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Bacterial Isolation, Identification and Antibiogram of Frequently Used Fomite in a Tertiary Hospital in Ado-Ekiti, Ekiti State, Nigeria

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Article history: Received 17 October 2024, Reviewed 27 November 2024, Accepted for publication 10 December 2024

Abstract

Background: Nosocomial infections or hospital-acquired infections (HAI) are infections which present within 48 hours of hospital admission, within three days of discharge, or postoperatively within a month. These infections are responsible for increased morbidity and mortality and treatment expenses due to extended stays in hospitals. This study identifies pathogens on fomites in a Multi-System Hospital, Ado-Ekiti, Ekiti State.

Method: A total of 90 fomite samples, were collected from various sources within the hospital using swab sticks and sent to the lab for the purpose of identifying the infectious agents. After being inoculated on MacConkey, blood, sabouraud, and chocolate agar, the samples were incubated for 18 to 24 hours at 37 °C.

Results: The prevalence rate of 47.8% was recorded in this study. Microbiology laboratory and accident and emergency units had the most contamination with 8.9% respectively while theatre unit and general outpatient department had the least contamination with 4.4% respectively. The door/drawer and fridge handles had the highest contamination rate of 16.7%, 3.3% were from mouse/keyboard, 7.8% were from sink, 6.7% were from tap handle, 2.2% were from safety cabinet, 2.2% were from work bench, 4.4% were from patients' bed, 3.3% were from oxygen tank and operating light respectively, while blood cell counter had the least contamination rate of 1.1%.

Conclusion: This study has revealed that inanimate surfaces from the hospital harbour member Enterobacteriaceae. It establishes the fact that Nosocomial infections still persist within our healthcare setting and proves that fomites are possible vehicles of transmission within healthcare facilities.

Keywords: Nosocomial infection, fomites, healthcare facility, antibiogram.

How to cite this article:

Agu CC, Aaron SZ, Akinseye JF, Eya CP, Ogunfolakan OO, Egbebi AH, Ogunyemi OM, Oluboyo BO. Bacterial Isolation, Identification and Antibiogram of Frequently Used Fomite in a Tertiary Hospital in Ado-Ekiti, Ekiti State, Nigeria. The Nigerian Health Journal 2024; 24(4):1799 – 1808.
https://doi.org/10.60787/tnhj.v24i4.934

Introduction

Hospital-acquired infections (HAI), also known as nosocomial infections, are defined as illnesses that appear three days after discharge, 48 hours after hospital admission, or one month after surgery.[1] The infection should not be active or incubating during admission; in other words, the infections should be acquired during contact with healthcare.[1,2] About 10-20% of admitted patients acquire nosocomial infections in India.[3] The prevalence of nosocomial infections in Africa is relatively high, but the available data are limited. The prevalence of nosocomial infections in Africa was estimated to be 12.2% [95% confidence interval (CI), 9.8–14.8%] in a systematic review and meta-analysis of studies carried out between 2000 and 2018.[4] A meta-analysis of studies conducted in Nigeria revealed that the overall prevalence of nosocomial infections in the country was 20.2%.[5]

Intensive care units (ICU) continue to be the principal locations for healthcare-associated infections (HAIs), accounting for 25% of all hospital infections.[6] These infections are responsible for increased morbidity and mortality and treatment expenses due to extended stays in hospitals.[7,8,9] In 2019, the World Health Organization recognized six pathogens as significant in nosocomial infections: *Pseudomonas aeruginosa, Acinetobacter baumannii*, *Escherichia coli, Streptococcus pneumoniae, Klebsiella pneumoniae,* and *Staphylococcus aureus*.[10] Many inanimate surfaces and medical equipment, including ultrasound machines and bedrails, have been reported to harbor drug resistant pathogens in healthcare facilities.[11,12]

Fomites are inanimate items that get infected by microorganisms and act as a conduit for the spread of those organisms. Most infectious outbreaks associated with inanimate objects result from sterile artifacts contaminated by microorganisms.[13] Fomites, when in regular contact with humans or the natural habitats of pathogenic organisms, are a major source of infectious disease transmission.[14] The outbreak of community acquired infections, and nosocomial infections have been found to be aided by surface bio-contamination of fomites.[15] Fomites play significant role in the transmission of many diseases, but it is unclear how much fomite reservoirs influence the total incidence of nosocomial or environmental infections.

