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EVALUATION OF THE PATTERN OF BACTERIAL CONTAMINATION IN MICROBIOLOGICAL LABORATORIES IN RELATION TO CLEANING AND DISINFECTION PRACTICES IN A MAJOR SPECIALIZED HOSPITAL IN SAUDI ARABIA.

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Abstract

Background: Microbiology laboratories are critical to modern healthcare but remain vulnerable to bacterial contamination due to constant handling of infectious materials. Inadequate cleaning and disinfection practices can compromise diagnostic accuracy and pose serious risks to laboratory personnel.

Objectives: This study aimed to evaluate the pattern of bacterial contamination in relation to cleaning and disinfection protocols in a microbiology laboratory within a major specialized hospital in Saudi Arabia.
Methods: A cross-sectional study was conducted from September to December 2024. A total of 3,200 surface swab samples were collected from high-touch areas, including workstations, incubators, and equipment handles. Samples were processed using standard microbiological techniques and analyzed via biochemical testing and the VITEK 2 system. The effectiveness of cleaning with 5% sodium hypochlorite was assessed by sampling at different time intervals. Statistical analysis was conducted using SPSS version 25.0.
Results: Of the 3,200 samples, 40% (n=1,280) were culture positive. The most frequently isolated organisms were aerobic spore-forming bacilli (n=248), Staphylococcus aureus (n=210), Escherichia coli (n=152), and Acinetobacter baumannii (n=150). Workstations and incubators showed the highest contamination rates. Polymicrobial growth was observed in over 90% of positive samples. Bacterial recovery significantly decreased after cleaning, demonstrating the effectiveness of disinfection ($p < 0.00001$).
Conclusion: The findings underscore the importance of consistent and effective cleaning protocols in reducing microbial contamination in laboratory settings. A comprehensive contamination control strategy—including routine disinfection, staff training, environmental monitoring, and strict adherence to biosafety practices—is essential to ensure diagnostic reliability and laboratory safety.

Keywords: Bacterial contamination, microbiology laboratory, cleaning practices, disinfection, hospital-acquired infection, Saudi Arabia, infection control

INTRODUCTION

Microbiology laboratories play a pivotal role in modern healthcare, serving as essential centers for diagnostic testing, disease surveillance, and medical research. Their accuracy and reliability are fundamental to patient care and infection control strategies [1,2]. However, due to the constant handling of microbial cultures and clinical specimens, these laboratories are particularly susceptible to bacterial contamination [3]. This not only poses operational challenges but also poses potential threats to both laboratory staff and patient safety [3,4].
The complexity of contamination control in these environments arises from a combination of contributing factors [5]. Suboptimal cleaning procedures, irregular disinfection practices, and frequent handling of high-risk biological specimens increase the likelihood of cross-contamination [6]. These conditions can negatively impact the integrity of diagnostic results and increase the risk of laboratory-acquired infections [3,6].
The situation is further complicated by the growing threat of multidrug-resistant organisms (MDROs). Equipped with powerful genetic defenses, these pathogens can persist on various surfaces such as laboratory benches, doorknobs, medical devices, and even personal items like cell phones and keyboards for extended periods [7]. Their ability to form biofilms and survive in varying environmental conditions, such as temperature, humidity, and the presence of organic matter, makes it extremely difficult to eliminate using conventional cleaning protocols [8].
The consequences of poor contamination control extend far beyond the laboratory. Hospital-acquired infections (HAIs), often fueled by contaminated surfaces and equipment, are a major concern in healthcare facilities [9]. The mortality rate following HAIs varies widely, ranging from 4% to 33%, depending on the patient population and healthcare setting, highlighting the potentially life-threatening impact of microbial contamination [10]. Furthermore, HAIs contribute to increased morbidity, prolonged hospital stays, re-admissions, and increased healthcare costs.
Despite the known risks, many hospital surfaces, especially those considered "non-critical" are often overlooked during routine cleaning. This neglect allows dangerous pathogens to persist in the environment, increasing the likelihood of transmission to healthcare workers, patients, and even visitors [11]. Although previous studies have explored bacterial contamination in general hospital environments, there is limited research focused specifically on microbiological laboratories within major specialized hospitals in Saudi Arabia.
This study aims to fill that gap by evaluating bacterial contamination patterns in relation to current cleaning and disinfection practices in a Major Specialized Hospital in Saudi Arabia.

STUDY OBJECTIVES

The primary objectives of this study are:

- To identify high-risk areas within microbiological laboratories most susceptible to bacterial contamination.

