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Research Article

Phenotypic Characterization and Antibiotic Resistance Profiles of Multidrug-Resistant Bacteria Isolated from Fomites in General Hospital Dutsin-Ma, Katsina State, Nigeria

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ABSTRACT
Hospital fomites play a significant role in the dissemination of multidrug-resistant (MDR) bacteria and contribute to healthcare-associated infections (HAIs). Recent studies showed that environmental surfaces and shared hospital equipment frequently harbor MDR pathogens, including *Staphylococcus aureus*, Enterobacterales and enterococci, emphasizing the need for surveillance in resource-limited settings. This study aimed to determine the level of bacterial contamination on hospital fomites, characterize the isolates using phenotypic methods and assess their antibiotic resistance patterns. A laboratory-based cross-sectional study was conducted between October 2024 and April 2025. Ten high-touch fomites were sampled using sterile swabs. Samples were cultured on selective and differential media, and isolates identified based on Gram stain and biochemical tests. Antimicrobial susceptibility testing (AST) was performed using Kirby–Bauer disk diffusion and interpreted according to CLSI standards and MDR isolates were determined based on bacterial resistance to ≥ 3 classes of antibiotics. Twenty isolates were recovered, comprising *Staphylococcus aureus* (40%), *Enterococcus* spp. (20%), *Escherichia coli* (20%), *Salmonella* spp. (10%) and *Klebsiella* spp. (10%). High total viable counts were found on the table top (6.3×10^3cfu/mL) and drip stand (5.0×10^3cfu/mL). AST revealed widespread resistance, including 100% resistance to Ampicillin. All isolates met MDR criteria, with *Klebsiella* spp. exhibiting complete resistance to all tested antibiotics. Hospital fomites in Dutsin-Ma harbor phenotypically multidrug-resistant bacteria, posing a potential risk for transmission within patient-care environments, highlighting the need for routine environmental monitoring, strengthened surface disinfection protocols and antimicrobial stewardship interventions.

Keywords: Antimicrobial susceptibility; Fomites; Nigeria; Multidrug resistance; Phenotypic identification; *Staphylococcus aureus*

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INTRODUCTION

Healthcare-associated infections (HAIs) remain one of the most persistent global public health challenges, particularly in low- and middle-income countries where limited resources, high patient loads and inconsistent infection prevention practices increase vulnerability to pathogen transmission. A growing body of evidence demonstrates that hospital environments—especially frequently touched surfaces such as bed rails, tables, switches, and medical equipment—serve as reservoirs of clinically significant bacteria capable of surviving for extended periods under typical ward conditions (Jabłońska-Trypuć *et al*., 2022). These persistent environmental reservoirs provide continuous opportunities for microbial transfer among patients, healthcare

workers and visitors, thereby, facilitating HAIs. Gram-negative bacteria such as *Enterococcus faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa* and *Enterobacter* species (ESKAPE) pathogens play a central role in hospital environmental contamination because of their ability to evade multiple antibiotics and their strong propensity for nosocomial transmission (Musa *et al*., 2025).

Fomites have been shown to harbor HAI-associated bacteria including *Staphylococcus aureus*, *Enterococcus* species, *Escherichia coli*, *Klebsiella* species and *Salmonella* species bacteria well-documented for their ability to acquire and disseminate antibiotic resistance mechanisms (Dixit *et al*., 2023; Yusuf *et al*., 2023). Several studies highlight that high-touch surfaces often mirror the antimicrobial resistance profiles circulating within a facility, demonstrating overlap between environmental isolates and clinical strains implicated in invasive infections. This convergence emphasizes the role of hospital surfaces not only as passive reservoirs but also as active nodes in resistance amplification and transmission pathways.

