Original Article

Patterns of Microorganisms Present on Non-Critical Equipment and Environmental Surfaces in Selected Medical Microbiology Laboratory Units of a Tertiary Hospital in North-Central Nigeria

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ABSTRACT

Laboratory equipment and environmental surfaces can act as reservoirs for pathogenic microorganisms, facilitating cross-contamination and increasing the risk of healthcare-associated infections. This study assessed the diversity of microorganisms persisting on selected non-critical equipment and environmental surfaces in Benue State University Teaching Hospital, Makurdi, Nigeria. A cross-sectional study was conducted using swab samples collected from frequently used laboratory equipment and environmental surfaces. Samples were cultured on appropriate microbiological media, and isolates were identified using standard microbiological techniques based on cultural, morphological, and biochemical characteristics. Total aerobic plate counts (TAPC) were determined to assess the level of microbial contamination on each sampled surface. Study findings showed that a total of eight microbial species were isolated from the sampled equipment and surfaces, namely: *Staphylococcus aureus*, *Streptococcus pyogenes*, *Escherichia coli*, *Klebsiella pneumoniae*, *Salmonella typhi*, *Pseudomonas aeruginosa*, *Candida albicans*, and *Aspergillus niger*. Laboratory tables/benches harboured the highest diversity of microbial contaminants. The mean TAPC ranged from 1.3 x 10^5 to 3.7 x 10^5 CFU/mL. The highest counts were recorded on tables (3.7 x 10^5 CFU/mL), sinks (3.5 x 10^5 CFU/mL), and wire loops (3.2 x 10^5 CFU/mL), while autoclaves and scissors exhibited the lowest counts (1.3 x 10^5 CFU/mL each). The isolation of both bacterial and fungal pathogens from frequently touched surfaces and equipment indicates substantial environmental contamination within the laboratory setting. The study demonstrated significant microbial contamination of laboratory equipment and environmental surfaces. Frequently used work surfaces and moist environments exhibited the highest microbial loads and diversity of contaminants. These findings underscore the importance of routine environmental surveillance, effective cleaning and disinfection procedures, proper sterilization of reusable instruments, and strict adherence to infection prevention and control measures to minimize microbial transmission, and promote a safer working environment for healthcare workers and patients.

Keywords: Environmental surfaces; Healthcare-associated infections; Hospital; Infection prevention and control; Non-critical equipment

INTRODUCTION

Healthcare-associated infections (HAIs) remain a major challenge to patient safety worldwide, contributing significantly to morbidity, mortality, prolonged hospitalization, and increased healthcare costs. The World Health Organization estimates that hundreds of millions of patients are affected by HAIs annually, with a disproportionately higher burden in low- and middle-income countries where infection prevention and control (IPC) measures are often inadequate.[1] A recent systematic review further emphasized that environmental contamination continues to play an important role in the transmission of healthcare-associated pathogens despite advances in healthcare delivery and infection prevention strategies.[2]

The healthcare environment serves as an important reservoir for a wide range of microorganisms capable of causing disease in susceptible individuals. Environmental surfaces and medical equipment can become contaminated through contact with patients, healthcare workers, visitors, contaminated specimens, and aerosols generated during

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routine clinical and laboratory procedures. Many microorganisms can survive on inanimate surfaces for prolonged periods, thereby facilitating their transmission through direct contact or indirectly via the hands of healthcare workers.[3,4] Consequently, environmental contamination has become a critical focus of infection prevention and control programmes worldwide.

According to the Spaulding classification, non-critical equipment comprises items that come into contact with intact skin but not mucous membranes. Although such equipment poses a lower risk of infection than critical and semi-critical devices, inadequate cleaning and disinfection may permit the persistence and spread of potentially pathogenic microorganisms. Frequently touched surfaces and equipment such as tables, sinks, benches, door handles, trays, refrigerators, laboratory instruments, and reusable devices are particularly susceptible to contamination because of repeated human contact and continuous exposure to microbial sources.[5] These contaminated surfaces may subsequently serve as reservoirs for pathogens and contribute to the transmission of healthcare-associated infections within healthcare facilities.

