderate. Limitations included convenience sampling, lack of confidence intervals, definitional variability, and limited adjustment for confounding reduce precision and comparability.

Blood culture contamination is a modifiable and measurable indicator in hospitals. Standard definitions, regular surveillance, and employment of evidence-based collection protocols have a potential to reduce unnecessary antibiotic exposure and associated healthcare costs.

Implications for Future Research
Multicenter prospective studies using Standard definitions and reporting, reporting confidence intervals, and evaluation of sustainability of interventions over time. Development of nationally endorsed guidance on contamination classification and reporting would further enhance benchmarking and diagnostic stewardship efforts, leading to strong antimicrobial resistance containment strategies in India.

DECLARATIONS

Funding
None.

Conflicts of Interest
The authors declare no conflicts of interest.

Ethical Approval
This study was a systematic review of previously published literature and did not involve direct human participation, patient identifiers, or collection of primary clinical data. Therefore, institutional ethical approval and informed consent were not required.

Artificial intelligence assistance
AI-assisted data organization was performed using ChatGPT (OpenAI), and all extracted data were independently verified by the authors.

No AI tool had decision-making authority. All AI assisted inputs were critically reviewed and verified against the primary literature by the authors. The authors accept full responsibility for the final manuscript

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