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Original Article

Microbiology Section

# Trends in Blood Culture Contamination in a Specialised Oncology Hospital: A Five-year Retrospective Observational Study

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## ABSTRACT

**Introduction:** Bloodstream Infections (BSIs) are a major source of morbidity and mortality in cancer patients who are immunocompromised. While blood culture remains the gold standard for BSI diagnosis, contamination during collection can result in false-positive results, leading to unnecessary antibiotic use, prolonged hospitalisation, and increased healthcare costs.

**Aim:** To analyse Blood Culture Contamination (BCC) rates over a five-year period in a tertiary care cancer hospital.

**Materials and Methods:** A retrospective observational study was conducted from January 2019 to December 2023. All blood culture specimens received in the Department of Microbiology, Homi Bhabha Cancer Hospital and Mahamana Pandit Madan Mohan Malaviya Cancer Centre, Varanasi, Uttar Pradesh, India were analysed. Contamination rates were analysed annually, department-wise, and by collection site i.e., (blood collected from peripheral vs central line). Data were represented as frequencies and percentages to determine the annual contamination rates over the months. Statistical analysis was performed using the Chi-square test, with p-value <0.05 considered statistically significant.

**Results:** Of the 2,651 positive cultures, 761 (28.7%) were identified as contaminants, corresponding to an overall contamination rate of 3.11%. Coagulase-Negative Staphylococci (CoNS) represented the predominant contaminants, with a statistically significant upward trend (p-value =0.047). A similar increase was observed for *Micrococcus* spp. (p-value <0.001). Higher contamination rates were observed in specimens collected from peripheral sites, particularly in the paediatric haemato-lymphoid, adult haematology, and uro-oncology departments, with statistically significant variation across the study years (p-value <0.001, p-value <0.001, and p-value =0.030, respectively). General wards: 513/13542 (3.79%) and chemotherapy: 97/3474 (2.79%) showed higher contamination rates compared to specialised units like bone marrow transplant: 12/886 (1.36%).

**Conclusion:** Although overall contamination rates remained close to the acceptable threshold set by the Clinical and Laboratory Standards Institute (CLSI) (<3%), significant variation was observed across departments and collection methods. Targeted training, strict adherence to aseptic techniques and continuous surveillance are essential to minimise contamination, improve diagnostic accuracy, and optimise patient outcomes. BCC remains a key challenge in accurately diagnosing BSIs among oncology patients.


**Keywords:** Bloodstream infection, Contamination rates, *Micrococcus* species

## INTRODUCTION

Bacteraemia is defined as an invasion of the bloodstream by viable microorganisms and can be categorised as transient, intermittent or persistent. BSIs continue to be a major cause of mortality and morbidity in hospitalised and cancer patients despite advances in therapy and supportive care [1,2]. Blood culture continues to serve as the cornerstone diagnostic method for detecting bacterial BSIs. This procedure bridges both clinical and laboratory efforts, making it a joint fundamental responsibility of the microbiology laboratory, physicians, nurses and phlebotomists [3]. When a BSI is suspected, obtaining a blood culture is often the first and most decisive step in determining whether a patient requires antimicrobial therapy. Even though invaluable, blood cultures are not infallible. One significant challenge lies in distinguishing the true pathogens from contaminants. Sometimes, the microorganisms detected in the blood sample do not represent an actual infection but rather result from contamination during the collection process. This can lead to misdiagnosis, inappropriate treatment, and unnecessary use of antibiotics; thus, implementing proper techniques of specimen collection and result interpretation is absolutely essential [4].