Several bacterial and fungal species commonly implicated in healthcare-associated infections have been isolated from hospital environments. These include *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Klebsiella pneumoniae, Streptococcus pyogenes,* and opportunistic fungi such as *Candida albicans and Aspergillus species*.[2,6] The presence of these organisms on hospital surfaces is particularly concerning because many possess virulence factors that facilitate environmental persistence and may exhibit resistance to commonly used antimicrobial agents. Their survival on non-critical equipment and environmental surfaces increases the likelihood of cross-contamination and subsequent infection among patients, especially those who are immunocompromised or undergoing invasive procedures.

Globally, studies continue to demonstrate extensive microbial contamination of healthcare environments. A recent review of the influence of the physical environment on healthcare-associated infections reported that contaminated surfaces and equipment remain important contributors to pathogen transmission and highlighted environmental hygiene as a critical component of infection prevention programmes.[2] Similarly, studies from Europe, North America, and Asia have consistently documented the recovery of clinically significant microorganisms from non-critical equipment and frequently touched surfaces, reinforcing the role of environmental reservoirs in sustaining healthcare-associated infections.[2,7]

In Africa, environmental contamination of healthcare facilities remains a significant concern because of increasing antimicrobial resistance and challenges in implementing optimal infection prevention practices. A multicentre study conducted in Kenya identified widespread contamination of hospital environments with multidrug-resistant bacteria across multiple departments and concluded that environmental reservoirs pose an elevated risk of healthcare-associated infections.[8] In a Ghanaian emergency unit, study findings revealed that standard hospital cleaning practices were ineffective. Importantly, the presence of multidrug-resistant (MDR) bacteria on clinical surfaces and oxygen accessories remained nearly identical both before and after routine disinfection, pointing directly to systemic failures in the facility's decontamination protocols.[9]

In Nigeria, healthcare-associated infections continue to represent a significant public health concern. A recent systematic review and meta-analysis reported a substantial burden of HAIs in Nigerian healthcare facilities and emphasized the need for strengthening infection prevention and control measures nationwide.[10] Several Nigerian studies have documented microbial contamination of hospital environments and non-critical equipment. One study reported the presence of pathogenic aerobic bacteria on non-critical surfaces within paediatric wards of a tertiary hospital, identifying organisms such as *Staphylococcus aureus* and *Escherichia coli* on frequently touched surfaces.[11] Another study demonstrated significant microbial contamination of hospital appliances, taps, doorknobs, and theatre equipment in a specialist hospital in southwestern Nigeria, highlighting the role of environmental reservoirs in healthcare-associated infections.[12] In the Niger Delta region, a study documented microbial contamination of non-critical medical equipment in the emergency department of a tertiary hospital, emphasizing the need for routine environmental surveillance and strict disinfection practices.[13] Furthermore, fungal contamination of hospital water distribution systems has been reported in Nigerian tertiary healthcare facilities, demonstrating the diversity of microorganisms capable of persisting within healthcare environments and potentially contributing to healthcare-associated infections.[14]

Clinical microbiology laboratories and specimen collection areas represent unique healthcare environments because they routinely handle potentially pathogenic microorganisms during specimen processing, culture, identification, and storage. Frequent contact with laboratory benches, work tables, sinks, refrigerators, autoclaves, trays, scissors, wire loops, and door handles create opportunities for environmental contamination and microbial persistence. In addition, high-traffic patient service areas such as phlebotomy units and general outpatient clinics may facilitate microbial dissemination through repeated human contact. Despite the importance of environmental hygiene and laboratory biosafety, there is limited information regarding the diversity of microorganisms persisting on non-critical equipment and environmental surfaces within diagnostic laboratory facilities in Nigeria.

