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Research Article

Hospital Fomites as Reservoirs of Multidrug-Resistant Enterobacteriaceae: Evidence from a Surgical Ward in Dutsin-Ma, Katsina State, Nigeria

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ABSTRACT
Hospital fomites are increasingly recognized as reservoirs of multidrug-resistant (MDR) pathogens, contributing to the transmission of hospital-acquired infections in resource-limited settings. This study assessed the prevalence and antibiogram profiles of enteric bacteria isolated from high-touch surfaces in the surgical ward of General Hospital, Dutsin-Ma, Katsina State, Nigeria. Twenty swab samples were collected from fomites including beds, sinks, door handles, stethoscopes, drip stands, and surgical instruments. Thirty-eight bacterial isolates were recovered: *Escherichia coli* (50.0%), *Klebsiella* spp (23.68%), *Salmonella* spp (10.53%), *Proteus* spp (10.53%), and *Shigella* spp (5.26%). Antibiotic susceptibility testing revealed high resistance across isolates. *Escherichia coli* showed 94.8% resistance to amoxicillin, 84.2% to chloramphenicol, and 68.4% to augmentin. *Klebsiella* spp exhibited 100% resistance to augmentin, ciprofloxacin, and chloramphenicol. *Salmonella* spp and *Proteus* spp were resistant to 100% of amoxicillin and augmentin, while *Shigella* spp showed complete resistance (100%) to all tested antibiotics. Limited susceptibility was observed: gentamicin inhibited 47.4% of *E. coli*, 66.7% of *Klebsiella* spp and 25–50% of *Salmonella* spp and *Proteus* spp while ofloxacin was effective against 22.2% of *Klebsiella* spp and 50% of *Salmonella* and *Proteus* spp. Some isolates exhibited multidrug resistance (MDR), with *Proteus* and *Salmonella* spp resistant to up to eight antibiotics, and *Shigella* spp to nine antibiotics. These findings underscore the persistence of MDR enteric bacteria on hospital fomites and their potential role in nosocomial infection transmission. Strengthened infection prevention strategies, rational antibiotic use, and routine environmental surveillance are urgently needed to curb the spread of resistant pathogens in Nigerian healthcare facilities.

Keywords: Enteric bacteria; Hospital-acquired infections; Hospital fomites; Multidrug resistance; Nosocomial infections

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INTRODUCTION

The global escalation of antimicrobial resistance (AMR) represents one of the foremost threats to public health (Aljeldah, 2022; Antimicrobial Resistance Collaborators, 2022). Recent systematic reviews showed that infections caused by multidrug-resistant (MDR) pathogens particularly in healthcare-associated settings have surged by more than 40 %,

with hospital-acquired infections contributing disproportionately to morbidity, mortality, and healthcare costs (Andrea *et al*., 2025). Among these pathogens, enteric bacteria such as *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus* spp, *Salmonella* spp and *Shigella* spp are of particular concern, due to their high capacity for resistance acquisition and their role in both community and nosocomial infections.

Hospital environments including high-touch surfaces or fomites are increasingly recognized as important reservoirs of MDR enteric and Gram-negative bacteria. In surgical ward, fomites act as potential sources for pathogen transmission via healthcare workers, patients, and even inanimate vectors (Nwankwo, 2012). Studies in sub-Saharan Africa reported persistently high contamination rates of environmental surfaces, medical files, surgical instruments, doorknobs, and sinks with MDR enteric bacteria, despite cleaning protocols (Shemse *et al*., 2020). For example, in Tanzania, more than 60 % of Gram-negative isolates from hospital surfaces exhibited MDR, including cephalosporin and carbapenem resistance (Joachim *et al*., 2023).

In Nigeria, environmental and One-Health studies are confirming the widespread circulation of antibiotic resistance genes (ARGs) and resistant strains in both hospital and non-clinical settings. A recent meta-analysis demonstrated prevalent of ARGs (such as bla_{NDM-1}, bla_{KPC}, and ESBL genes) in fomites and shared environmental waste, highlighting the failure of disinfection routines and the risk to public health (Ibrahim *et al*., 2023). Additionally, examples from tertiary healthcare facilities have documented frequent isolation of MDR enteric bacteria from surfaces, with resistance particularly high against β-lactams, aminoglycosides, and other common antibiotics in clinical use (Bassey *et al*., 2022).