- To evaluate the effectiveness of current cleaning and disinfection protocols.
- To analyze the types of bacterial strains isolated from different surfaces and their resistance patterns.
- To propose evidence-based recommendations specifically designed to improve contamination control in similar laboratory environments.
- Study design and setting
- MateRIals and Methods

MATERIALS AND METHODS

STUDY DESIGN AND SETTING

This cross-sectional descriptive study was conducted between September and December 2024 in the microbiology laboratory of a Major Specialized Hospital in Saudi Arabia. It aimed to assess bacterial contamination patterns in relation to routine cleaning and disinfection practices. Sampling targeted various high-touch zones, including work surfaces, benches, and equipment handles. Observational data were also collected, covering disinfectant type and concentration, number of cleaning strokes, time since last cleaning, and cleaning cloth hygiene. All data were recorded using a standardized form to ensure consistency.

Ethical approval was not required, as the study was part of routine infection control monitoring, involved no patient data, and followed all relevant safety protocols.

BACTERIOLOGICAL SAMPLING

A total of 3200 surface swab samples were collected from different areas of the microbiology laboratory during the study. Sampling focused on high-touch and high-risk zones such as workbenches, equipment handles, and door knobs. Sterile, pre-moistened swabs were used following standard procedures, and samples were collected at consistent times to align with routine cleaning schedules. All swabs were quickly sent for analysis to ensure accuracy. This method helped reflect real contamination levels in relation to cleaning and disinfection practices across the lab.

SAMPLING PROCEDURE

Surface swab samples were collected using sterile cotton-tipped swabs pre-moistened with sterile saline solution. Sampling was carried out by systematically swabbing targeted surfaces such as workbenches, equipment handles, and other frequently touched areas, ensuring complete coverage of each selected site. Each swab was labeled with a unique identification code to document the sampling location and to facilitate accurate tracking during microbiological processing and analysis [12].

PROCESSING OF SWAB SAMPLES

All swab samples were processed immediately after collection. In the laboratory, each swab was streaked onto blood agar and MacConkey agar plates, then incubated at 37°C for 24 hours. After incubation, the plates were inspected for bacterial growth. Identified colonies were further analyzed using standard biochemical tests, and confirmation of bacterial species was done using the VITEK 2 system (bioMérieux), to ensure accurate identification [12,13].

STATISTICAL ANALYSIS

Data were analyzed using SPSS software (version 25.0). Descriptive statistics were used to present the frequency and distribution of bacterial isolates across different areas of the laboratory. To assess the effectiveness of cleaning and disinfection practices, Chi-square tests were used to compare bacterial presence before and after cleaning. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 3,200 surface swab samples were collected across different areas of the microbiology laboratory. Of these, 1,280 samples (40%) were culture-positive, while 1,920 samples (60%) showed no bacterial growth. The most isolated organisms were aerobic spore-forming bacilli (248 isolates), followed by Staphylococcus aureus (210), Escherichia coli (152), and Acinetobacter baumannii (150).

Table 1.Distribution of bacterial isolates from all surface swab samples (N = 3200)

Organism Isolated	Number of Isolates
Aerobic spore-forming bacilli (ASB)	248
Acinetobacter baumannii	150
Coagulase-negative Staphylococcus (CONS)	128
Escherichia coli	152
Klebsiella pneumoniae	140
Micrococcus spp.	108

Pseudomonas aeruginosa	120
Staphylococcus aureus	210

Most of the culture-positive samples yielded more than one bacterial species, with 2,902 swabs (90.7%) showing polymicrobial growth, and only 298 swabs (9.3%) yielding a single isolate.
Regarding contamination levels across different laboratory zones, Table 2 displays the distribution of bacterial isolates by surface type. The highest rates of contamination were observed on workstations and incubators, while surfaces such as sterilized equipment (e.g., autoclaves and ovens) showed minimal or no growth.