Benue State University Teaching Hospital (BSUTH), Makurdi, is a major tertiary healthcare institution serving Benue State and its neighbours. The high volume of clinical specimens processed within its microbiology laboratory and the continuous interaction among laboratory personnel, healthcare workers, patients, and

visitors, create opportunities for environmental contamination and microbial transmission. However, information on the diversity of microorganisms persisting on non-critical equipment and environmental surfaces within the hospital remains limited. Therefore, this study aimed to determine the diversity of microorganisms persisting on selected non-critical equipment and environmental surfaces in Benue State University Teaching Hospital, Makurdi, Nigeria. The findings will provide evidence for strengthening environmental hygiene, laboratory biosafety practices, and infection prevention and control programmes aimed at reducing the risk of healthcare-associated infections and occupational exposure to pathogenic microorganisms.

MATERIALS AND METHODS

Study Area and Setting

The study was conducted in Makurdi, the capital of Benue State, located in the North-Central region of Nigeria. Makurdi lies within the Benue valley along the banks of River Benue, with the town physically divided into north and south banks. The study setting was the Medical Microbiology Laboratory and General Outpatient Department (GOPD) clinic of Benue State University Teaching Hospital (BSUTH), Makurdi. BSUTH Makurdi, is a tertiary healthcare institution that is a major training and research centre for medical and allied health professionals. It serves as a referral centre and provides specialized diagnostic and therapeutic services to patients within Benue and neighbouring states. The Medical Microbiology Laboratory is responsible for the diagnosis and monitoring of infectious diseases and consists of several functional units, including the bacteriology laboratory, serology laboratory, media preparation laboratory, and phlebotomy unit, which handle a high volume of clinical specimens.

Study Design and Population

A hospital-based cross-sectional study was carried out to determine the diversity of microorganisms persisting on non-critical equipment and environmental surfaces within specific areas of Benue State University Teaching Hospital (BSUTH), Makurdi. The study population comprised non-critical laboratory equipment and frequently touched environmental surfaces within the GOPD clinic, phlebotomy unit, Medical Microbiology Laboratory and associated laboratory units of BSUTH, Makurdi. The non-critical equipment and environmental surfaces included tables, sinks, refrigerator handles, autoclaves, scissors, wire loops, trays, door handles, and laboratory benches.

Sampling Technique

A purposive sampling technique was employed to select non-critical equipment and environmental surfaces with frequent human contact and potential for microbial contamination. Sampling sites were chosen from the bacteriology, serology, media preparation, and Chest Clinic laboratories; GOPD clinic and phlebotomy unit.

Sample Collection Sites

Samples were collected from selected non-critical laboratory equipment and frequently touched environmental surfaces located within various units of the Medical Microbiology Laboratory complex, GOPD clinic and phlebotomy unit of BSUTH, Makurdi. The selected sampling sites included tables, sinks, refrigerator handles, autoclaves, scissors, wire loops, trays, door handles, and laboratory benches. These sites were selected because they are frequently handled by laboratory personnel during routine diagnostic and specimen-processing activities, making them potential reservoirs for the persistence and transmission of microorganisms within the healthcare environment.

Specifically, table surfaces were sampled from the bacteriology laboratory, serology laboratory, GOPD, and Chest Clinic laboratory. Sink surfaces were sampled from the bacteriology laboratory, serology laboratory, and Chest Clinic laboratory. The handle of the laboratory refrigerator located in the media preparation laboratory was sampled. Three autoclaves situated in the media preparation laboratory were sampled from both their internal and external surfaces.

Other equipment sampled included scissors from the bacteriology and serology laboratories, wire loops from the bacteriology and media preparation laboratories, and trays from the serology and media preparation laboratories. Door handles were sampled from the phlebotomy unit, bacteriology laboratory, and serology laboratory, while laboratory benches were sampled from the bacteriology laboratory, media preparation laboratory, and Chest Clinic laboratory.

