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*Original article*

### **Bacterial Diversity and Antibiotic Resistance Patterns of Microorganisms Isolated from Hospital Fomites: Implications for Infection Control and Antibiotic Stewardship**

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#### **ABSTRACT**

Introduction:

Hospital fomites serve as reservoirs for pathogenic microorganisms and contribute significantly to the transmission of healthcare-associated infections (HAIs). Understanding their microbial diversity and resistance patterns is essential for infection control.

Methods:

Ten hospital surfaces—including beds, desks, benches, and diagnostic equipment—were sampled for microbial contamination. Surface swabs were collected aseptically, cultured using standard microbiological techniques, and subjected to biochemical identification. Antibiotic susceptibility testing was performed using the disc diffusion method.

Results:

A diverse range of Gram-positive and Gram-negative bacteria were isolated, with patient beds and benches showing the highest microbial diversity. Antibiotic resistance was notably high against Ofloxacin (92.5%) and Ceftriaxone (87.5%), while Gentamicin exhibited the greatest susceptibility (47.5%).

Conclusion:

Hospital fomites play a critical role in the persistence of nosocomial pathogens. The findings underscore the urgent need for enhanced disinfection protocols and robust antibiotic stewardship to mitigate the risk of HAIs.

**KEYWORDS: HOSPITAL FOMITES, HEALTHCARE-ASSOCIATED INFECTIONS, BACTERIAL DIVERSITY, ANTIBIOTIC RESISTANCE, ANTIBIOTIC STEWARDSHIP.**

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## INTRODUCTION

Healthcare-associated infections (HAIs) remain a formidable challenge for health systems worldwide, posing significant threats to patient safety, increasing morbidity and mortality rates, and placing substantial financial burdens on healthcare infrastructures (Haque et al., 2018; Oluyele et al., 2023). The risk of HAIs is compounded by the global rise of multidrug-resistant (MDR) pathogens, which undermine the efficacy of conventional antimicrobial therapies and limit treatment options (Falowo et al., 2018; Tacconelli et al., 2018; Awolope et al., 2020; Habboush and Guzman, 2024; Oluyele, 2025). As antimicrobial resistance (AMR) continues to escalate, particularly within healthcare settings, the need to understand and mitigate environmental sources of transmission becomes increasingly critical.

Hospital environments—especially high-touch surfaces such as bed rails, examination tables, stethoscopes, infusion pumps, and electronic diagnostic devices—act as reservoirs and transmission vectors for a broad spectrum of pathogenic microorganisms (Lopez et al., 2013). These fomites often facilitate the indirect transfer of infectious agents between patients, healthcare personnel, and visitors. Notably, certain bacterial species exhibit remarkable resilience on inanimate surfaces, surviving for extended periods and forming robust biofilms that enhance their resistance to desiccation, disinfectants, and antibiotics (Lincy et al., 2016). Spore-forming organisms further exacerbate this issue due to their innate structural defenses against conventional cleaning procedures.

Recent studies have underscored the alarming prevalence of MDR bacteria on hospital surfaces, including methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant Enterococci (VRE), carbapenem-resistant *Acinetobacter baumannii*, and extended-spectrum  $\beta$ -lactamase (ESBL)-producing *Klebsiella* and *Escherichia coli* strains (Haun et al., 2016). These environmental isolates often harbor genes conferring resistance to multiple classes of antibiotics, complicating therapeutic decision-making and contributing to persistent outbreaks and increased patient lengths of stay.

Despite continuing efforts of hospital infection control measures, hospital associated infections are still a major public health problem globally and are on the increase in developing countries especially in Sub-Saharan Africa. It contributes significantly to morbidity and mortality of all age groups (Alp and Damani, 2015; Eldeglia et al., 2016; Oluyele et al., 2017). Besides harming patients, HAIs can affect health care workers and anyone who has contact with the hospital (Maryam et al., 2014). About 10% of all hospital patients acquire some type of HAIs as a result of contact with some contaminated hospital equipment (Hammoud et al., 2023).

This study aims to characterize the bacterial diversity associated with frequently touched hospital fomites and to evaluate the antibiotic resistance profiles of the isolated organisms. By linking contamination patterns with resistance trends, the findings are intended to guide targeted interventions that improve environmental hygiene and mitigate the risk of nosocomial transmission of multidrug-resistant (MDR) pathogens.