Despite widespread recognition of these risks, there remains a paucity of recent data from the northern regions of Nigeria, particularly from surgical wards, where vulnerable patients' populations are at higher risk of acquiring nosocomial infections. Fomites in surgical wards such as bed rails, stethoscopes, door handles, drip stands, sinks, and equipment face constant contact by multiple users and may serve as persistent reservoirs for MDR enteric pathogens. Therefore, this study was conducted in the surgical ward of General Hospital, Dutsin-Ma, Katsina State, Nigeria to determine if fomites in the hospital are potential reservoir of MDR enterobacteriaceae.

MATERIALS AND METHODS

Study Area

The study was conducted at the surgical ward of General Hospital, Dutsin-Ma, Katsina State, Nigeria. Dutsin-Ma is located approximately 60 km southeast of the state capital, Katsina in a semi-arid region characterized by distinct wet and dry seasons. The General Hospital is a secondary healthcare facility serving both urban and rural populations, providing essential medical and surgical care. Like many hospitals in resource-limited settings, the facility faces challenges related to high patient turnover, limited infection prevention infrastructure, and increased risk of hospital-acquired infections (HAIs).

Ethical Approval

Approval for this study was obtained from the Katsina State Ministry of Health Research and Ethics Committee (Approval No: MOH/ADM/SUB/1152/1/1062). All procedures were conducted in compliance with the ethical standards for research involving microbial sampling in healthcare environments.

Sample Collection

A total of 20 swab samples (two per fomite) were aseptically collected in February, 2025 from frequently touched surfaces in the surgical ward, including beds, table, door handle, sinks, floor, stethoscopes, drip stands, light switches, forceps and scissors. Sterile cotton-tipped swabs moistened with sterile physiological saline (0.85% NaCl) were used to sample an area of approximately 25 cm^2 from each surface, in accordance with standardized hospital environmental surveillance protocols (World Health Organization, 2016). Each swab was immediately placed into sterile transport tubes and transported on ice to the Microbiology Laboratory, Department of Microbiology, Federal University Dutsin-Ma, within one hour of collection for further analysis.

Culture Media Preparation

Standard bacteriological media including Nutrient agar, MacConkey agar, Eosin Methylene Blue (EMB) agar and Salmonella-Shigella (SS) agar were prepared according to the manufacturer's instructions (Oxoid, UK). Media were sterilized by autoclaving at 121 °C for 15 minutes and allowed to

cool to 45–50 °C before pouring into sterile Petri dishes. Plates were incubated at 37 °C for sterility checks prior to inoculation.

Isolation and Identification of Bacteria

Swabs were first enriched in sterile nutrient broth and incubated at 37 °C for 18–24 h. Aliquots from enriched cultures were streaked onto MacConkey agar, Eosin Methylene Blue agar and Salmonella-Shigella agar plates for selective isolation of enteric bacteria. Plates were incubated aerobically at 37 °C for 24 h after which colonies were examined for characteristic morphology. Distinct colonies were sub-cultured to obtain pure isolates, which were subsequently preserved on nutrient agar slants at 4 °C prior to further Gram staining, biochemical and antibiotic susceptibility testing. Biochemical identification followed standard protocols described by Cheesbrough (2006) and recent Clinical and Laboratory Standards Institute (CLSI, 2024) recommendations. The tests performed included catalase, oxidase, indole, citrate utilization, urease, motility, triple sugar iron (TSI), methyl red, and Voges-Proskauer (MR-VP). Identification was confirmed using Bergey's Manual of Systematic Bacteriology and comparison with reference patterns.