Sampling sites and non-critical equipment/surfaces sampled

Unit	Equipment/surface sampled
Bacteriology Laboratory	Tables, sinks, scissors, wire loops, door handles, benches
Serology Laboratory	**Tables, sinks, scissors, trays, door handles**
Media Preparation Laboratory	Refrigerator handle, autoclaves (internal and external surfaces), wire loops, trays, benches
Chest Clinic Laboratory	**Tables, sinks, benches**
GOPD clinic	Tables
Phlebotomy Unit	**Door handles**

Sample Collection Procedure

Samples were collected from selected hospital surfaces and medical equipment using sterile swab sticks. Each sterile swab was moistened with sterile normal saline before use. The moistened swabs were then used to aseptically swab the surfaces and medical equipment. After collection, each swab was immediately placed into a separately labelled sterile test tube. The samples were transported to the Microbiology Laboratory of Benue State University Teaching Hospital, Makurdi, within one hour of collection and processed immediately upon arrival to ensure the viability of microorganisms and minimize contamination.

Isolation and Cultivation of Microorganisms

Microorganisms were isolated by inoculating each swab sample onto Nutrient Agar (Titan Biotech Ltd., India) for bacterial isolation and Potato Dextrose Agar (Titan Biotech Ltd., India) for fungal isolation. The inoculation was carried out using the streak plate technique to obtain discrete colonies. The inoculated plates were incubated aerobically at 37°C for 24 hours. Following incubation, the plates were examined for microbial growth based on the

presence of visible colonies. Total microbial load was determined by counting the number of visible colonies on each plate. Distinct colonies were selected and sub-cultured as necessary to obtain pure isolates for further characterization and identification.

Identification of Isolates

Microbial isolates were identified using a combination of colonial morphology, Gram staining, and biochemical characterization. Following incubation, representative colonies were examined for their cultural characteristics and subjected to Gram staining according to standard microbiological procedures. Briefly, heat-fixed smears were stained with crystal violet, treated with Lugol's iodine, decolorized with acetone-alcohol, counterstained with neutral red, and examined microscopically under oil immersion (100 x objective).

Further identification was performed using standard biochemical tests, including catalase, coagulase, motility, and Triple Sugar Iron (TSI) agar tests. For the catalase test, a colony was emulsified in hydrogen peroxide and observed for bubble production. The coagulase test was carried out using plasma to detect clumping of bacterial cells. Motility was assessed using the hanging drop method and examined microscopically for directional movement of bacterial cells. The TSI test was performed by inoculating TSI agar slants through stabbing the butt and streaking the slant surface, followed by incubation at 35°C for 18–24 hours. Identification of isolates was based on the results of Gram staining and biochemical reactions in accordance with standard microbiological identification protocols.

Data Analysis

Data generated were entered, cleaned, and analyzed using Microsoft Excel 2016. Descriptive statistics including frequencies and percentages were used to summarize the findings, while Total Aerobic Plate Count (TAPC) values obtained from sampled surfaces and equipment were calculated and summarized as mean colony-forming units (CFU).

Ethical Considerations

- Ethical approval was obtained from the Ethical Review Committee of the Benue State University Teaching Hospital, Makurdi.
- Permission to collect samples from hospital surfaces and medical equipment was obtained from the Management of BSUTH, Makurdi.
- The study involved environmental sampling of hospital surfaces and medical equipment and did not include human participants, patient specimens, or collection of personal information. As such, no direct risk was posed to patients or healthcare workers.
- All sampling procedures were conducted in a manner that did not interfere with routine hospital activities or compromise patient care.
- Standard laboratory biosafety guidelines were strictly followed during sample collection, transportation, processing, and disposal of microbiological materials to protect both researchers and the environment.

RESULTS

A total of eight microbial species were identified, comprising bacterial and fungal organisms of clinical significance. The bacterial isolates included two Gram-positive organisms, namely *Staphylococcus aureus* and *Streptococcus pyogenes*, and four Gram-negative organisms, namely *Escherichia coli*, *Klebsiella pneumoniae*, *Salmonella typhi*, and *Pseudomonas aeruginosa*. In addition, two fungal isolates were recovered, consisting of the yeast *Candida albicans* and the filamentous fungus *Aspergillus niger*.