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

Organism	Workstations	Tables	Incubators	Sterile Fridge	Unsterile Fridge	Hot Air Oven	Autoclave	Media Room WS
No growth	241	25	315	320	81	320	320	320
ASB	89	64	68	0	26	0	0	0
Micrococcus	33	14	25	0	33	0	0	0
CONS	42	23	17	0	42	0	0	0
Staphylococcus aureus	63	41	69	0	31	0	0	0
Acinetobacter baumannii	34	38	43	0	35	0	0	0
Escherichia coli	50	46	32	0	26	0	0	0
Klebsiella pneumoniae	48	34	38	0	22	0	0	0
Pseudomonas aeruginosa	38	30	28	0	20	0	0	0

To assess the effectiveness of cleaning practices, swabs were collected from workstations at four-time intervals: before culture plate reading (9:00 am), after plate reading (11:00 am), after sample processing (1:00 pm), and after cleaning with 5% sodium hypochlorite (4:00 pm). The isolation rates at each time point are detailed in Table 3.

Table 3.Bacterial isolation rates at different time intervals from laboratory workstations

Organism	9:00 am (Before Plate Reading)	11:00 am (After Plate Reading)	1:00 pm (After Processing)	4:00 pm (After Cleaning)
No growth	62	21	13	162
ASB	26	28	25	6
Micrococcus	16	9	7	1
CONS	6	14	21	0
Staphylococcus aureus	20	19	22	0
Acinetobacter baumannii	4	15	14	0
Escherichia coli	2	19	26	0
Klebsiella pneumoniae	5	15	26	0
Pseudomonas aeruginosa	2	18	19	0

A notable reduction in bacterial load was observed after the final cleaning step. This improvement in surface hygiene was found to be statistically significant ($p < 0.00001$), as shown in the comparative data in Table 4.

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

Status	Before Cleaning (1:00 pm)	After Cleaning (4:00 pm)	p-value
No growth	13	162	< 0.00001
Bacterial growth	187	10	

DISCUSSION

This study evaluated the bacterial contamination patterns in a microbiology laboratory of a specialized hospital in Saudi Arabia, focusing on the relationship between contamination levels and cleaning practices. Of the 3,200 surface swab samples collected, 40% were culture-positive, reflecting a considerable level of microbial contamination across laboratory surfaces and highlighting the need for strict environmental hygiene.

Notably, over 90% of the positive samples contained multiple bacterial species, suggesting a polymicrobial contamination environment, which is consistent with similar findings in high-use laboratories [14]. The most common isolates included aerobic spore-forming bacilli, Staphylococcus aureus, Escherichia coli, and Acinetobacter baumannii [15]. These organisms are persistent in healthcare settings and are known for their potential to cause opportunistic infections [14,16]. Their presence in a controlled environment suggests possible lapses in cleaning or protocol adherence. Workstations and incubators had the highest contamination rates, likely due to frequent handling and specimen processing in these zones. This reinforces the importance of prioritizing high-touch surfaces in routine cleaning efforts [17,18].

A key finding was the sharp decline in bacterial recovery after disinfecting with 5% sodium hypochlorite, especially on workstations. Sampling at different time points during the day showed that contamination increased with activity but decreased significantly after cleaning [19]. While cleaning procedures were effective, the presence of bacteria before cleaning highlights gaps in frequency or technique. This indicates the need to reinforce compliance and ensure consistent application of disinfection protocols [20]. Contamination sources may include airborne particles, poor aseptic technique, spills, dust, improper sterilization, or cross-contamination during sample handling [21]. Therefore, a comprehensive strategy is essential to reduce microbial presence in the lab environment.

This should involve strict cleaning schedules, staff training, regular environmental monitoring, proper use of biosafety cabinets, effective ventilation, prompt spill response, and adherence to sterilization and waste disposal protocols. Limiting unnecessary access, optimizing workflow, and applying internal quality control can further enhance safety [22].

Overall, the results of this study reinforce the need for proactive and well-monitored infection control strategies in laboratory environments. Not only do these practices safeguard the health of laboratory personnel, but they also contribute directly to the accuracy, reliability, and quality of microbiological diagnostic services.

CONCLUSION

This study highlights the presence of significant bacterial contamination within the microbiology laboratory of a specialized hospital, with a culture positivity rate of 40% among 3,200 surface swab samples. The frequent recovery of multiple organisms, including clinically relevant pathogens such as Staphylococcus aureus and Acinetobacter baumannii, reflects the potential risk of laboratory-acquired infections and diminished diagnostic reliability. Although routine cleaning with 5% sodium hypochlorite is effective, the persistence of contamination prior to disinfection suggests gaps in cleaning consistency and technique. These findings underscore the urgent need for stricter adherence to cleaning protocols, enhanced staff training, and continuous environmental monitoring. Implementing a systematic, multi-layered contamination control strategy is essential to ensure a safe working environment and maintain the quality and accuracy of microbiological diagnostics.

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