Antibiotic Susceptibility Testing (AST)

Bacterial inocula were standardized using the 0.5 McFarland standard, equivalent to approximately 1.5 × 10^8 CFU/mL. The turbidity of overnight cultures in nutrient broth was visually compared to the McFarland standard or adjusted using sterile saline. Optical density was verified at 590 nm, ensuring consistent inoculum density for antibiotic susceptibility testing (CLSI, 2024). Antibiotic susceptibility profiles were determined using the Kirby-Bauer disc diffusion method on Mueller-Hinton Agar, following CLSI guidelines (CLSI, 2024). Standardized bacterial suspensions were inoculated onto Mueller-Hinton Agar plates using sterile swabs. Antibiotic discs (Oxoid, UK) were aseptically placed on the inoculated plates, which were then incubated at 37 °C for 18–24 h. The antibiotics tested included septrin (Trimethoprim-sulfamethoxazole, 30 µg), chloramphenicol (30 µg), sparfloxacin (10 µg), ciprofloxacin (30 µg), amoxicillin (30 µg), augmentin (Amoxicillin-Clavulanic Acid, 30 µg), gentamicin (10 µg), pefloxacin (10 µg), tarivid (Ofloxacin, 10 µg) and streptomycin (10 µg). Zones of inhibition were measured in millimeters and interpreted according to CLSI breakpoints (CLSI, 2024). Isolates resistant to ≥3 different antibiotic classes were classified as multidrug resistant (MDR) (Magiorakos *et al*., 2012).

Data Analysis

Data were analyzed descriptively to determine the prevalence of bacterial species across fomites and their resistance profiles. The frequency and percentage of resistant isolates were calculated. Results were presented in tables to illustrate species distribution, antibiotic susceptibility, and MDR patterns. Statistical significance was set at $p < 0.05$.

RESULTS

Prevalence of enteric bacteria on hospital fomites

A total of 20 swab samples collected from various fomites in the surgical ward of General Hospital Dutsin-Ma yielded 38 bacterial isolates. The bacterial isolates belonged to five enteric bacterial species: *Escherichia coli*, *Shigella* spp, *Salmonella* spp, and *Klebsiella* spp and *Proteus* spp. *Escherichia coli* was recovered from all surfaces while *Shigella spp* was least isolated overall. Among the fomites sampled, the sink was the most (25%) frequently contaminated (5 isolates) while the forceps and scissors recorded the lowest (10%) contamination (2 isolates). Table 1 showed the distribution of isolates by fomite type.

Percentage occurrence of bacterial isolates: The percentage occurrence of each species among the total isolates was calculated to determine species distribution. *Escherichia coli* was the most frequently isolated bacterium (50%), followed by *Klebsiella* spp (23.68%), *Salmonella* spp (10.53%), Proteus spp (10.53%) and *Shigella* spp (5.26%) (Table 2).

Antibiotic Resistance Profiles

Antibiotic susceptibility testing demonstrated widespread resistance (Table 3). *Escherichia coli* showed 94.8% resistance to amoxicillin, 84.2% to chloramphenicol, and 68.4% to augmentin. *Klebsiella* spp exhibited 100% resistance to augmentin, ciprofloxacin, and chloramphenicol. *Salmonella* spp and *Proteus* spp were resistant to 100% of amoxicillin and augmentin, while *Shigella* spp showed complete resistance (100%) to all tested antibiotics. Limited susceptibility was observed: gentamicin inhibited 47.4% of *E. coli*, 66.7% of *Klebsiella* spp and 25–50% of *Salmonella* spp and *Proteus* spp, while ofloxacin was effective against

22.2% of *Klebsiella* spp and 50% of *Salmonella* and *Proteus* spp.

Multidrug Resistance

Some isolates demonstrated resistance to ≥3 antibiotic classes, qualifying as multidrug resistant (MDR). Among these, *Proteus* spp and S*almonella* spp isolates resisted up to eight different antibiotics, whereas *Shigella* spp isolates demonstrated the highest resistance level, showing resistance to nine antibiotics across multiple antimicrobial classes (Table 4).