## MATERIALS AND METHODS

### *Study Design and Sampling*

A cross-sectional study was conducted across multiple hospital departments in Akungba-Akoko. Ten different types of fomites frequently used or touched in hospital settings were selected for sampling: bed surfaces, desks, benches, kidney plates, zinc surfaces, surgical flasks, stethoscopes, centrifuges, genotype machines, and microscopes.

### *Sample Collection and Bacterial Isolation*

Sterile cotton swabs moistened with sterile normal saline were used to aseptically collect samples from various high-contact hospital fomites. Surfaces such as patient beds, desks, benches, door handles, and diagnostic equipment were swabbed by rolling the swab over approximately 5–10 cm<sup>2</sup> of the surface area while rotating the swab to maximize microbial recovery. Each swab was immediately inoculated onto a panel of selective and differential culture media (including MacConkey agar, Mannitol Salt agar, Cetrimide agar, and Blood agar) and incubated aerobically at 35–37 °C for 24–48 hours, depending on the medium

and suspected organisms. After incubation, colonies were examined for morphological characteristics, including colony size, shape, colour, elevation, and haemolytic patterns where applicable. Distinct colonies were subcultured onto nutrient agar plates to obtain pure isolates. Purified colonies were subjected to Gram staining to determine cell wall characteristics and cellular morphology (cocci vs. bacilli, arrangement), and identification was confirmed using standard biochemical assays organized by bacterial groups: catalase and coagulase for staphylococci, oxidase for non fermenters, and a suite of tests for Enterobacteriaceae including methyl red and Voges Proskauer for differentiation, motility and indole production, sugar fermentation profiles, citrate utilization, urease activity, and triple sugar iron (TSI) reactions to assess carbohydrate fermentation and hydrogen sulfide production; results were interpreted according to established microbiological protocols (Oluyele et al., 2023), ensuring accurate detection and classification of bacterial species.

### **Antibiotic Susceptibility Testing**

The antibiotic susceptibility of the isolated bacterial strains was determined using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar (MHA). Pure colonies of each bacterial isolate were suspended in sterile normal saline and adjusted to the turbidity of a 0.5 McFarland standard. A sterile swab was then used to evenly spread the standardized inoculum over the entire surface of the MHA plate to ensure uniform growth. After the inoculum had absorbed into the agar surface, commercially prepared antibiotic disks were carefully placed on the agar using sterile forceps with adequate spacing between disks. The antibiotics tested included: Ceftriaxone (CEF), Ofloxacin (OFX), Amoxicillin-Clavulanate (AU), Pefloxacin (PEF), Ceftazidime (CTZ), Gentamicin (CN), Ciprofloxacin (CPX), Cefpodoxime (CEP), and Trimethoprim-Sulfamethoxazole (TRX). These antibiotics were selected based on their clinical relevance and common usage in treating bacterial infections. The inoculated plates were incubated at 37°C for 18–24 hours, after which the zones of inhibition around each disk were measured in millimeters. The results were interpreted as susceptible, intermediate, or resistant according to the Clinical and Laboratory Standards Institute (CLSI) guidelines (Osei et al., 2024).

## **RESULTS AND DISCUSSION**

### **Diversity of Bacterial Isolates from Hospital Fomites**

Diverse genera of clinically relevant Gram-positive and Gram-negative bacteria were isolated across all sampled surfaces (Table 1). Hospital beds harbored the highest diversity, including *Pseudomonas aeruginosa*, *Bacillus cereus*, *Rhodococcus equi*, *Corynebacterium jeikeium*, *Staphylococcus epidermidis*, *Clostridium difficile*, *Rhodococcus fascians*, and *Listeria monocytogenes*. Other fomites like benches and desks also supported complex bacterial communities, with notable presence of *Bacillus*, *Corynebacterium*, *Staphylococcus*, and *Listeria species*. The microscope and centrifuge showed colonization by *Rhodococcus* and *Corynebacterium* species, suggesting persistent contamination of shared diagnostic equipment.