Table 1 shows the distribution of microbial isolates recovered from the various non-critical equipment and environmental surfaces sampled. The highest diversity of microorganisms was observed on benches/tables, where five different organisms were isolated, namely *Salmonella typhi*, *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, and *Escherichia coli*. The remaining equipment and surfaces yielded single microbial species.

Table 2 presents the mean total aerobic plate count (TAPC) of the sampled non-critical equipment and environmental surfaces. The highest microbial load was recorded on tables, with a mean TAPC of 3.7 x 10^5 CFU/ml, followed closely by sinks (3.5 x 10^5 CFU/ml) and wire loops (3.2 x 10^5 CFU/ml). Intermediate levels of contamination were observed on refrigerator handles and hand jars, each with a mean TAPC of 2.5 x 10^5 CFU/ml. The lowest microbial loads were recorded on autoclaves and scissors, both of which had a mean TAPC of 1.3 x 10^5 CFU/ml.

Figure 1 shows the percentage distribution of microbial contamination across the sampled non-critical equipment and environmental surfaces. Tables/benches exhibited the highest level of contamination, accounting for 28.9% of the total isolates recovered. This was followed by sinks (15.7%), wire loops (14.4%), and hand jars (13.3%). Refrigerator handles contributed 12.0% of the contamination burden, while scissors accounted for 9.6%. The lowest level of contamination was observed on autoclaves, which represented 6.0% of the total isolates.

Table 1: Distribution of isolates by non-critical equipment/surface

Equipment/surface	Organism(s) isolated
Bench/table	*Salmonella typhi, Staphylococcus aureus, Streptococcus pyogenes, Pseudomonas aeruginosa, Escherichia coli*
Sink	***Klebsiella pneumoniae***
Refrigerator handle	*Escherichia coli*
Autoclave	***Aspergillus niger***
Wire Loop	*Candida albicans*
Scissors	***Pseudomonas aeruginosa***

Equipment	Mean TAPC (CFU/ml)*
Table	3.7×10^5
Sink	3.5×10^5
Wire loop	3.2×10^5
Refrigerator handle	2.5×10^5
Hand jar	2.5×10^5
Autoclave	1.3×10^5
Scissors	1.3×10^5

CFU/ml = Colony-Forming Units per millilitre of sample

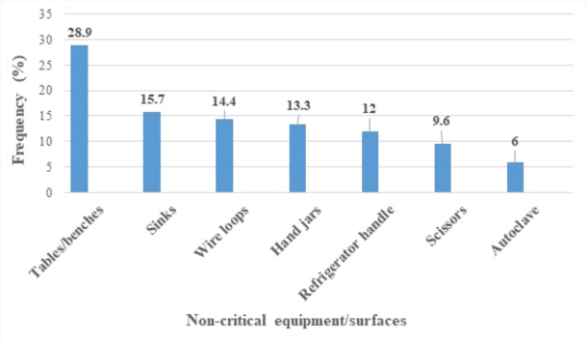

Figure 1: Percentage contamination by non-critical equipment/surface

DISCUSSION

Diversity of microorganisms persisting on equipment and environmental surfaces

The present study demonstrates the diverse range of microorganisms that contaminate non-critical laboratory equipment and environmental surfaces within the Medical Microbiology Laboratory complex, general outpatient department (GOPD) clinic, and phlebotomy unit of Benue State University Teaching Hospital (BSUTH), Makurdi. The predominance of bacterial isolates, particularly Gram-negative organisms, suggests that laboratory surfaces and equipment may serve as reservoirs for potentially pathogenic microorganisms capable of contributing to healthcare-associated infections (HAIs). The isolation of *Staphylococcus aureus* is of particular concern because the organism is a common cause of skin, soft tissue, bloodstream, and device-associated infections. Its presence on laboratory surfaces may indicate contamination through direct human contact, as the organism commonly colonizes the skin and nasal passages of healthy individuals. *Streptococcus pyogenes* is associated with a wide range of infections, including pharyngitis, impetigo, cellulitis, necrotizing fasciitis, and streptococcal toxic shock syndrome.