Despite technological advancements in blood culture methods, BCC remains a persistent issue [5]. Best practice standards have been proposed for various aspects of blood culture because it is a multistep process involving clinical, ancillary, and laboratory staff across many departments, and there are multiple opportunities for failure of standard practices [6]. It is very important to distinguish between a true BSI and a contaminated blood culture to avoid unnecessary use of antibiotics, a longer hospital stay, and extra treatment costs. In the era of modern blood culture techniques, virtually all BCC occurs during collection. The source of contaminants is usually the patient's skin or the hub or cannula of an indwelling catheter (i.e., when an existing catheter is used to obtain the specimen). Frequent causes include poor collection technique and insufficient skin disinfection. Typical organisms causing BCC include CoNS*, Corynebacterium* spp.*, and Bacillus* spp. Other than *Bacillus anthracis, Micrococcus* spp., and *Cutibacterium acnes,* among others [4]. The causes of contamination may be inappropriate sampling, staff with limited experience in processing or transporting the blood or blood product, non-compliance with aseptic sample collection techniques, high traffic and overcrowding in the areas of blood collection, or difficulty in drawing blood from children, obese and elderly patients [7]. Whether the culture is pathogen or contaminated should be judged according to the symptoms of the patient, elevated infection markers such as procalcitonin, the number of positive blood culture sets, the time to positivity, the presence of an indwelling catheter during hospitalisation and some microbes that rarely cause BSIs [8].

Based on the recommendations of the CLSI 2022, the acceptable rate of BCC in health institutions is less than 3% [9]. The BCC rate is usually monitored in hospital settings because a low rate of BCC is

a key performance indicator of laboratory, phlebotomy and nursing quality. A contamination rate threshold is to be defined, and at specified intervals the sources of contamination should be tracked down to minimise BCC rate in an institution [6].

Although BCC is a well-recognised quality indicator, there is limited long-term, single-institution data from specialised oncology centres evaluating temporal trends along with detailed stratification by hospital location (ICU, OPD, ward, emergency) and collection site (peripheral vs central line) over an extended five-year period.

The novelty of this study lies in a comprehensive five-year longitudinal analysis of BCC in a high-volume tertiary oncology centre. Simultaneous evaluation of department-wise, location-wise, and site-wise contamination patterns. Identification of high-risk areas and collection practices specific to oncology settings, where immunocompromised patients are particularly vulnerable to diagnostic and therapeutic consequences of contamination.

This integrated analysis provides institution-specific evidence to support targeted interventions, improve phlebotomy practices, and strengthen diagnostic stewardship in oncology care settings.

The study aimed to analyse the contamination rate of blood culture samples over a period of five years.

The primary objective of the study was to identify the departments with the highest rates of contamination, along with the microorganisms isolated from the blood samples. The secondary objective was to compare blood contamination rates at various locations (ICU, OPD, Ward, and Emergency) in samples collected from peripheral and central lines.

## MATERIALS AND METHODS

This was a retrospective observational study conducted in the Department of Microbiology at Homi Bhabha Cancer Hospital and Mahamana Pandit Madan Mohan Malaviya Cancer Centre, Varanasi, India. Data were collected for all blood culture samples processed from January 2019 to December 2023 and were subsequently compiled and analysed from August 2024 to February 2025. The study was initiated after obtaining approval from the Institutional Ethics Committee (IEC) of the institute, with approval number (OIEC/11000791/2024/00001). As this was a retrospective laboratory-based study, waiver of informed consent was granted by the IEC. All patient data were anonymised and handled with strict confidentiality in accordance with institutional ethical guidelines.

As this was a time-bound study, no formal sample size calculation was performed. All blood culture samples received and processed during the study period were included in the analysis to ensure complete evaluation of contamination trends. This approach is consistent with previous studies assessing BCC, where all available laboratory records over defined time periods were analysed for trend assessment [10-13].

**Inclusion criteria:** All blood culture specimens received in the microbiology laboratory from January 2019 to December 2023 were included in the study.

**Exclusion criteria:** Blood culture samples with incomplete or missing laboratory records required for analysis were excluded from the study.

### Study Procedure

All blood culture samples received during the study period were processed in the microbiology laboratory using an automated blood culture system (Becton, Dickinson and Company, USA) as per institutional protocol. Positive cultures were evaluated for organism identification and interpreted based on established microbiological criteria, including the number of positive culture bottles/sets, type of organism isolated (true pathogen vs common skin commensals), time to positivity, concordance between paired blood culture bottles, and antimicrobial susceptibility patterns.