Surface colonization of various inanimate objects in a hospital setting by microorganism has been reported as a potential vehicle for the transmission of nosocomial pathogens.[16] In Nigeria, proactive programmes are not in place to curb the spread of nosocomial infections through fomites.

Microorganisms such as *Streptococcus* spp., *Acinetobacter* spp., *enterococci, Pseudomonas aeruginosa*, Coagulase negative *staphylococci*, *Staphylococcus aureus*, *Bacillus cereus*, *Legionella*, and members of the *Enterobacteria* family are among the organisms that are frequently involved in nosocomial infections. Medical interventions, poor health standards of the hospital environment can cause HAIs. Poor personal hygiene of hospital staff and patients' poor practice of personal hygiene among hospital staff and patients can also cause HAIs.[17] However, the major/leading cause of HAIs is lack of compliance to health and safety guidelines of hospitals.[18]

In today's healthcare and community settings, there is a growing concern regarding the presence and spread of pathogenic bacteria on frequently touched surfaces, or fomites, such as doorknobs, keyboards, and countertops. The lack of comprehensive data on the types of bacteria presents on these surfaces, their identification, and their antibiotic resistance profiles poses significant challenges in infection control and prevention efforts. Therefore, there is a critical need to systematically isolate, identify, and perform antibiogram analysis of bacteria found on commonly touched surfaces to understand the potential risks they pose and to develop effective strategies to mitigate the spread of infectious agents. The aim of this study is to isolate, identify, and assess the antibiotic susceptibility patterns of bacteria found on frequently used fomites in a Multi-System Hospital, Ado-Ekiti, Ekiti State.

Method

Study area

This study was carried out at Afe Babalola University Multi-System Hospital, Ado-Ekiti, the capital city of Ekiti State, Nigeria. It is the headquarters of the Ekiti central senatorial district, southwest, Nigeria. The total land area is 293 km^2 (113 square millilitres). Ado Ekiti is the Ekiti state capital, and a Local Government Headquarter in one of the sixteen Local Government Area in Ekiti state. It lies within Latitude 7°10' and 7°45' north of the Equator and Longitudes 5°10' and 5°28' east of the Greenwich meridian.[19] Ekiti State is a State in southwestern Nigeria, bordered to the north by Kwara State, to the northeast by Kogi state, to the south and southeast by Ondo State, and to the west by Osun State.

Ethical Approval

Ethical approval was obtained from the Multisystem Hospital with ethical approval number AB/EC/24/06/053

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Sample size

The sample size for this study was calculated using Cochran's formular (Cochran *et al.,* 1954) [20]. A total of 90 samples were used for this study.

$N = \frac{Z^2 \times P \times (1-P)}{C^2}$

N = required sample size
Z = confidence level (95%)
P = estimated prevalence (7%) (Garba *et al*., 2018) [21]
C = margin of error at 5%

$N = \frac{196^2 \times 0.07 \times (1-0.07)}{0.05^2} = 90$

Sample collection

Each sample was collected using a sterile swab stick by swabbing the surface of the fomites with the swab stick which was dipped into sterile peptone water. The samples were labelled and coded appropriately. All samples were then transported to the laboratory of the Department of Medical Laboratory Science.

Sampling Areas

Samples were collected from the haematology, chemical pathology, microbiology, phelebotomy, theatre unit, accident and emergency and general outpatient department.

Sample processing

First, we sterilized all the materials we used and autoclaved at 121°C for 15 minutes. Incubators, inoculating and growth chamber were also fumigated with 40% formaldehyde. Work benches were disinfected by cotton wool previously moistened with 70% ethanol.

Inoculation, Isolation, Characterization and Identification

The swab sticks for bacterial and fungal culture were incubated in peptone water for 8hrs then inoculated on MacConkey, blood agar, sabouraud dextrose agar and chocolate agar. They were incubated at 37°C for 18-24hours and those for fungal screening were inoculated on sabouraud dextrose agar and incubated at room temperature for 72hours.

Culture examination

At the end of incubation period, the plates were examined for growth and the morphological appearance of the micro-organism on the agars used was observed. The following biochemical tests were carried out for characterization and identification of the organisms; Gram staining, catalase, coagulase, citrate, urea deposition, indole, motility, sugar fermentation and triple sugar iron agar (TSIA).

