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Evaluation of Pattern of Bacterial Contamination of Microbiological Laboratory in Relation to Cleaning and Disinfection Practices in a Super Specialization Hospital in Delhi, India

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ABSTRACT

Background: Microbiological laboratories are critical for diagnostic testing and infectious disease surveillance. However, they are prone to microbial contamination, which can impact diagnostic accuracy and patient safety. This study aimed to evaluate the pattern of bacterial contamination in a microbiological laboratory at a super-specialized hospital in Delhi and to develop effective contamination control strategies.

Methods: A cross-sectional study was conducted from August 2022 to December 2022, involving the collection of 4000 surface swab samples from various laboratory areas. Samples were cultured on blood and MacConkey agar, incubated for 24 hours, and bacterial colonies were identified using standard microbiological techniques. Statistical analyses were performed to assess contamination levels and the effectiveness of cleaning protocols.

Results: The culture positivity rate was 39%, with 1563 out of 4000 samples detected as positive for bacteria. Of these, 90.47% had multiple isolates, with the most common being aerobic spore-forming bacilli, *Staphylococcus aureus*, *Escherichia coli*, and *Acinetobacter baumannii*. Laboratory workstations and incubators showed the highest contamination. Cleaning significantly reduced bacterial presence, with a p-value < 0.00001. Specific organisms isolated from different areas included ASB, *Micrococcus*, Coagulase-negative staphylococcus species, *Staphylococcus aureus*.

Conclusion: The study highlights substantial bacterial contamination across laboratory surfaces, underscoring the need for stringent contamination control measures. Key recommendations include routine cleaning and disinfection, staff training on aseptic techniques, environmental monitoring, and strict adherence to sterilization and biosafety protocols. These measures are essential to maintain diagnostic accuracy and safeguard personnel against laboratory-acquired infections.

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Introduction

Microbiological laboratories play a pivotal role in healthcare, serving as epicenters for diagnostic testing, research, and surveillance of infectious diseases. Despite their crucial function, these environments are susceptible to microbial contamination, posing significant challenges to laboratory operations and patient safety (1, 2).

In microbiological laboratories, unique factors contribute to the complexity of microbial contamination. The nature of laboratory work, involving handling diverse microbial cultures and specimens, creates fertile grounds for microbial proliferation. Coupled with suboptimal cleaning practices and lapses in disinfection protocols, these conditions perpetuate the risk of cross-contamination and compromise the accuracy of diagnostic testing (3, 4).

Moreover, the emergence of multidrug-resistant organisms poses a formidable threat to contamination control efforts within laboratory settings. These resilient pathogens, armed with an arsenal of genetic adaptations, challenge conventional approaches to containment and eradication (5, 6).

The importance of appropriate cleaning protocols within microbiological laboratories cannot be overstated. Effective cleaning and disinfection practices are essential for maintaining a safe and sterile laboratory environment, thereby minimizing the risk of laboratory-associated infections and ensuring the accuracy of diagnostic results. Inadequate cleaning protocols can lead to the persistence of microbial contaminants on surfaces and equipment, potentially compromising the integrity of laboratory processes and posing risks to both patients and laboratory personnel (7). While previous studies have examined bacterial contamination in healthcare settings, there is a paucity of research specifically focusing on microbiological laboratories in the context of super-specialty hospitals in developing countries. This study aims to address this gap by systematically assessing contamination levels, identifying sources of microbial colonization, and evaluating the effectiveness of control measures in a super-specialty hospital in Delhi, India.

The primary objectives of this study were to Identify target areas of high contamination within the microbiological laboratory, to Evaluate the effectiveness of current cleaning and disinfection practices, and to develop evidence-based contamination control strategies tailored to the specific needs of the laboratory. By achieving these objectives, this study aims to contribute to the improvement of laboratory hygiene practices and enhance the reliability of microbiological testing in similar healthcare settings.

Materials and Methods

Study Design

This study was conducted from August 2022 to December 2022 to assess the pattern of bacterial contamination within the microbiological laboratory of G.B. Pant Hospital in Delhi, India. The study followed a cross-sectional design, focusing on collecting surface swab samples from various areas within the laboratory. Ethical clearance was not required for this study as it was conducted as part of routine contamination control measures within the hospital. The study was conducted with the utmost consideration for safety and compliance with standard practices. All procedures were performed in accordance with the hospital's infection control policies to ensure that no harm came to patients or laboratory personnel (2, 3).

Sample collection

A total of 4000 surface swab samples were collected from different areas of the microbiological laboratory during the study period. The sampling was stratified to ensure representation from key areas prone to microbial

contamination. Specifically, 800 surface swab samples were collected from laboratory workstations, 800 from incubators, and 400 each from laboratory tables, sterile fridges, unsterile fridges, hot air ovens, autoclaves, and media room workstations (4).

Sampling procedure

Surface swab samples were collected using sterile cotton-tipped swabs moistened with sterile saline solution. Sampling was performed by systematically swabbing the surfaces of interest, ensuring coverage of the entire area. Each swab was then labeled with a unique number to track sample location and processing (4).