The global dissemination of antimicrobial resistance (AMR), particularly the concerning rise of resistance to first-line antibiotics and multidrug-resistant pathogens, represents a paramount challenge to public health systems worldwide (Sani *et al*., 2025). Globally, resistance among HAI-causing pathogens has escalated to alarming levels. Methicillin-resistant *S. aureus* (MRSA), vancomycin-resistant enterococci (VRE), multidrug-resistant Enterobacterales (including ESBL- and AmpC-producing strains), and MDR *Klebsiella* species are increasingly reported from healthcare settings, contributing to prolonged hospital stays, higher morbidity and increased healthcare costs (Magiorakos *et al*., 2012). Environmental monitoring in hospitals has revealed that these bacteria can persist on surfaces for days to months under favorable conditions, retaining their infectivity and resistance traits (Jabłońska-Trypuć *et al*., 2022).

Emerging evidence also demonstrates that hospital plumbing systems and restroom infrastructures may act as hidden ecological reservoirs of MDR bacteria, including β-lactamase-producing Enterobacterales capable of translocating from sinks, drains and sanitary installations to patient-care surfaces through aerosolization or manual contact (Valzano *et al*., 2024). These findings suggest that environmental contamination is more complex than previously assumed and that MDR bacteria may circulate between water systems, surfaces and human hosts within hospitals.

High rates of antimicrobial resistance, particularly resistance to β-lactams, aminoglycosides, sulfonamides and macrolides, have been documented in environmental isolates from healthcare facilities in West Africa and Nigeria, reflecting both widespread antibiotic misuse and inadequate infection control structures (Yusuf *et al*., 2023). The increasing detection of MDR bacteria on hospital fomites raises concerns for both direct and indirect transmission routes, especially in settings where hand hygiene compliance and cleaning audits may not be consistently enforced. Because HAIs caused by MDR pathogens significantly restrict therapeutic options, early identification of environmental reservoirs becomes foundational to antimicrobial stewardship and infection prevention strategies.

Given the critical role of fomites in sustaining and disseminating resistant bacteria and considering the limited environmental surveillance studies in northern Nigeria, especially in secondary healthcare facilities such as General Hospital Dutsin-Ma, the need for local evidence is substantial. Understanding the bacterial composition of fomites and their resistance patterns can provide crucial insights into contamination pressures, cleaning effectiveness and potential transmission risks. Therefore, this study aimed to characterize bacteria contaminating high-touch hospital surfaces in General Hospital Dutsin-Ma and to describe their antibiotic resistance profiles, with particular emphasis on multidrug resistance patterns that may influence HAI risk and local antimicrobial stewardship priorities.

MATERIALS AND METHODS

Study Area

The study was conducted in Dutsin-Ma, the administrative headquarters of Dutsin-Ma Local Government Area of Katsina State, Nigeria, located at approximately 12°27′17″N and 7°29′29″E and covering an estimated land area of 527 km². The town is bordered by several smaller rural settlements whose residents frequently depend on Dutsin-Ma for

essential services, including healthcare, reflecting its role as a central service hub within the region (Adesoji *et al*., 2019).

Figure 1: Map of Katsina State, Nigeria, Highlighting Dutsin-Ma LGA

The selected hospital was General Hospital Dutsin-Ma, a government-owned secondary healthcare facility located in Dutsin-Ma Local Government Area of Katsina State, northwestern Nigeria. The hospital provides a broad range of clinical services including outpatient consultation, general medicine, minor surgery, obstetrics, pediatrics and emergency care to the population. The typical ward layout features shared patient spaces with multiple high-touch surfaces such as bed rails, furniture, fans, light switches, drip stands and door handles, all of which are frequently exposed to contact by patients, caregivers and healthcare workers. While the hospital maintains routine cleaning schedules performed by environmental service personnel, variations exist in adherence, frequency, disinfectant type and staff training. These factors create conditions under which microorganisms—including multidrug-resistant strains—may persist on surfaces for extended periods, a phenomenon well documented in hospital ecology literature (Jabłońska-Trypuć *et al*., 2022).