Gram Staining

A heat fixed smear of 18-24 hours old culture was prepared on a clean microscope slide. The smear was stained with crystal violet for 30-60 seconds; after which the stain was rinsed off with distilled water under a running tap. Logol's iodine, a mordant was added to intensify stain for 60 seconds and was rinsed off with distilled water. 95% ethanol was added to the slides as a decolourizer for 10-15 seconds and rinsed off under a running tap. Safranin O' a counter stain was added to the smear for 30 seconds, rinsed off with distilled water. The slide was allowed to air dry and then observed under × 100 oil immersion objective binocular microscope.

Catalase test

2-3 ml of hydrogen peroxide solution was poured into test tube and sterile wooden stick is used to remove several colonies of the test organism and immerse in the hydrogen peroxide solution. Immediate production of bubbles indicates a positive result, while no production of bubbles indicates a negative result.

Coagulase test

A drop of distilled water was placed on each end of clean grease-free slide with the aid of sterile inoculating loop, a colony of the test organism was picked aseptically using sterile inoculating loop and the colony was emulsified on the drop of distilled water. An inoculating loop was used to add a loopful of plasma suspension and was checked for clumping of organisms. No plasma was added to the second suspension thus this is used to differentiate any granular appearance of the organism from true coagulase clumping. Clumping of the organism indicates a positive result, while no clumping indicates a negative result.

Motility test

For the motility test, culture broth was prepared. In preparation of culture broth, double strength of nutrient broth was prepared, it was allowed to settle, and the broth was gently dispensed into the test tube, the test tubes were then sterilized and after sterilization the broth were allowed to cool and the bacteria was inoculated into the broth and incubated at 37°C for 24 hours. After incubation period, clean glass cavity slide and cover slip were used in which Vaseline was applied to all edges of the cover slip, this allows the adhesion of the cover slip to the cavity slide. The culture broth inside each test tube was shaken and inoculating loop was used to transfer two loopful of the culture broth into the cavity slide and covered with cover slip. The cavity slide was inverted quickly for the drop not to run off to one side and if it was examined under × 40 objective microscope.

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Indole test

These was performed by growing the isolates in 10 ml sterile Tryptone Water (Oxoid, Basingstoke, UK) for 24 hours at 37°C. Kovacs' reagent (0.5 ml) was then added to the culture using a pipette. The test tube was shaken and examined after one minute. The presence of Indole was detected by the appearance of a red layer in the medium while its absence was denoted by a yellow layer.

Citrate utilization test

Two sets of slants of Simmons citrate agar were prepared in bijou bottles, with the aid of sterile straight wire normal saline suspension of the test organisms were streaked on the slants and were incubated at 37°C for 48 hours. A bright blue colour on the agar slants in the tubes inoculated which indicated positive result.

Urease test

A little of the culture of the test bacteria was streaked over the surface of the agar slant of urease test medium with phenol red as indicator and incubated at 37°C for 7 days. A control of the basal medium containing no added urea was equally inoculated. A colour change of the medium from yellow to pink or red was an indication of a positive result and no colour change indicate a negative result.

Oxidase test

This test was done to identify *Pseudomonas aeruginosa*. The oxidase reagent was prepared by dissolving 0.1 g of tetramethyl-p-phenylenediamine in 10 ml of sterile distilled water. A fresh culture of the isolate to be tested was prepared. Clean Whatman No.2 filter paper was placed in Petri dish and three drops of the freshly prepared oxidase reagent added to it. The culture of the isolate was smeared across the impregnated paper with a platinum loop. A positive reaction was indicated by the appearance of a dark purple colour on the paper within 10 seconds

Triple Sugar Iron Agar Test (TSIA)

A wire loop of bacteria isolate culture was inoculated by stabbing into the Triple sugar iron gel and streaking over the surface of a slope of the agar which was incubated overnight at 37°C for 18-24 hours and was examined for sugar fermentation (color change at the but and slant), gas production and hydrogen sulphide production.

Results

Distribution of Microorganisms Isolated from fomites

Table 1 showed the distribution of microorganisms and isolates from fomites in the study area. The results obtained showed that a total of 43 (47.8%) organisms were isolated from this study comprising *Bacillus spp* (4.4%), *Candida spp* (2.2%), *Citrobacter fuendi* (5.6%), *Escherichia coli* (8.9%), *Klebsiella spp* (6.7%), *Proteus* (2.2%), *Pseudomonas aeruginosa* (4.4%), *Staphylococcus aureus* (4.4%), *Staphylococcus epidermidis* (7.8%) and *Streptococcus pyogenes* (1.1%) respectively.