The BCC was defined as: Isolation of common skin commensals (e.g., CoNS, *Micrococcus* spp., *Corynebacterium* spp., *Bacillus* spp. other than *Bacillus anthracis*, and *Cutibacterium acnes*) in a single blood culture bottle, or growth of discordant organisms or inconsistent antimicrobial susceptibility patterns in paired blood culture sets [14]. Cultures were considered contaminated if common skin commensals were isolated in a single bottle or if discordant organisms or susceptibility patterns were observed in paired blood culture bottles [15], whereas recovery of the same organism from multiple sets or with consistent susceptibility profiles was interpreted as true BSI.

The contamination rate was calculated as the proportion of contaminated cultures among total blood cultures received during the study period and expressed as a percentage. Data were further analysed annually, department-wise, and according to collection site (peripheral versus central line).

The blood culture which flagged positive and showed growth of contaminants were analysed to assess the BCC rate with respect to department, location and site of sample collection. Results of blood culture were considered to be contaminants grown if common skin commensal microorganisms were grown in culture in only one of the blood culture bottles [16]. In addition, blood cultures were also considered contaminated if both blood culture bottles were positive with different bacterial species or if the isolates had different antibiotic susceptibility patterns. The contamination rate was determined by dividing the number of contaminated cultures by the total number of cultures collected during the defined time duration [9].

Site specific contamination rates were calculated for peripheral and central line blood cultures [4].

## STATISTICAL ANALYSIS

Statistical analysis was performed using R software (version 4). Data were expressed as frequencies and percentages. Differences in annual contamination rates were analysed using the Chi-square test, with p-value <0.05 considered statistically significant.

## RESULTS

During the five-year study period, a total of 24,491 culture samples were received. Of these, 2651 samples tested positive; of these positives, 761 grew contaminants. Of the total contaminants, 529/761 (69.51%) were males and 232/761 (30.49%) were females. The overall blood culture positivity rates and contamination rates were 2651/24491 (10.82%) and 761/24491 (3.11%), respectively.

Over five years, the blood contamination rate was below 5% at all times [Table/Fig-1].

| Year | Total blood culture samples | Positive blood cultures | Positive blood cultures with contaminants | Blood contamination rate (total contaminants/total blood culture) |
|---|---|---|---|---|
| 2019 | 1721 | 253 | 70 | 4.07% |
| 2020 | 3368 | 407 | 74 | 2.20% |
| 2021 | 4628 | 534 | 186 | 4.02% |
| 2022 | 7085 | 690 | 194 | 2.74% |
| 2023 | 7689 | 767 | 237 | 3.08% |

**[Table/Fig-1]:** Annual Blood Culture Contamination (BCC) Rates (2019–2023).

CONS showed a statistically significant variation over the years (p-value =0.047), with an overall increase by 2023. Although GPB counts increased numerically, the trend was not statistically significant (p-value =0.215). *Micrococcus*, which was absent in 2019, began appearing in 2020 (2 cases) and increased significantly (p-value <0.001) to 34 cases in 2023. The p-value (p-value <0.001) showed a statistically significant difference [Table/Fig-2].

On comparison of BCC rates among Disease Management Groups (DMGs), a statistically significant variation in contamination rates across years in paediatric solid tumour and paediatric hemato-lymphoid (p-value <0.001), uro-oncology (p-value =0.030), and adult hematology (p-value <0.001) [Table/Fig-3].

On comparing the locations for sample collection in different years it was found that General ward (p-value =0.002), Haematolymphoid (HL) ward with isolation ward (p-value <0.001), and chemo ward (p-value =0.032) showed statistically significant variation in contamination rates [Table/Fig-4].