Study Design and Duration

A descriptive laboratory-based cross-sectional study design was used to characterize bacterial contamination on fomites at a single time-point. Sampling and microbiological analysis were carried out from October 2024 through April 2025, a period chosen to accommodate potential seasonal differences in hospital traffic and cleaning frequency. Cross-sectional environmental surveillance studies such as this provide valuable insight into the baseline microbial load of hospital surfaces, which is increasingly recognized as a critical component of infection prevention programs (CDC, 2024).

Sampling Strategy

Ten fomites were purposively selected based on frequency of direct contact, relevance to patient care activities and likelihood of harboring clinically important bacteria. These included a bed rail, file shelf, door handle, window handle, drip stand, tourniquet, fan regulator, light switch, table top and chair handle. Each surface was sampled once to

obtain a representative snapshot of environmental contamination. Purposive sampling is widely accepted in environmental microbiology for assessing contamination of "high-touch" surfaces shown to act as reservoirs for pathogens associated with healthcare-associated infections (HAIs). High-touch surfaces have been repeatedly implicated as vehicles of pathogen spread, especially in areas where cleaning practices vary across wards (Valzano *et al*., 2024).

Sample Collection

Surface sampling followed standardized environmental swabbing methodology recommended for healthcare settings (CDC, 2024). Sterile cotton swabs were pre-moistened in sterile physiological saline (0.85% NaCl) to enhance microbial recovery. A surface area of approximately 10 cm × 10 cm was delineated visually, and the swab was rolled across the area in multiple directions with firm, even pressure to maximize retrieval of microorganisms that may be weakly adherent. After sampling, each swab was immediately inserted into a sterile tube containing 2–3 mL of normal saline and labeled according to sampling location. Samples were transported to the microbiology laboratory in a cold box maintained at approximately 4–8°C and processed within two to four hours of collection.

Total Viable Bacterial Count

In the laboratory, tubes were vortexed vigorously for 30–60 seconds to disperse microorganisms into suspension. Serial ten-fold dilutions were prepared where necessary. Aliquots of 0.1 mL of selected dilutions were inoculated onto nutrient agar plates using the surface spread method. Plates were incubated aerobically at 37°C for 24–48 hours, after which colonies were counted manually on plates showing 30–300 colonies. The colony counts were multiplied by the dilution factor and expressed as colony-forming units per milliliter (cfu/mL). The approach mirrors standard plate count methods widely used to quantify environmental microbial load and is recommended for semi-quantitative assessment of fomite contamination levels in healthcare environments (Güner *et al*., 2025).

Culture and Isolation of Bacteria

To isolate viable bacteria, aliquots from undiluted swab suspensions were used to recover organisms present at low concentrations, while serially diluted suspensions were plated to obtain countable colonies and prevent overgrowth in samples with high bacterial loads. Nutrient agar was used for general-purpose growth, blood agar for detecting hemolytic and fastidious organisms, MacConkey agar for differentiating lactose-fermenting and non-lactose-fermenting Gram-negative bacilli, and Mannitol Salt Agar for selective recovery of staphylococci. All plates were incubated aerobically at 37°C for 24–48 hours.

Distinct colonies arising on each plate were examined for size, color, margin, elevation and hemolytic patterns before sub-culturing onto fresh media to obtain pure isolates. Preliminary classification of bacterial isolates was based on Gram staining, cell morphology and arrangement. These procedures conform to recognized environmental microbiology standards and reflect methodological practices documented in hospital surface surveillance research (Hiba *et al*., 2024).

Phenotypic Identification of Bacterial Isolates

Each purified isolate was further characterized using a suite of biochemical tests. Catalase and coagulase tests were performed to distinguish *Staphylococcus aureus* from coagulase-negative staphylococci. Oxidase testing was used to differentiate oxidase-positive isolates from oxidase-negative Enterobacterales. Additional biochemical tests such as indole, methyl red, Voges–Proskauer, citrate utilization, urease activity and triple sugar iron (TSI) reactions were employed to identify Gram-negative rods. Presumptive identification of *Enterococcus* species was supported by growth characteristics and bile esculin hydrolysis. The use of biochemical identification remains standard in many low-resource settings where molecular diagnostics are unavailable and has been consistently used in research examining bacterial contamination of hospital fomites (Dixit *et al*., 2023; Hiba *et al*., 2024).