The recovery of this organism from laboratory surfaces suggests possible contamination through respiratory droplets, contaminated hands, or contact with infected clinical specimens. Similarly, the recovery of enteric organisms such as *Escherichia coli*, *Klebsiella pneumoniae*, and *Salmonella typhi* suggests possible contamination from inadequately sanitized hands, contaminated specimens, or environmental reservoirs. The detection of *Pseudomonas aeruginosa*, an opportunistic pathogen known for its environmental persistence and intrinsic antimicrobial resistance, further highlights the potential infection risks associated with contaminated laboratory equipment. Furthermore, the presence of *Aspergillus niger* and *Candida albicans* may pose risks to immunocompromised individuals, especially people living with HIV (PLHIV).

The spectrum of microorganisms recovered in the present study aligns with findings from recent systematic reviews.[10,15] In 2024, a review encompassing studies from 14 countries across North America, South America, Europe, and Asia, identified *S. aureus*, *P. aeruginosa*, *E. coli*, *K. pneumoniae*, and fungal contaminants including *Candida species*, as among the most frequently reported microorganisms on hospital surfaces and medical devices.[15] Likewise, a review in 2025 reported that healthcare environments in Nigeria commonly harbour a diverse range of bacterial and fungal contaminants.[10] The commonest organisms reported were *Proteus species* and *S. aureus*, followed closely by *E. coli*, *Klebsiella* and *Pseudomonas*.[10]

In two tertiary hospitals in Abia State, Nigeria, the predominant isolates were *S. aureus*, followed by coagulase-negative *Staphylococci*, and *E.coli*. *Streptococcus spp* and *K. pneumoniae* were the least prevalent isolates.[16] Another study conducted in five Kenyan hospitals systematically sampled and characterized multidrug-resistant (MDR) ESKAPEE pathogens (*Enterococcus faecalis/faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Enterobacter spp*., and *Escherichia coli*) from high-touch hospital environments. Among the organisms recovered were *K. pneumoniae*, *E. coli*, and *P. aeruginosa*, which were also identified in the present study.[8] Taken together, these findings suggest that contamination of medical equipment and environmental surfaces remains a global challenge and reinforces concerns regarding their potential role as reservoirs for healthcare-associated infections and antimicrobial resistance transmission.

Distribution of isolates by non-critical equipment and surfaces

In the present study, tables and laboratory benches harboured the greatest diversity of microorganisms, with five bacterial species isolated, namely *Salmonella typhi*, *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, and *Escherichia coli*. This finding reflects the frequent use of these work surfaces and suggests repeated microbial deposition through specimen processing, hand contact, aerosol generation, and inadequate surface decontamination. The presence of both enteric organisms (*E. coli* and *S. typhi*) and opportunistic pathogens (*S. aureus* and *P. aeruginosa*) indicates multiple potential sources of contamination and highlights the role of work surfaces as reservoirs for cross-contamination within the laboratory environment.

K. pneumoniae was isolated from sinks, a finding consistent with the organism's ability to survive and proliferate in moist environments. Similar studies have identified sinks and drainage systems as important reservoirs of Gram-negative bacteria including *K. pneumoniae* in healthcare settings.[17-19] The isolation of *E. coli* from a refrigerator handle suggests contamination likely resulting from inadequate hand hygiene or transfer from contaminated specimens. Also, *P. aeruginosa* recovered from scissors highlights the risk of contamination of reusable laboratory instruments, emphasizing the need for effective cleaning and disinfection practices. Furthermore, fungal contamination was observed, with *Candida albicans* isolated from a wire loop and *Aspergillus niger* from an autoclave. These findings indicate that both equipment and environmental surfaces can serve as reservoirs for bacterial and fungal pathogens. Studies in hospital settings in Nigeria have also reported the presence of *Candida* and *Aspergillus spp* on hospital appliances,[20] while *Aspergillus spp* was found in the water distribution system of a tertiary hospital.[14]