Table 1. Distribution and prevalence of Enteric Bacterial Isolates from Fomites in Surgical Ward

Fomites	***Klebsiella* spp n (%)**	***Proteus* spp n (%)**	***Salmonella* spp n (%)**	***Shigella* spp n (%)**	***Escherichia coli* n (%)**
Table	1 (5)	1 (5)	0 (0)	0 (0)	2 (10)
Floor	0 (0)	0 (0)	2 (10)	0 (0)	2 (10)
Bed	0 (0)	2 (10)	0 (0)	0 (0)	2 (10)
Door handle	2 (10)	0 (0)	2 (10)	0 (0)	1 (5)
Sink	0 (0)	1 (5)	0 (0)	2 (10)	2 (10)
Light switch	2 (10)	0 (0)	0 (0)	0 (0)	2 (10)
Forceps	0 (0)	0 (0)	0 (0)	0 (0)	2 (10)
Scissors	0 (0)	0 (0)	0 (0)	0 (0)	2 (10)
Drip stands	2 (10)	0 (0)	0 (0)	0 (0)	2 (10)
Stethoscope	2 (10)	0 (0)	0 (0)	0 (0)	2 (10)
Total isolates	**9 (45)**	**4 (20)**	**4 (20)**	**2 (10)**	**19 (95)**

Table 2. Percentage occurrence of bacterial isolates

Bacterial Isolates	**Frequencies**	**Percentage Occurrence (%)**
Escherichia coli	19	50
Klebsiella spp	9	23.68
Shigella spp	2	5.26
Salmonella spp	4	10.53
Proteus spp	4	10.53
Total	38	100

Table 3. Antibiotic Resistance Profiles of Bacterial Isolates

Antibiotic	***Escherichia coli* n (%)**	***Klebsiella* spp n (%)**	***Salmonella* spp n (%)**	***Shigella* spp n (%)**	***Proteus* spp n (%)**
Septrin	16 (84.2%)	7 (77.8%)	4 (100%)	2 (100%)	2 (50%)
Chloramphenicol	16 (84.2%)	9 (100%)	3 (75%)	2 (100%)	4 (100%)
Sparfloxacin	12 (63.6%)	7 (77.8%)	2 (50%)	2 (100%)	2 (50%)
Ciprofoloxacin	14 (73.7%)	9 (100%)	2 (50%)	2 (100%)	4 (100%)
Amoxicillin	18 (94.8%)	8 (88.9%)	4 (100%)	2 (100%)	4 (100%)
Augmentin	13 (68.4%)	9 (100%)	4 (100%)	2 (100%)	4 (100%)
Gentamycin	9 (47.4%)	6 (66.7%)	1 (25%)	2 (100%)	2 (50%)
Perfloxacin	17 (89.5%)	7 (77.8%)	3 (75%)	2 (100%)	4 (100%)
Tarivid	0 (0.0)	2 (22.2%)	2 (50%)	2 (100%)	2 (50%)
Streptomycin	11 (57.9%)	8 (88.9%)	2 (50%)	2 (100%)	4 (100%)

Table 4. Antibiotic Resistance Patterns of Multidrug-Resistant (MDR) Isolates

Isolate code	Bacterial species	No of Antibiotics Resisted	Resistance Pattern
E1	*Escherichia coli*	6	SXT, CH, SP, CPX, AM, PEF
E3	*Escherichia coli*	5	SXT, CH, CPX, AM, AU
K5	*Klebsiella* spp	7	SXT, CH, SP, CPX, AM, AU, PEF
K8	*Klebsiella* spp	5	SXT, CH, SP, CPX, AM,
SAL 1	*Salmonella* spp	8	SXT, CH, SP, CPX, AM, AU, PEF, S
SAL 4	*Salmonella* spp	7	SXT, CH, CPX, AM, AU, CN, PEF
SH1	*Shigella* spp	7	SXT, CH, SP, CPX, AM, AU, PEF
SH2	*Shigella* spp	9	SXT, CH, SP, CPX, AM, AU, CN, PEF, S,
P2	*Proteus* spp	8	SXT, CH, AM, AU, CN, PEF, OFX, S
P3	*Proteus* spp	8	SXT, CH, SP, CPX, AM, AU, PEF, S

Keys: SXT= Septrin, CH=Chloramphenicol, SP= Sparfloxacin, CPX= Ciprofloxacin, AM= Amoxicillin, AU= Augmentin, CN= Gentamicin, PEF= Pefloxacin, OFX= Tarivid, S= Streptomycin