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing (AST) was conducted using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar (Oxoid) in accordance with CLSI M100 (2023) guidelines. A standardized 0.5 McFarland inoculum was evenly spread on the agar surface before applying the antibiotic disks. The antibiotics evaluated in this study included penicillin (10 IU), gentamicin (10 µg), trimethoprim–sulfamethoxazole (1.25/23.75 µg, totaling 25 µg), ciprofloxacin (5 µg), ampicillin (10 µg), pefloxacin (5 µg), and ampiclox (ampicillin–cloxacillin)

at a disk potency of 30 µg, in addition to erythromycin (15 µg) and tetracycline (30 µg). The inoculated plates were incubated at 35–37°C for 16–18 hours, after which inhibition zone diameters were measured and interpreted following CLSI performance standards. Because CLSI does not provide specific breakpoints for ampiclox, interpretive criteria for ampicillin and oxacillin were applied as surrogates, consistent with diagnostic practices commonly used in Nigerian clinical microbiology laboratories. Multidrug resistance (MDR) was determined using the international definition proposed by Magiorakos *et al*. (2012), in which an isolate is considered MDR if it demonstrates non-susceptibility to at least one antimicrobial agent in three or more antibiotic classes. All results were analyzed using descriptive statistical methods.

Data Analysis

Data from colony counts, biochemical identification and antimicrobial susceptibility testing were recorded into structured laboratory data sheets and subsequently entered into Microsoft Excel for descriptive analysis. Microbial loads were expressed as cfu/mL. Frequencies and percentages were calculated to summarize the distribution of bacterial species and their susceptibility profiles. Because of the modest sample size and descriptive nature of the study, no inferential statistics were applied.

Ethical Approval

This study does not require ethics committee approval as it does not involve data collection from human or animal subjects.

RESULTS

All ten fomites sampled in this study yielded viable bacterial growth, although the level of contamination varied considerably across surface types. As shown in Table 1, the highest microbial load was recorded on the table top, with a count of 6.3×10^3 cfu/mL, followed by the drip stand at 5.0×10^3 cfu/mL. Light switches and bed rails also exhibited relatively high viable counts of 4.3×10^3 cfu/mL and 4.1×10^3 cfu/mL respectively. Moderate contamination levels were observed on the window handle, fan regulator, tourniquet and chair handle, with counts ranging from 3.1×10^3 to 3.7×10^3 cfu/mL. The file shelf showed the lowest bacterial load at 1.3×10^3 cfu/mL. These findings indicate that high-touch and frequently used surfaces generally harbored higher microbial burdens compared with less frequently contacted surfaces.

A total of twenty bacterial isolates were recovered from the sampled fomites. Phenotypic characterization revealed that the isolates comprised five bacterial groups: *Staphylococcus aureus*, *Enterococcus* spp., *Escherichia coli*, *Salmonella* spp. and *Klebsiella* spp. The distribution of isolates is presented in Table 2. *Staphylococcus aureus* was the most frequently isolated bacterium, accounting for 40% of all isolates. *Enterococcus* spp. and *E. coli* each constituted 20% of the isolates, while *Salmonella* spp. and *Klebsiella* spp. represented 10% each. Overall, Gram-positive cocci were isolated more frequently, although notable proportions of clinically important Gram-negative Enterobacterales were also recovered.