On comparing the BCC with respect to the sample collection site in different years, it was found that the peripheral site showed the maximum contamination rate in [Table/Fig-5].

| Organism | 2019 [n=70] | 2020 [n=74] | 2021 [n=186] | 2022 [n=194] | 2023 [n=237] | $\chi^2$ value | p-value |
|---|---|---|---|---|---|---|---|
| CONS | 51 (72.86%) | 45 (60.81%) | 122 (65.59%) | 105 (54.12%) | 147 (62.03%) | 9.63 | 0.047 |
| GPB | 19 (27.14%) | 27 (36.49%) | 43 (23.12%) | 51 (26.29%) | 56 (23.63%) | 5.79 | 0.215 |
| *Micrococcus* species | NA | 02 (2.70%) | 21 (11.29%) | 38 (19.59%) | 34 (14.35%) | 14.21 | <0.001 |

**[Table/Fig-2]:** Trends in common contaminant organisms isolated from blood cultures (2019-2023).
NA: Not applicable, CONS: Coagulase negative Staphylococcus species, GPB: Gram positive bacilli
Statistical test used-Chi-square test for proportions (without continuity correction)

| DMG | 2019 (n=70/1721, 4.07%) | 2020 (n=74/3368, 2.20%) | 2021 (n=186/4628, 4.01%) | 2022 (n=194/7085, 2.74%) | 2023 (n=237/7689, 3.08%) | $\chi^2$ value | p-value |
|---|---|---|---|---|---|---|---|
| Breast service | 10/125 (8%) | 0/44 | 1/11 (9.09%) | 0/03 | 1/3 (33.3%) | - | 0.114 |
| Gynaecology | 4/57 (7.01%) | 4/53 (7.54%) | 0/6 | 0/05 | NA | - | 0.832 |
| Head and neck | 3/103 (2.91%) | 1/69 (1.44%) | 0/29 | 1/103 (0.97%) | 09/145 (6.2%) | - | 0.102 |
| Paed solid tumour, paed hem-lymph | 8/420 (1.9%) | 38/1631 (2.32%) | 134/2946 (4.55%) | 124/3997 (3.10%) | 124/4228 (2.93%) | 24.32 | <0.001 |
| Thoracic | 3/61 (4.91%) | 0/36 | 0/8 | 0/5 | 0/11 | - | 0.554 |
| Uro-oncology | 1/68 (1.47%) | 02/50 (4%) | 1/3 (33.3%) | 0/5 | 0/9 | - | 0.030 |
| Adult haematology | 32/576 (5.55%) | 24/1229 (1.95%) | 44/1408 (3.12%) | 62/2681 (2.31%) | 96/3014 (3.18%) | 22.78 | <0.001 |
| Bone-soft tissue | 02/65 (3.07%) | 01/70 (1.42%) | 5/170 (2.94%) | 05/203 (2.46%) | 06/202 (2.97%) | - | 0.962 |
| Gastrointestinal | 07/234 (2.99%) | 04/171 (2.33%) | 0/19 | 0/12 | 0/10 | - | 0.859 |
| Preventive oncology | 0/1 | NA | 01/01 (100%) | NA | 0/02 | - | 0.135 |
| Neuro-oncology | 0/11 | 0/15 | 0/27 | 02/71 (2.81%) | 01/65 (1.53%) | - | 0.819 |

**[Table/Fig-3]:** Distribution of blood culture contaminants across disease management groups (DMGS) over 5 years.
NA: Not applicable DMG: Disease management group
Statistical test used: Chi-square test for proportions (without continuity correction) or Fisher-Exact test$.