DISCUSSION

Among the 38 isolates recovered, *Escherichia coli* (50.0%) was the most prevalent species, followed by *Klebsiella* spp (23.68%). *Salmonella* spp and *Proteus* spp accounted for 10.53% while *Shigella* spp (5.26%) was least frequent. The predominance of *E. coli* and *Klebsiella* spp mirrors findings from other Nigerian studies. For example, Bassey *et al*. (2022) reported *E. coli* as the leading isolate from fomites in Calabar healthcare facilities, while Adekanmbi *et al*. (2024) noted high carriage of *K. pneumoniae* among patients in Ibadan. Similar distributions were documented in Kenya, where high-touch surfaces yielded *E. coli* and *K. pneumoniae* as dominant contaminants (Odoyo *et al*., 2023). The presence of *Shigella* spp on sinks and moist fomites also aligned with earlier reports that wet environments favor survival and dissemination of enteric bacteria due to biofilm formation (Otter *et al*., 2014).

The recovery of multiple bacterial species from stethoscopes, drip stands, and beds highlights the role of frequently handled equipment in pathogen transmission. This observation corroborated studies in Ethiopia and Sudan, where stethoscopes and bed rails were found to harbor MDR Enterobacterales, reflecting the risks posed by inadequate disinfection of medical devices (Darge *et al*., 2019; Abdelgader *et al*., 2024).

Antibacterial susceptibility testing revealed high resistance rates across all isolates. *Escherichia coli* and *Klebsiella* spp demonstrated more than 80% resistance to amoxicillin, augmentin, chloramphenicol, ciprofloxacin, and pefloxacin. These resistance patterns are consistent with reports from southwestern Nigeria, where environmental Enterobacterales showed similar profiles, particularly to β-lactams and fluoroquinolones (Adekanmbi *et al*., 2024). *Shigella* spp exhibited 100% resistance to all tested antibiotics, paralleling the findings of Nwankwo (2012), who observed pan-resistance among fomite isolates from hospital environments in Kano. The limited susceptibility of some isolates to ofloxacin (tarivid) and gentamicin agreed with earlier reports that fluoroquinolones and aminoglycosides may retain partial activity against environmental Enterobacterales (Okeke *et al*., 2000; Iroha *et al*., 2008).

However, increasing resistance to these agents, as shown in this study, indicates narrowing therapeutic options for managing nosocomial infections in surgical settings. The high prevalence of resistance to augmentin and chloramphenicol reflects patterns seen in regional surveillance studies, where misuse and over-the-counter availability of antibiotics drive resistance selection (Ventola, 2015; Albukhari, 2025). Importantly, the resistance profiles observed here overlap with those documented in clinical isolates from Nigerian patients, suggesting possible environmental-to-clinical transmission pathways (Adekanmbi *et al*., 2024).

Some isolates in this study qualified as MDR, with *Klebsiella* spp and *Salmonella* spp resistant to up to eight antibiotics, and *Shigella* spp showed resistant to nine antibiotics. These findings aligned with the MDR definitions proposed by Magiorakos *et al*. (2012) and reflect trends reported across sub-Saharan Africa, where MDR prevalence among environmental Enterobacterales exceeds 70% (Tilahun *et al*., 2024).

The resistance profile of *Shigella* spp (septrin, chloramphenicol, sparfloxacin, ciprofloxacin, amoxicillin, augmentin, gentamicin, pefloxacin and streptomycin) is particularly concerning, as it indicates resistance to multiple antibiotic classes, leaving few options for treatment. Comparable pan-resistance has been documented in hospital environments in Ghana and Tanzania, where MDR isolates carried ESBL and carbapenemase genes such as bla_{CTX-M} and bla_{NDM-1} (Mshana *et al*., 2009; Sampah *et al*., 2023). The phenotypic data from this study suggest similar resistance mechanisms may be circulating in the study setting, although molecular confirmation is required.

CONCLUSION

This study concludes that surgical ward fomites at General Hospital, Dutsin-Ma, are contaminated with multidrug-resistant enteric bacteria, predominantly *E. coli* and *Klebsiella* spp. The high resistance rates to commonly prescribed antibiotics highlight a critical risk for hospital-acquired infections and treatment failure. More so, strengthening infection prevention practices, implementing routine environmental surveillance, and promoting rational antibiotic use are urgently required to limit pathogen transmission and mitigate the growing antimicrobial resistance burden in healthcare settings.

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