Table 1. Total Bacterial Count of Fomites in General Hospital Dutsin-Ma

Sample	Total Viable Count (cfu/mL)
Bed rails	4.1×10^3
File shelf	1.3×10^3
Door handle	3.0×10^3
Window handle	3.5×10^3
Drip stand	5.0×10^3
Tourniquet	3.3×10^3
Fan regulator	3.7×10^3
Light switch	4.3×10^3
Table top	6.3×10^3
Chair handle	3.1×10^3

Table 2. Occurrence of Bacteria Isolated from Fomites

Organism	Number of Isolates (%)
Staphylococcus aureus	8 (40.0%)
Enterococcus spp.	4 (20.0%)
Escherichia coli	4 (20.0%)
Salmonella spp.	2 (10.0%)
Klebsiella spp.	2 (10.0%)
Total	20 (100%)

The antimicrobial susceptibility patterns of the isolates showed substantial resistance across all antibiotic classes tested. A summary of susceptibility proportions is provided in Table 3. Among *S. aureus* isolates, the highest level of susceptibility was observed with pefloxacin (87.5%), followed by ciprofloxacin (75%). Susceptibility to erythromycin was moderate (50%), while susceptibility to gentamicin, trimethoprim–sulfamethoxazole and tetracycline was low, and no isolates were susceptible to ampicillin. Only 25% demonstrated susceptibility to ampiclox.

Enterococcus spp. also demonstrated susceptibility to ciprofloxacin and pefloxacin at 50% and 75% respectively, while susceptibility to other antibiotics remained low. None were susceptible to ampicillin or tetracycline. *E. coli* isolates showed complete susceptibility to ciprofloxacin and pefloxacin, with limited susceptibility to ampicillin (25%), ampiclox (25%) and erythromycin (25%). All *E. coli* isolates were resistant to gentamicin, trimethoprim–sulfamethoxazole and tetracycline.

Klebsiella spp. exhibited complete resistance to all antibiotics tested, with no observed susceptibility to any agent. *Salmonella* spp. showed full susceptibility to pefloxacin and partial susceptibility to ciprofloxacin and erythromycin, while demonstrating resistance to all remaining drugs. These patterns indicate widespread resistance among both Gram-positive and Gram-negative isolates, with fluoroquinolones generally retaining greater activity compared with other antibiotic classes.

Using the standard MDR definition, every isolate recovered in this study met the criteria for multidrug resistance. The resistance profiles of *S. aureus*, *Enterococcus* spp., *E. coli* and *Salmonella* spp. demonstrated non-susceptibility to antibiotics spanning at least three antimicrobial categories. *Klebsiella* spp. showed resistance across all antibiotic classes tested. The MDR classification for each organism type is summarized in Table 4.

Table 3. Antibiotic Susceptibility Pattern of Bacterial Pathogens Isolated from Fomites

Organism (n tested)	CN 10 (µg)	SXT 25 (µg)	CPX 5 (µg)	AMP 10 (µg)	PEF 5 (µg)	APX 30 (µg)	ERY 15 (µg)	TET 30 (µg)
S. aureus (n=8)	1 (12.5%)	1 (12.5%)	6 (75%)	0 (0%)	7 (87.5%)	2 (25%)	4 (50%)	1 (12.5%)
Enterococcus spp. (n=4)	1 (25%)	1 (25%)	2 (50%)	0 (0%)	3 (75%)	1 (25%)	1 (25%)	0 (0%)
E. coli (n=4)	0 (0%)	0 (0%)	4 (100%)	1 (25%)	4 (100%)	1 (25%)	1 (25%)	0 (0%)
Klebsiella spp. (n=2)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Salmonella spp. (n=2)	0 (0%)	0 (0%)	1 (50%)	0 (0%)	2 (100%)	0 (0%)	1 (50%)	0 (0%)

Key: AMP = Ampicillin; APX = Ampiclox; CN = Gentamicin; SXT = Trimethoprim–sulfamethoxazole; CPX = Ciprofloxacin; PEF = Pefloxacin; ERY = Erythromycin.