| Location | 2019 (n=70) | 2020 (n=74) | 2021 (n=186) | 2022 (n=194) | 2023 (n=237) | $\chi^2$ value | p-value |
|---|---|---|---|---|---|---|---|
| Gen ward | 37/918 (4.03%) | 35/1538 (2.27%) | 133/2876 (4.62%) | 135/3860 (3.49%) | 173/4350 (3.97%) | 16.64 | 0.002 |
| HL ward + isolation ward | 13/195 (6.6%) | 9/542 (1.66%) | 10/528 (1.89%) | 11/713 (1.54%) | 12/739 (1.62%) | 23.03 | <0.001 |
| Paediatric ward | 06/202 (2.97%) | 15/693 (2.16%) | 19/713 (2.66%) | 20/1091 (1.83%) | 24/1173 (2.04%) | 2.10 | 0.717 |
| Chemo ward | 14/405 (3.45%) | 15/593 (2.52%) | 24/508 (4.72%) | 24/955 (2.51%) | 20/1013 (1.97%) | 10.57 | 0.032 |
| BMT | 0/1 | 0/2 | 0/3 | 04/466 (0.85%) | 08/414 (1.93%) | - | 0.740 |

**[Table/Fig-4]:** Location-wise distribution of Blood Culture Contamination (BCC) (2019-2023).
Statistical test used-Chi-square test for proportions (without continuity correction) or Fisher-Exact test$

| Site | 2019 (n=70) | 2020 (n=74) | 2021 (n=186) | 2022 (n=194) | 2023 (n=237) | $\chi^2$ value | p-value |
|---|---|---|---|---|---|---|---|
| Peripheral | 65/1517 (4.28%) | 52/2347 (2.21%) | 120/2850 (4.21%) | 142/4396 (3.23%) | 195/5176 (3.76%) | 20.37 | <0.001 |
| Central line | 05/204 (2.45%) | 22/1021 (2.15%) | 66/1778 (3.71%) | 52/2689 (1.93%) | 42/2513 (1.67%) | 22.10 | <0.001 |

**[Table/Fig-5]:** Comparison of contamination by blood collection site (peripheral vs central line) over 5 years.
Statistical test used-Chi-square test for proportions (without continuity correction)

## DISCUSSION

The present study demonstrated an overall BCC rate of 3.11%, which remained close to the recommended benchmark of ≤3% proposed by the CLSI 2022 [9]. This finding was comparable with several studies conducted in tertiary care settings, where contamination rates have been reported between 2% and 3.5% [12,17,18]. For instance, studies by Hall KK and Lyman JA, and Self WH et al., have documented contamination rates near the accepted threshold, emphasising the persistent challenge of eliminating contamination despite adherence to protocols [4,18]. These similarities suggest that while standard guidelines are effective in maintaining acceptable limits, further reduction requires targeted and context-specific interventions.

In the present study, the blood culture positivity rate was 10.82%, with a considerable proportion of isolates identified as contaminants. Comparable positivity rates (8-12%) have been reported across multiple tertiary care centres [13,17,19]. However, the proportion of associated isolates increased sharply from five cases in 2019 to a peak of 66 cases in 2021, followed by a gradual decline to 42 cases in 2023. Despite this fluctuation in absolute numbers, the trend remains statistically significant (p-value <0.001), indicating a meaningful change over time.

Over the five-year period, both peripheral and central line–associated isolates showed statistically significant changes (p-value <0.001 for both) in [Table/Fig-5]. For peripheral samples, the number of isolates increased steadily from 65 cases in 2019 to 195 cases in 2023. Although the absolute number of isolates rose, this trend should be interpreted in the context of the increasing total number of samples processed each year (denominators ranging from 1,517 to 5,176). This suggests that the rise may reflect increased sampling, improved detection, or higher patient load rather than a true proportional increase in infection rates. In contrast, central line-

contaminants among positive cultures in the present study remains substantial. Similar findings have been described by Bekeris LG et al., and Weinstein MP who reported contamination contributing to a significant fraction of positive cultures, often ranging from 20% to 40% [10,12]. These observations highlight a consistent issue across healthcare settings, where contamination complicates clinical interpretation and may lead to unnecessary antimicrobial therapy and increased healthcare burden.