Processing of swab samples

Upon collection, swab samples were processed immediately. In the laboratory, each swab sample was streaked onto blood and MacConkey agar and incubated for 24 hours. After the incubation period, plates were examined for the presence of bacterial colonies and identification was done using a battery of biochemical testes and VITEK 2 system (bioMérieux) (4, 7).

Statistical analysis

Data were analyzed using SPSS version 25.0. Descriptive statistics were used to summarize the distribution of bacterial isolates across different laboratory areas. Chi-square tests were employed to assess the effectiveness of cleaning protocols by comparing bacterial presence before and after cleaning. A p-value <0.05 was considered statistically significant.

Results

Of the 4000 surface swab samples collected, 1563 (39%) were culture-positive, while 2437 (60.93%) samples were culture-negative. Multiple bacterial isolates were obtained from 3619 swabs (90.47%), while only 381 swabs (9.53%) yielded a single bacterial isolate.

The predominant isolates identified were aerobic spore-bearing bacilli (ASB) (310/4000) *Staphylococcus aureus* (257/4000), *Escherichia coli* (190/4000), *Acinetobacter baumannii* (187/4000).

Laboratory workstations and incubators showed the highest levels of contamination. Table 2 details the distribution of bacterial isolates across different areas of the microbiology laboratory.

Surface swab samples from laboratory workstations were taken at different time intervals to assess the effectiveness of cleaning protocols. Table 3 shows the bacterial isolation rates before culture plate reading (9 am), after culture plate reading (11 am), after sample processing (1 pm), and after cleaning with 5% sodium hypochlorite solution (4 pm).

A marked decrease in bacterial isolation was observed after cleaning of laboratory workstations, which was statistically significant (Table 4).

Discussion

The findings of our study revealed significant insights into the patterns of bacterial contamination within the microbiological laboratory of of G.B. Pant Hospital in Delhi, India. With a total of 4000 surface swab samples collected from various areas of the laboratory, our analysis provides a comprehensive assessment of microbial contamination levels and the distribution of bacterial isolates.

Table 1. Presents the complete distribution of bacterial isolates from all surface swab samples.

Organisms isolated	Total
Aerobic spore-forming bacilli	310
Acinetobacter baumannii	187
Coagulase-negative *Staphylococcus* species	160
Escherichia coli	190
Klebsiella pneumoniae	178
Micrococcus	135
Pseudomonas aeruginosa	146
Staphylococcus aureus	257
ASB: Aerobic spore-forming bacilli CONS: Coagulase-negative *Staphylococcus* species	

Table 2. The distribution of bacterial isolates across different areas of the microbiology laboratory.

Organisms isolated	Laboratory work stations	Tables	Incubators	Fridge (Sterile)	Fridge (Unsterile)	Hot air oven	Autoclave	Media room workstation
No growth	301	32	403	400	101	400	400	400
ASB	113	81	84	0	32	0	0	0
Micrococcus	43	18	31	0	43	0	0	0
CONS	54	30	22	0	54	0	0	0
Staphylococcus aureus	79	52	87	0	39	0	0	0
Acinetobacter baumannii	43	48	53	0	43	0	0	0
Escherichia coli	61	59	39	0	31	0	0	0
Klebsiella pneumoniae	59	43	47	0	29	0	0	0
Pseudomonas aeruginosa	47	37	34	0	28	0	0	0
ASB: Aerobic spore-forming bacilli CONS: Coagulase-negative *Staphylococcus* species								

Table 3. The bacterial isolation rates taken at different time intervals.

Organisms isolated	Before plate reading (9 am)	After plate reading (11 am)	After processing (1 pm)	After cleaning (4 pm)
No growth	72	25	16	188
ASB	34	36	33	10
Micrococcus	21	11	9	2
CONS	8	18	28	0

Staphylococcus aureus	27	25	27	0
Acinetobacter baumannii	5	20	18	0
Escherichia coli	3	24	34	0
Klebsiella pneumoniae	7	19	33	0
Pseudomonas aeruginosa	3	22	22	0
ASB: Aerobic spore-forming bacilli CONS: Coagulase-negative *Staphylococcus* species				

Table 4. Comparison of bacterial isolates before and after cleaning of laboratory workstations.

	Before cleaning	After cleaning	p-value
No growth	113	188	<0.00001
Bacterial growth	487	12	

The culture positivity rate of 39% indicates a substantial presence of bacterial contaminants across different surfaces within the laboratory. This underscores the importance of robust contamination control measures to mitigate the risk of laboratory-associated infections and ensure the reliability of diagnostic testing (3, 4). Moreover, the predominance of multiple bacterial isolates from swabs (90.47%) highlights the polymicrobial nature of contamination, emphasizing the complexity of microbial dynamics within laboratory environments (2).