Table 4. Multidrug Resistance Classification of Isolates

Organism	No. of Isolates	Resistant Antibiotics (Phenotype)	Resistant Classes (≥3)	MDR Status
Staphylococcus aureus	8	AMP, APX, CN, SXT	β-lactam, aminoglycoside, sulfonamide	MDR
Enterococcus spp.	4	AMP, APX, CN, SXT, ERY	β-lactam, aminoglycoside, macrolide	MDR
Escherichia coli	4	AMP, APX, CN, SXT	β-lactam, aminoglycoside, sulfonamide	MDR
Klebsiella spp.	2	AMP, APX, CN, SXT, CPX, PEF, ERY	All tested classes	MDR
Salmonella spp.	2	AMP, APX, CN, SXT	β-lactam, aminoglycoside, sulfonamide	MDR

Key: AMP = Ampicillin; APX = Ampiclox; CN = Gentamicin; SXT = Trimethoprim–sulfamethoxazole; CPX = Ciprofloxacin; PEF = Pefloxacin; ERY = Erythromycin

DISCUSSION

This study provides comprehensive evidence that fomites within General Hospital Dutsin-Ma serve as reservoirs for clinically important multidrug-resistant (MDR) bacteria. The detection of *Staphylococcus aureus*, *Enterococcus* spp., *Escherichia coli*, *Klebsiella* spp. and *Salmonella* spp. on high-touch surfaces emphasizes the persistent risk of indirect transmission of healthcare-associated infections (HAIs) in the facility. These findings align with global evidence demonstrating that hospital surfaces frequently harbor pathogens capable of surviving for extended periods, thereby facilitating cross-contamination whenever hand hygiene lapses occur (Jabłońska-Trypuć *et al*., 2022).

The predominance of *S. aureus* (40%) in the present study is consistent with results from environmental surveillance studies in Africa, Europe and Asia, where *S. aureus* is consistently associated with contaminated patient-care surfaces (Hiba *et al*., 2024). Its high prevalence may be attributed to its ability to survive desiccation, form biofilms and persist on inanimate objects for days to weeks. The contamination of bed rails, switches and table tops, which are frequently touched by healthcare workers and patients, provides a plausible route for *S. aureus* dissemination in the facility. The implications are substantial because environmental *S. aureus* often reflects circulating clinical strains, including methicillin-resistant variants (MRSA), which have been implicated in outbreaks originating from surface contamination (Weber & Rutala, 2013).

The isolation of Enterobacterales—particularly *E. coli* and *Klebsiella* spp.—highlights a more concerning dimension of environmental contamination. These bacteria are not only common causes of HAIs but also efficient disseminators of antimicrobial resistance genes through plasmids and integrons. The presence of *E. coli* on 20% of fomites corresponds with findings from Nigerian and international studies that report widespread environmental contamination by Enterobacterales in healthcare and community environments (Yusuf *et al*., 2023; Dada *et al*., 2023). The occurrence of *Klebsiella* spp., though lower in frequency (10%), is epidemiologically significant because *Klebsiella* species frequently possess extended-spectrum β-lactamases (ESBLs) and carbapenemases, enabling them to withstand multiple antibiotic classes. The complete resistance demonstrated by *Klebsiella* isolates in this study mirrors patterns reported by Valzano *et al*. (2024), who documented multidrug-resistant *Klebsiella* in hospital plumbing and sanitary installations, indicating that environmental persistence of such organisms can be both extensive and difficult to eliminate using routine cleaning.

The recovery of *Salmonella* spp. from fomites further indicates the potential for enteric pathogens to contaminate patient-care surfaces, especially in settings where sanitation practices vary and waste handling systems may occasionally allow for cross-contamination. Several African studies have documented *Salmonella* on environmental and clinical surfaces, suggesting that hospital fomites may serve as incidental reservoirs that reflect lapses in environmental decontamination or the presence of asymptomatic carriers (Elmanama *et al*., 2023). Although *Salmonella* constituted only 10% of isolates here, its detection is epidemiologically important, as nontyphoidal *Salmonella* can persist in biofilms and survive in dry environments longer than many other Gram-negative bacteria.

The high microbial loads on the table top, drip stand and light switch observed in this study are noteworthy because these surfaces are repeatedly touched throughout clinical routines. Literature showed that contamination levels correlate strongly with contact frequency and cleaning lapses, suggesting that high-touch surfaces represent critical control points for interrupting transmission (Palmer & Onifade, 2019). Inadequately cleaned drip stands and switches have previously been implicated in outbreaks involving *S. aureus*, *Enterococcus* spp. and Enterobacterales (Kramer *et al*., 2006), showing the importance of intensified cleaning and monitoring protocols.