Table 1: Distribution of Microorganisms Isolated from fomites

Organisms	Freq	(%)
Bacillus spp	4	4.4
Candida spp	2	2.2
Citrobacter fuendi	5	5.6
Escherichia coli	8	8.9
Klebsiella spp	6	6.7
Proteus	2	2.2
Pseudomonas aeruginosa	4	4.4
Staphylococcus aureus	4	4.4
Staphylococcus epidermidis	7	7.8
Streptococcus pyogenes	1	1.1
Total	**43**	**47.8**

***Prevalence of microorganisms* according to sample location**

Table 2 showed the prevalence of microorganisms isolated from fomites according to sample location. The results obtained showed from the 43 isolated microorganisms, 7 (7.8%) were from haematology laboratory, 8 (8.9%) were from microbiology laboratory, 7 (7.8%) were from chemical pathology laboratory, 5 (5.6%) were from phlebotomy unit, 4(4.4%) were from theatre unit, 8 (8.9%) were from accident and emergency unit and 4 (4.4%) were from general outpatient department respectively. Microbiology laboratory and accident and emergency units had the most contamination, while theatre unit and general outpatient department had the least contamination. Statistically, there was no significant difference in the distribution of microorganism according to sample location ($p = 0.477$).

Prevalence of Microorganisms according to the type of fomites

Table 3 showed the prevalence of microorganisms isolated according to the type of fomites. The results obtained showed from the 43 isolated microorganisms, 15 (16.7%) were from door/drawer and fridge handles, 3 (3.3%) were from mouse/keyboard, 7 (7.8%) were from sink, 6 (6.7) were from tap handle, 1 (1.1%) was from blood cell counter, 2 (2.2%) were from safety cabinet, 2 (2.2%) were from work bench, 4 (4.4%) were from patients' bed and 3 (3.3%) were from oxygen tank and operating light respectively. The results showed that door/drawer and fridge handles had the highest contamination, while blood cell counter had the least

Print ISSN: 0189-9287 Online ISSN: 2992-345X

contamination. Statistically, door/drawer and fridge handles had significant higher (p=0.011) contamination compared with other fomites sources.

Antibiotics sensitivity pattern of Gram-negative isolates from fomites

Table 4 showed the antibiotics sensitivity pattern of Gram-negative isolates from fomites. The results obtained showed that the sensitive antibiotics were AUG (100%), CTX (93.1%), OFX (75.9%), CXM (65.5%), ACX (75.9%), ZEM (89.7%) and LBC (68.9%) respectively. On the other hand, the most resistant antibiotics were GN (58.6%), NA (41.4%) and IMP (34.5%) respectively.

Antibiotics sensitivity pattern of Gram-positive isolates from fomites

Table 5 showed the antibiotics sensitivity pattern of Gram-positive isolates from fomites. The results obtained showed that the sensitive antibiotics were OF (100%), GM (100%), TE (83.3%), S (83.3%), CP (91.7%), CF (75.0%) and LE (75.0%), while the most resistant antibiotics were RO (58.3%), BA (50.0%), CX (50.0%) and AS (50.0%) respectively.

Discussion

In any hospital setting, identifying pathogens that are common contaminants of fomites, and their antibiotics sensitivity pattern profiles are important interventions to contain hospital acquired infections (HAIs) also known as nosocomial infections and the spread of drug-resistant strains

Nosocomial infections create a major problem for health workers because it continues to hinder effective management of health care delivery in hospitals all over the world. According to a study of the literature, hospital-wide HAI prevalence in Africa ranges from 2.5% to 14.8%; on surgical wards, the cumulative incidence varies from 5.7% to 45.8%. According to Sepideh *et al.* 2011),[22] the majority of studies concentrated on surgical site infections, which had a cumulative incidence ranging from 2.5% to 30.9%.