Mean total aerobic plate count (TAPC) of sampled equipment and surfaces

Overall, the TAPC values of the present study demonstrates that non-critical equipment and environmental surfaces within the laboratory environment can harbour substantial microbial loads. The highest counts were observed on tables (3.7×10^5 CFU/mL) and sinks (3.5×10^5 CFU/mL), suggesting that frequently used work surfaces and moist environments are important reservoirs of microorganisms. The lowest counts were observed on autoclave and scissors (1.3×10^5 each). In a study conducted in Ethiopia, results showed bacterial colony counts on hospital environmental surfaces and medical equipment ranging from 18 to 43.3 CFU/cm² across paediatric, medical intensive care, neonatal intensive care, and operating room units; while fungal counts ranged from 5.25 to 32.3 CFU/cm², with the highest contamination recorded in the paediatric ward.[21] It should be noted however, that direct comparison between the present study and the one conducted in Ethiopia[21] is limited by differences in sampling methods and reporting units. Nevertheless, both studies demonstrate that healthcare and laboratory environments can harbour substantial microbial populations capable of contributing to environmental contamination and potential pathogen transmission. This emphasizes the need for regular environmental monitoring, strict adherence to cleaning and disinfection protocols, and reinforcement of hand hygiene practices to minimize the risk of cross-contamination and healthcare-associated infections.

STRENGTHS AND LIMITATIONS

This study provides important baseline data on the diversity and burden of microorganisms persisting on non-critical medical equipment and environmental surfaces within medical microbiology laboratory units of a tertiary hospital in North-Central Nigeria, an area with limited published evidence. The use of direct microbiological sampling and standard culture-based identification allowed objective measurement of microbial load (CFU counts) and improved reliability of findings. Sampling across multiple laboratory units also enabled comparison of contamination levels across different clinical settings, supporting targeted infection prevention and control measures.

Some limitations should also be considered. The cross-sectional design limits assessment of temporal variation and causality. Culture-based methods may have underestimated microbial diversity by missing fastidious or non-culturable organisms. Variations in sampling time relative to cleaning and workload may have influenced results. In addition, the absence of molecular characterization techniques limited species-level resolution and prevented assessment of antimicrobial resistance genes or strain typing, which would have provided deeper epidemiological insights. Finally, the findings are based on a single tertiary hospital in North-Central Nigeria and may therefore have limited generalizability to other healthcare facilities with different infrastructure, staffing levels, or infection control practices.

CONCLUSION

This study demonstrated that non-critical laboratory equipment and environmental surfaces at Benue State University Teaching Hospital (BSUTH), Makurdi, were contaminated with a diverse range of potentially pathogenic microorganisms, including *Staphylococcus aureus*, *Streptococcus pyogenes*, *Escherichia coli*, *Klebsiella pneumoniae*, *Salmonella typhi*, *Pseudomonas aeruginosa, Candida albicans*, and *Aspergillus niger*. Laboratory benches/tables harboured the greatest diversity of isolates, while tables and sinks recorded the highest mean total aerobic plate counts, indicating substantial microbial contamination of frequently used work surfaces and moist environmental sites.

The recovery of clinically important bacterial and fungal pathogens from non-critical equipment and surfaces highlights their potential role as reservoirs for cross-contamination and laboratory-associated transmission of microorganisms. These findings underscore the importance of routine environmental microbiological surveillance, strict adherence to cleaning and disinfection protocols, proper sterilization of reusable instruments, and consistent hand hygiene practices among laboratory personnel.

Strengthening infection prevention and control measures within laboratory environments is essential to minimize microbial contamination, reduce the risk of pathogen dissemination, and promote a safer working environment for healthcare workers and patients. Further studies incorporating antimicrobial susceptibility testing and molecular characterization of environmental isolates are recommended to better understand the public health implications of laboratory surface contamination and the potential emergence of antimicrobial-resistant pathogens.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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