Regarding organism distribution, CoNS were the most frequently isolated contaminants in the present study, with a statistically significant increasing trend. This was in agreement with multiple studies that consistently identify CoNS as the predominant blood culture contaminants due to their presence as normal skin flora and their association with indwelling medical devices [20-22]. Gram-positive bacilli, including *Corynebacterium* and *Bacillus* species, were also identified, although without a statistically significant increase. Similar patterns have been reported in earlier studies, where these organisms are commonly linked to environmental contamination or suboptimal aseptic technique [23,24]. Additionally, *Cutibacterium* species have been recognised as low-virulence contaminants, particularly in anaerobic cultures and device-related contexts [25].

The observed increase in CoNS and *Micrococcus* species over the study period should be interpreted with caution, as this trend is likely influenced by multiple clinical and methodological factors. These organisms are well-recognised components of normal skin flora and are among the most common contaminants in blood cultures. Therefore, the increasing isolation rate more likely reflects variations in specimen collection practices, sampling frequency, or laboratory detection methods rather than a true rise in BSIs caused by these organisms.

A notable finding in the present study was the significant increase in *Micrococcus* species over time. Comparable trends have been described in recent studies, where improved diagnostic modalities such as automated identification systems and MALDI-TOF mass spectrometry have enhanced the detection of less commonly reported organisms [26,27]. Other researchers have suggested that increased sampling frequency and heightened surveillance in high-risk populations may also contribute to the rising detection of such commensals [19,28]. However, consistent with existing evidence, the clinical significance of *Micrococcus* remains limited in most cases, and its isolation should be interpreted cautiously in the absence of supporting clinical evidence [29].

From a clinical perspective, the findings of the present study reinforce the multifactorial nature of BCC. Several studies have demonstrated that interventions such as dedicated phlebotomy teams, adherence to standardised aseptic protocols, and continuous staff education significantly reduce contamination rates [30,31]. The higher contamination rates observed in specific patient groups and hospital locations in the present study are consistent with prior reports, where increased workload, frequent sampling, and complex care settings were identified as contributing factors [8,18]. Future efforts should focus on implementing structured quality improvement initiatives, including audit and feedback systems, contamination tracking, and diagnostic stewardship programs. Additionally, further research is needed to develop robust clinical criteria to distinguish contamination from true bacteraemia and to evaluate the cost-effectiveness of preventive strategies in diverse healthcare settings.

### Limitation(s)

This study had certain limitations that should be considered while interpreting the findings. Being a retrospective, single-centre study conducted in a tertiary oncology hospital, the results may not be generalisable to other healthcare settings. The study relied on routinely recorded laboratory and clinical data, limiting assessment of factors such as staff training, adherence to aseptic techniques, skin preparation practices, workload conditions, and detailed catheter-related variables that may influence BCC rates. In addition, classification of contamination was primarily based on microbiological criteria without complete clinical correlation in all cases, which may have led to misclassification of some isolates. Variables such as time-to-positivity and number of culture sets per episode were also not evaluated. Furthermore, as an observational study, causal relationships between contamination rates and contributing factors could not be definitively established.

## CONCLUSION(S)

This study highlights BCC as an important quality indicator for assessing both phlebotomy practices and laboratory performance in healthcare settings. Higher contamination rates in specific departments emphasise the need for targeted training and focused quality improvement interventions in high-risk areas. Strict adherence to aseptic techniques during peripheral venepuncture and proper hub disinfection during central line sample collection are essential to minimise contamination from skin flora. Regular surveillance of contamination rates, along with timely feedback to healthcare workers, can improve compliance with standardised blood collection protocols. Reducing BCC not only enhances diagnostic accuracy but also helps prevent unnecessary antibiotic use, prolonged hospital stays, and increased healthcare costs. Overall, continuous monitoring and department-specific corrective measures can significantly improve patient outcomes and the quality of healthcare delivery.

**Authors' contribution:** AC: Data compilation, analysis, manuscript preparation, critical revision; RS: Conception, analysis, manuscript preparation, critical revision, final approval; SB, VB, AM: Manuscript preparation, critical revision; DR, OM: Data collection;KAS:Data entry and data collection.

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