Findings from this research work showed an alarming prevalence rate of 47.8%. The incidence of nosocomial infections varies according to the setting, that is, the type of hospital or ICU, the patient population, type of fomites and the precise definition and surveillance techniques used to identify a nosocomial infection.[23]

The high prevalence of nosocomial pathogens in the hospital reported here is consistent with other findings.[23,24] On the contrary, the infections rate reported in this study was greater than the rates reported from other part of Nigeria: Obafemi Awolowo University Teaching Hospital, Ife 2.7%,[25] Lagos State University Teaching Hospital 3.6%[26] and 4.2% from hospitals in Ilorin.[27] The high prevalence rate observed in this study could be attributed to non-compliance to healthcare associated infections guidelines, overcrowding, and inadequate surveillance system.[28,29,30]

This study revealed significant bacterial contamination of fomites with Gram-positive bacteria being isolated more frequently than Gram-negative bacteria. The increased predominance of Gram-positive bacteria over Gram-negative bacteria is consistent with prior research and corroborates the assertion that Gram-positive bacteria outnumber Gram-negative bacteria as the primary group of bacteria recovered from fomites.[31,26] This observation is due to the fact that Gram-positive bacteria are a natural part of both healthy and sick people's body flora and can be spread by hand, respiratory tract, or contact with animate or inanimate objects.[32]

In this study, ten different organisms were isolated from the different fomites comprising of nine bacteria and one fungus. The bacteria organisms isoloated and their percentage prevalence were *Bacillus spp* (4.4%), *Citrobacter fuendi* (5.6%), *Escherichia coli* (8.9%), *Klebsiella spp* (6.7%), *Proteus* (2.2%), *Pseudomonas aeruginosa* (4.4%), *Staphylococcus aureus* (4.4%), *Staphylococcus epidermidis* (7.8%) and *Streptococcus pyogenes* (1.1%) respectively. The reported organisms isolated in this study agree with those obtained from previous studies.[33,34,35] Yallew *et al.* (2019)[34] reported that *Staphylococcus aureus*, *Pseudomonas aeroginosa*, and *Klebsiella* species are the most common pathogens in Africa isolated from hospital fomites. Another review in Africa reported Klebsiella, *Staphylococcus aureus*, *Pseudomonas aeroginosa*, and *E. coli* as the most common microorganisms in HAIs.[33] These three microorganisms, in addition to being easier to transport than others, have significant resistance to antibiotics. On the other hand, they are more resistant to sterilization and disinfection methods than the others. Due to these characteristics, these microorganisms have a higher prevalence rate than others.[34] The preponderance of *Staphylococcus aureus* may be due to its existence as normal flora of the skin and the upper respiratory tract, and its ability to be transmitted via various human activities such as sneezing, talking, and contact with moist skin.[36]

In this study one fungus was isolated. The *Candida albicans* (2.2%) was isolated mostly from patient's bed

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linen. The isolation of fungi from bed linen may be due to improper drying which might aid spore germination.

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Table 2: Prevalence of Microorganisms according to sample location

Organisms	Haematology	Microbiology	Chemical Pathology	Phlebotomy	Theatre Unit	Accident & Emergency	General Outpatient Dept
			Frequency (%)				
Bacillus spp	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.1)	3 (3.3)	0 (0.0)
Candida spp	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.1)	1 (1.1)	0 (0.0)
Citrobacter fuendi	1 (1.1)	1 (1.1)	1 (1.1)	2 (2.2)	0 (0.0)	0 (0.0)	0 (0.0)
Escherichia coli	1 (1.1)	3 (3.3)	2 (2.2)	1 (1.1)	0 (0.0)	0 (0.0)	1 (1.1)
Klebsiella spp	1 (1.1)	2 (2.2)	2 (2.2)	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)
Proteus	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.1)	1 (1.1)
Pseudomonas aeruginosa	1 (1.1)	0 (0.0)	0 (0.0)	1 (1.1)	1 (1.1)	0 (0.0)	1 (1.1)
Staphylococcus aureus	1 (1.1)	1 (1.1)	1 (1.1)	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)
Staphylococcus epidermidis	2 (1.1)	0 (0.0)	1 (1.1)	1 (1.1)	1 (1.1)	1 (1.1)	1 (1.1)
Streptococcus pyogenes	0 (0.0)	1 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total	**7 (7.8)**	**8 (8.9)**	**7 (7.8)**	**5 (5.6)**	**4 (4.4)**	**8 (8.9)**	**4 (4.4)**