Among the bacterial isolates identified, aerobic spore-bearing bacilli (ASB), *Staphylococcus aureus*, *Escherichia coli*, and *Acinetobacter baumannii* were the most prevalent as shown in table 1. These findings align with previous research highlighting the ubiquitous nature of these microorganisms in healthcare settings (3, 4). The presence of opportunistic pathogens such as *Staphylococcus aureus* and *Acinetobacter baumannii* underscores the importance of targeted interventions to reduce microbial contamination and prevent laboratory-associated infections (5, 6). Analysis of swab culture reports from different areas of the microbiological laboratory revealed variations in contamination levels. Laboratory workstations and incubators exhibited higher rates of contamination compared to other areas shown in table 2, likely due to the frequent handling of samples and microbial cultures (7). These findings are consistent with previous studies highlighting the role of high-touch surfaces in microbial transmission (3, 7-9).

The sources of contamination in a microbiological laboratory are multifaceted and include:

i. Airborne Contaminants: Microbial contaminants can be introduced into the laboratory environment through the air, especially during procedures that generate aerosols. Proper ventilation and the use of biological safety cabinets can help mitigate this risk (1, 9-10).

ii. Inappropriate Sample Collection: Poor technique during sample collection can lead to contamination. Training laboratory personnel on proper aseptic techniques is crucial (8).

iii. Spills: Accidental spills of cultures or reagents can lead to localized contamination. Immediate and proper cleanup protocols are necessary to prevent the spread of contaminants (9).

iv. Equipment and Dust: Contaminants can persist on laboratory equipment and in dust particles. Regular cleaning and maintenance of equipment are essential (2).
v. Improper Sterilization: Failure to adequately sterilize laboratory tools and surfaces can lead to the persistence and spread of contaminants. Ensuring proper sterilization techniques are followed is critical (7).
vi. Cross-Contamination: Handling multiple samples without proper decontamination between procedures can lead to cross-contamination. Strict adherence to contamination control protocols is necessary to prevent this (4).

An effective and robust contamination control program in clinical microbiology is essential to prevent laboratory infections and ensure the diagnostic accuracy of culture reports. This program should include:
i. Routine Cleaning and Disinfection: Adherence to evidence-based cleaning protocols, as demonstrated by the significant decrease in bacterial isolation post-cleaning, is crucial. Regular and thorough cleaning of all laboratory surfaces and equipment should be mandatory (4, 7)
ii. Training and Education: Continuous training of laboratory staff on contamination control practices, aseptic techniques, and the importance of personal protective equipment (PPE) is essential. This includes training staff to adhere to standard precautions, follow good microbiological lab practices, handle specimens and equipment correctly, and maintain awareness about lab safety and a contamination-free environment (2).
iii. Environmental Monitoring and Surveillance: Regular monitoring of the laboratory environment for microbial contamination can help identify problem areas and evaluate the effectiveness of cleaning protocols. This includes maintaining a cleaning checklist in the lab, signed by the technical supervisor daily at the end of the day, compliance surveillance for lab staff, regular environmental surveillance, and culture checks on surface contamination (4, 7).
iv. Proper Ventilation: Ensuring adequate ventilation in the laboratory to reduce the concentration of airborne contaminants (1, 10) .
v. Immediate Spill Response: Implementing protocols for the immediate cleanup of spills to prevent the spread of contaminants (9).
vi. Sterilization Protocols: Adhering to strict sterilization protocols for all laboratory tools and surfaces (7).
vii. Use of Biosafety Cabinets: Processing samples within biosafety cabinets to prevent airborne contamination and protect laboratory personnel (10).
viii. Compliance with Standard Precautions: Ensuring all laboratory personnel comply with standard precautions, including the use of gloves, masks, and other protective gear (2).
ix. Proper Disposal of Laboratory Waste: Following Biomedical Waste (BMW) guidelines for the disposal of laboratory waste to prevent environmental contamination and potential infections (10).
x. Routine Monitoring and Surveillance Strategies: Implementing routine monitoring and surveillance strategies to maintain a contamination-free laboratory. This includes the maintenance of a cleaning checklist in the lab, signed by the technical supervisor daily at the end of the day, compliance surveillance for lab staff, regular environmental surveillance, and culture checks on surface contamination. Identifying potential sources of contamination and taking timely corrective actions are also critical (4, 7).
xi. Quality Control Measures: Implementing proper quality control measures to detect cross-contamination and keep check on erroneous results (5).
xii. Restricting Entry and Traffic Flow: Restricting entry into the laboratory to control traffic flow and reduce the risk of contamination (9).

xiii. Efficient Workflow: Ensuring an efficient workflow to minimize the handling of samples and reduce the risk of cross-contamination (7).

Conclusion

It is paramount to recognize that the accuracy and reliability of culture reports are intrinsically linked to the level of contamination present in the laboratory environment. Laboratory-acquired infections pose significant risks to laboratory staff, emphasizing the need for rigorous contamination control measures. To ensure the highest standards of diagnostic accuracy and personnel safety, contamination control must be prioritized through the implementation of a comprehensive and robust contamination control plan that includes routine surface monitoring, strict compliance with infection control measures, robust cleaning and disinfection protocols, regular equipment maintenance, and ultimately contributing to better patient care and safety.

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Ethics approval and consent to participate

Not needed.

Conflict of interest

None.

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