### **Antibiotic Resistance Profiles of Bacterial Isolates from Hospital Fomites**

The susceptibility profiles of the isolated bacteria to nine commonly used antibiotics revealed a high level of resistance across board (Table 2). The highest resistance was observed for Ofloxacin (OFX; 92.5%) and Ceftriaxone (CEF; 87.5%), while the lowest resistance was noted for Gentamicin (CN; 52.5%). Resistance to other agents such as Cefpodoxime (CEP), Ciprofloxacin (CPX), and Trimethoprim/Sulfamethoxazole (TRX) ranged between 65.0% and 82.5%. Only a minority of isolates were susceptible to any of the antibiotics tested, with susceptibility peaking at 47.5% for Gentamicin.

## **DISCUSSION**

Hospital environments, especially frequently touched surfaces, serve as key reservoirs for microbial contamination and the transmission of healthcare-associated infections (HAIs). The persistence of multidrug-resistant (MDR) pathogens in these settings is a serious global health concern, often driven by

poor hygiene and insufficient disinfection practices (Facciola et al., 2019). This study reveals a concerning prevalence of antibiotic-resistant bacteria across various hospital fomites, highlighting their role as

**Table 1. Bacterial Diversity Isolated from Hospital Fomites in Akungba-Akoko**

<b>Fomite</b>	<b>Bacteria Isolated</b>
<b>Bed</b>	<i>P. aeruginosa</i> , <i>B. cereus</i> , <i>R. equi</i> , <i>C. jeikeium</i> , <i>S. epidermidis</i> , <i>C. difficile</i> , <i>R. fascians</i> , <i>L. monocytogenes</i>
<b>Desk</b>	<i>Bacillus subtilis</i> , <i>Bacillus megaterium</i> , <i>Bacillus thuringiensis</i> , <i>Bacillus licheniformis</i>
<b>Bench</b>	<i>Bacillus subtilis</i> , <i>B. cereus</i> , <i>Corynebacterium ulcerans</i> , <i>Staphylococcus saprophyticus</i> , <i>Listeria ivanovii</i> , <i>Rhodococcus erythropolis</i> , <i>Enterococcus faecium</i> , <i>Corynebacterium pseudotuberculosis</i> , <i>R. fascians</i> , <i>L. monocytogenes</i> , <i>Staphylococcus aureus</i>
<b>Kidney Plate</b>	<i>Bacillus pumilus</i>
<b>Zinc</b>	<i>Corynebacterium diphtheriae</i> , <i>Corynebacterium amycolatum</i> , <i>Bacillus polymyxa</i> , <i>Nocardia brasiliensis</i>
<b>Surgical Flask</b>	<i>Micrococcus luteus</i>
<b>Stethoscope</b>	<i>Bacillus pumilus</i>
<b>Centrifuge</b>	<i>Bacillus pumilus</i> , <i>R. fascians</i>
<b>Genotype Machine</b>	<i>Streptococcus bovis</i>
<b>Microscope</b>	<i>Rhodococcus erythropolis</i> , <i>Corynebacterium xerosis</i> , <i>Arthrobacter globiformis</i>

**Table 2. Susceptibility Patterns of Microorganisms Isolated from Hospital Fomites in Akungba-Akoko**

Antibiotic	% Resistant	% Susceptible
CEF	87.5%	12.5%
OFX	92.5%	7.5%
AU	67.5%	32.5%
PEF	65.0%	35.0%
CTZ	67.5%	32.5%
CN	52.5%	47.5%
CPX	82.5%	17.5%
CEP	77.5%	22.5%
TRX	70.0%	30.0%

environmental reservoirs that sustain HAIs. High microbial diversity, including both pathogenic and opportunistic organisms, was observed on surfaces frequently touched by patients, particularly beds and benches. Isolated organisms included *Pseudomonas aeruginosa*, *Clostridium difficile*, and multiple species of *Listeria* and *Staphylococcus*, all of which are commonly implicated in nosocomial outbreaks.

Consistent with previous studies from Africa, including Ethiopia, *Staphylococcus aureus*, coagulase-negative *Staphylococcus* (CoNS), *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus* species, and *Pseudomonas aeruginosa* have been isolated from healthcare workers' stethoscopes, mobile phones, and white coats (Chikere et al., 2008; Misgana et al., 2015; Haun et al., 2016; Segujja et al., 2016). Similarly, Olajide et al. (2024) reported 89 isolates from door handles, comprising genera such as *Citrobacter*, *Pseudomonas*, *Parabulkoidea*, *Paenacaligenes*, and *Serratia*.