$X^2 = 1.098$, df = 2, p = 0.4

Table 3: Prevalence of Microorganisms according to the type of fomites

Organisms	Door/drawer/ Fridge handle	Mouse/ Keyboard	Sink	Tap handle	Blood cell counter	Safety cabinet	Work bench	Patient bed	Oxygen tank/ operating light
				Frequency (%)					
Bacillus spp	3 (3.3)	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Candida spp	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.1)	1 (1.1)	0 (0.0)
Citrobacter fuendi	0 (0.0)	1 (1.1)	2 (2.2)	1 (1.1)	0 ()	1 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)
Escherichia coli	3 (3.3)	1 (1.1)	1 (1.1)	1 (1.1)	0 (0.0)	1 (1.1)	1 (1.1)	0 (0.0)	0 (0.0)
Klebsiella spp	1 (1.1)	1 (1.1)	2 (2.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (2.2)
Proteus	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)
Pseudomonas aeruginosa	1 (1.1)	0 (0.0)	0 (0.0)	1 (1.1)	1 (1.1)	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)
Staphylococcus aureus	1 (1.1)	0 (0.0)	1 (1.1)	1 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)
Staphylococcus epidermidis	6 (6.7)	0 (0.0)	0 (0.0)	1 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Streptococcus pyogenes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.1)
Total	**15 (16.7)**	**3 (3.3)**	**7 (7.8)**	**6 (6.7)**	**1 (1.1)**	**2 (2.2)**	**2 (2.2)**	**4 (4.4)**	**3 (3.3)**

$X^2 = 4.312$, df = 2, p = 0.011

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Table 4: Antibiotics sensitivity pattern of Gram-negative isolates from fomites

Antibiotics	Sensitive (%)	Intermediate (%)	Resistant (%)
Amoxicillin clavulanate	29 (100.0)	0 (0.0)	0 (0.0)
Cefotaxime	27 (93.1)	1 (3.4)	1 (3.4)
Imipenem	17 (58.6)	3 (10.3)	10 (34.5)
Ofloxacin	22 (75.9)	1 (3.4)	6 (20.7)
Gentamycin	10 (34.5)	3 (10.3)	17 (58.6)
Nalidixic Acid	11 (37.9)	6 (20.7)	12 (41.4)
Nitrofurantoin	8 (27.6)	4 (13.8)	17 (58.6)
Cefuroxime	19 (65.5)	2 (6.9)	8 (27.6)
Ceftriaxone Sulbactam	24 (82.8)	0 (0.0)	5 (17.2)
Ampiclox	22 (75.9)	3 (10.3)	4 (13.8)
Cefexime	26 (89.7)	1 (3.4)	2 (6.9)
Levofloxacin	20 (68.9)	3 (10.3)	6 (20.7)

Table 5: Antibiotics sensitivity pattern of Gram-positive isolates from fomites

Antibiotics	Sensitive (%)	Intermediate (%)	Resistant (%)
Co-Trimoxazole	5 (41.7)	1 (8.3)	6 (50.0)
Erythromycin	8 (66.7)	0 (0.0)	4 (33.3)
Tetracycline	10 (83.3)	1 (8.3)	1 (8.3)
Cefotaxime	9 (75.0)	1 (8.3)	2 (16.7)
Ciprofloxacin	11 (91.7)	0 (0.0)	1 (8.3)
Ofloxacin	12 (100.0)	0 (0.0)	0 (0.0)
Streptomycin	10 (83.3)	1 (8.3)	1 (8.3)
Roxithromycin	5 (41.7)	0 (0.0)	7 (58.3)
Cloxacillin	6 (50.0.0)	0 (0.0)	6 (50.0)
Gentamicin	12 (100.0)	0 (0.0)	0 (0.0)
Levofloxacin	9 (75.0)	2 (16.7)	1 (8.3)
Ampicillin/sulbactam	4 (33.3)	2 (16.7)	6 (50.0)

In this study, the doorknobs were the most contaminated of the surfaces sampled. The doorknobs recorded and overall contamination rate of 16.7%. *Staphylococcus epidermidis* was found to contaminate tap handles, *Pseudomonas aeruginosa* and *Escherichia coli* were found to be predominant on sink knob. The presence of *P. aeruginosa* on sink knob could be attributed to its ability to grow in disinfectants, sinks, water and other materials in the hospitals since *P. aeruginosa* is mostly associated with humid environments.[27] Its might also be since *P. aeruginosa*, is commonly found on the skin and in mucous membranes, and spreads through direct contact, thus surfaces become contaminated when carrier of this organisms come in contact with them.[37] The contamination of the sink knob by microorganisms have been found to be because of water splash and settlement of dirt on the knob during hand washing, thus providing suitable substrates for microbial growth. Saka *et al.* (2019)[38] reported that during hand washing activities in sink, drain contents splashed at least one meter from the sink and the polluted water carries microorganisms that cause infections in patients.