Antimicrobial susceptibility results revealed extensive resistance patterns, particularly to β-lactams, aminoglycosides and trimethoprim–sulfamethoxazole. These findings are consistent with national and regional reports describing increasing antimicrobial resistance in both clinical and environmental isolates (Okeke *et al*., 2023; Olayinka *et al*., 2022). The universal resistance to ampicillin, ampiclox and penicillin across all bacterium is not unexpected, given the widespread misuse of β-lactams in community and hospital settings, which has contributed significantly to selective pressure.

Similar resistance trends were reported by Yusuf *et al*. (2023), who found high-level resistance to β-lactams among fomite isolates in northern Nigeria.

Fluoroquinolones—particularly ciprofloxacin and pefloxacin—retained moderate activity against several species, although resistance was still evident in *Klebsiella* isolates. Ciprofloxacin susceptibility remained high for *S. aureus*, *Enterococcus* spp. and *E. coli*, consistent with patterns observed in prior Nigerian fomite and wastewater studies (Yusuf *et al*., 2023). However, the emergence of fluoroquinolone resistance globally is concerning, as it reduces reliance on key therapeutic options for common infections. *Klebsiella* resistance to all antibiotics tested in the present study, including fluoroquinolones, reflects an alarming trend also documented in global AMR surveillance, where *Klebsiella pneumoniae* ranks among the top priority pathogens due to increasing resistance to nearly all major antibiotic classes (WHO, 2025).

The most striking finding of this study is the classification of 100% of isolates as multidrug-resistant. This level of MDR prevalence is higher than many previously published environmental surveillance reports, although comparable trends have been observed in some resource-limited health systems where antimicrobial stewardship programs are less robust (Dixit *et al*., 2023; Hiba *et al*., 2024). The reasons for such high MDR burden are multifactorial and may include inadequate surface cleaning practices, intermittent use of disinfectants, improper dilution of cleaning solutions, low hand hygiene compliance, and persistent antibiotic pressure within the hospital and community environments. MDR organisms colonizing fomites pose an increased risk for transmission to patients, particularly those with comorbidities, invasive devices or prolonged hospital stays, as well as to healthcare workers who frequently interact with these surfaces.

The 100% MDR prevalence observed in this study is consistent with reports from Nigerian and global environmental surveillance studies showing that hospital fomites frequently harbor bacteria already resistant to multiple first-line antibiotics probably due to prolonged antimicrobial pressure and widespread β-lactam misuse (Yusuf *et al*., 2023). Many of the recovered species—particularly *Klebsiella* spp., *E. coli* and *Enterococcus* spp.—are known to possess intrinsic or plasmid-mediated resistance determinants, which increases the likelihood of MDR classification when applying the internationally accepted definition of Magiorakos *et al*. (2012). Similar high MDR proportions have been documented in environmental isolates from LMIC hospitals, reflecting both selective pressure and the survival advantage of resistant strains on high-touch surfaces (Jabłońska-Trypuć *et al*., 2022).

CONCLUSION

This study showed that high-touch fomites in General Hospital Dutsin-Ma are contaminated with clinically important bacteria, including *S. aureus*, *Enterococcus* spp., *E. coli*, *Klebsiella* spp. and *Salmonella* spp., with all isolates exhibiting multidrug resistance. The widespread resistance—especially universal resistance to penicillin and reduced susceptibility across multiple antibiotic classes—indicates a significant environmental reservoir of MDR bacteria within the hospital. These findings highlighted the need to strengthen infection prevention and control measures, including improved surface cleaning, strict hand hygiene, and routine environmental monitoring. Enhanced antimicrobial stewardship is also essential to limit further resistance development and reduce the risk of transmission of MDR pathogens in healthcare settings.

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