Notably, *Pseudomonas aeruginosa*—a biofilm-forming and multidrug-resistant pathogen—was frequently recovered from patient beds, reinforcing evidence of its significant role in cross-contamination (Olasehinde et al., 2022). The detection of *Clostridium difficile*, a resilient spore-former, further underscores the limitations of conventional disinfection protocols in eradicating persistent hospital pathogens.

The bacterial isolates exhibited marked resistance to multiple antibiotics, aligning with findings by Sharma et al. (2023) and Akinrotayo et al. (2019), who reported high resistance levels to most antibiotics tested. In contrast, Tefera et al. (2019) found relatively low resistance (below 50%) among isolates from toilet handles in Ethiopia, though penicillin resistance remained high. Likewise, Alonge et al. (2019) and Edi et al. (2020) observed low resistance rates (0–44.4%) from isolates on toilet door handles, suggesting variability that may be due to differences in bacterial ecology—particularly between commensal and pathogenic species. Pathogens typically demonstrate higher resistance due to increased selective pressure and genetic adaptation mechanisms.

The resistance profiles observed in this study are particularly alarming: nearly all isolates exhibited resistance to fluoroquinolones (ofloxacin and ciprofloxacin) and third-generation cephalosporins (ceftriaxone and ceftazidime)—drugs commonly used in empirical therapy. Despite Parhizgari et al. (2014) reporting high susceptibility of fomite-associated bacteria to ciprofloxacin, our findings contrast sharply, with ofloxacin resistance reaching 92.5%. This is consistent with Onaolapo et al. (2015) and Otokunefor et al. (2020), who reported high resistance levels among *Staphylococcus aureus* and enterococci, respectively. Gentamicin showed comparatively better efficacy (47.5% susceptibility), echoing Maryam et al. (2016), who noted high susceptibility of Gram-negative bacteria to this aminoglycoside.

El Hassy et al. (2018) reported that *P. aeruginosa* was resistant to ciprofloxacin but susceptible to colistin, while *S. aureus* showed resistance to amoxicillin-clavulanate, ceftriaxone, and ceftazidime. In contrast, Mani et al. (2023) found all isolates to be sensitive to ciprofloxacin, amoxiclav, piperacillin, and cefuroxime, yet resistant to certain  $\beta$ -lactams such as cefepime and ceftazolin, particularly the carbapenems imipenem and meropenem.

These varying resistance patterns may reflect selective pressure from inappropriate or overuse of antibiotics, compounded by horizontal gene transfer in polymicrobial environments such as fomites. This aligns with global concerns that hospital surfaces not only serve as microbial reservoirs but also act as micro-ecosystems for resistance gene exchange.

The presence of opportunistic bacteria such as *Rhodococcus*, *Nocardia*, and *Arthrobacter* on diagnostic equipment (e.g., microscopes and genotype machines) suggests lapses in the cleaning of non-critical medical devices, which are often excluded from routine disinfection protocols. Additionally, the detection of *Streptococcus bovis*—a known indicator of gastrointestinal pathology—on the genotype machine raises biosafety concerns regarding contamination from biological samples, underscoring the need for stricter decontamination and sample handling practices.

## CONCLUSIONS

The study underscores the critical role of inanimate hospital surfaces as reservoirs and transmission points for multidrug-resistant bacteria. The wide spectrum of isolated organisms and their resistance to frontline antibiotics highlight an urgent need to re-evaluate current infection prevention strategies. These findings reinforce the notion that environmental hygiene is not peripheral but central to effective infection control, particularly in resource-limited healthcare settings.

## Future Directions and Recommendations

To mitigate the risks posed by contaminated fomites, healthcare institutions should implement stricter, evidence-based disinfection protocols that extend to both critical and non-critical surfaces. Regular

surveillance of microbial contamination and antimicrobial resistance patterns on hospital surfaces should be institutionalized. Additionally, staff training on infection control, prudent antibiotic use, and biosafety should be prioritized. Future studies should explore the genetic mechanisms underlying resistance in these environmental isolates and assess the effectiveness of novel or alternative disinfectants against persistent nosocomial pathogens.

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### Conflict of interest

The authors have no conflict of interest regarding this article.

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