Antibiotic resistance varied widely among the isolates in this study. Gram-positive isolates had high rates of resistance to ceftazidime (100%), cefuroxime (100%), ceftriaxone (100%), cloxacillin (98.4%), and erythromycin (87.8%), while Gram-negative isolates were commonly resistant to Augmentin (86.2%), tetracycline (79.3%), and ceftazidime (82.8%) respectively. These patterns confirm previous reports of substantial percentages of Gram-negative bacteria isolates that are resistant to various antibiotics, both in clinical and environmental settings.[39,40,41] This indicates that these antibiotics cannot be used to treat infections caused by these bacteria. Antibiotics are reportedly consumed in vast quantities in clinical and environmental settings each year, which, among other causes, contributes considerably to the escalating prevalence of antibiotic-resistant bacteria.[42] Bacterial resistance to antibiotics may be caused by improper antibiotic use in humans and livestock, as well as incorrect and inferior prescriptions written by unqualified medical personnel and poor diagnosis.[43]

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Implications of the findings of this study

This study revealed that fomites serve as reservoirs and vehicle for transmission of nosocomial infections, highlighting critical areas to target in infection prevention strategies. The findings from this study showed a high prevalence of antibiotic-resistant bacteria in the environment, stressing the need for responsible antibiotic usage. Policymakers and public health authorities can use these findings to enforce stricter regulations on antibiotic use and environmental hygiene.

Strengths and Limitations of the Study

A good understanding of commonly present bacteria on frequently used fomites will help in controlling nosocomial infection which is a major concern in our healthcare setting. This finding can help create awareness on the importance of hygiene among hospital visitors and non-healthcare workers and as well influence policies on sanitation.

As a result of financial constraints, advanced identification method such as molecular techniques, could not be used in the bacterial identification. The findings from this study may not be generalizable to other regions or environments with different fomite usage patterns or cleaning practices.

Conclusion

A high diversity of bacteria was found on fomites in the study environments, with Gram-positive bacteria being isolated more frequently than Gram-negative bacteria. The organisms isolated were *Bacillus spp*, *Candida spp*, *Citrobacter fuendi*, *Escherichia coli*, *Klebsiella spp*, *Proteus*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Staphylococcus epidermidis* and *Streptococcus pyogenes* respectively. This study establishes the fact that Nosocomial infections persist within our healthcare setting as reported in similar studies and fomites serve as reservoir for pathogenic micro-organisms, which is evident in the isolation of diseases causing bacteria from fomites surfaces in this study, thus proves that fomites are possible vehicles of transmission of nosocomial infections within healthcare facilities.

List of abbreviations

HAI - Hospital-acquired infections
ICU- Intensive care units
TSIA **-** Triple Sugar Iron Agar Test

Declarations

Ethical Consideration: Ethical approval was gotten from Afe Babalola University Multi-System Hospital with reference no: AB/EC/19/05/036.

Authors' Contribution: Oluboyo OO, Akinseye JF, Agu CC and Eya CP oversaw the project's conceptualization and design. Agu CC carried out the process of data curation. Agu CC conducted a formal analysis. Agu CC and Eya CP carried out the investigation. The authors presented the methodology. The project administration was carried out by Akinseye JF, Agu CC, Ogunfolakun OO, Egbebi AH, Ogunyemi OM and Eya CP obtained resources. The software was obtained by Agu CC. The supervision was conducted by Akinseye JF and Ogunfolakun OO. The validation process was carried out by Eya CP and Agu CC. The first draft of the writing was done by Agu CC. The task of reviewing and editing the writing was undertaken by Agu CC and Eya CP.

Conflict of interest: There are no competing interests in this research work from the authors.

Funding: No fund was generated from any external organization.

Acknowledgment: The authors acknowledge the support of the staff of the Department of Medical Laboratory Science, Afe Babalola University, Ado-Ekiti, Ekiti State, Nigeria.

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Print ISSN: 0189-9287 Online ISSN: 2992-345X