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PREVALENCE AND ANTIMICROBIAL SENSITIVITIES OF BACTERIAL ISOLATES FROM AUTOMATED TELLER MACHINE IN NSUKKA METROPOLIS

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ABSTRACT

The Automated Teller Machine (ATM) is likely to be contaminated with various microorganisms due to their vast dermal contact by multiple users. This study examined ATM metallic keypads as potential sources of bacterial contamination and characterized the antibiogram of the isolated organisms. The study involved several procedures like isolation, culturing, and identification of the organisms using the Kirby-Bauer disc diffusion method for antibiotic sensitivity tests. Swabs from the keypad of 20 ATM were examined and the results indicated the contamination of keypads with *Staphylococcus aureus* 18(34.6%), *Escherichia coli* 16(30.7%), *Salmonella spp* 15 (28.8%), *P. aeruginosa* 3(5.76%). The antibiogram was ascertained using Kirby Bauer disc diffusion method and the result showed that *Staphylococcus aureus, Escherichia coli, salmonella spp* and *P aeruginosa* were resistant to vancomycin (80.7 %) and cefoxitin (78.8%) and were susceptible to these antibiotics Ciprofloxacin (100%) followed by Gentamycin (96.2%), Tetracycline (86.6%), Amoxicillin (71.2%), Erythromycin (59.7%) and cefepime (59.7%). The hygiene, aesthetics and environmental safety conditions have been left for employed general cleaners that do not have appropriate training about generalized and specialised cleaning. They may use rags for cleaning the toilets, tables to clean ATM thereby transmitting germs. Public awareness should be created on the health implications so as to inculcate hand washing by the users of ATM and a cleaning regimen with disinfectant should be practiced to reduce contamination of ATMs.

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KEYWORDS

Automated teller machine (ATM), antibiogram, contamination, hand washing, disinfectant

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INTRODUCTION

Several studies of the human environment have demonstrated colonization and contamination of objects such as door handles, faucets, phones money, fabrics and plastics [1]. People come into daily contact with all sorts of fomites, with an increasing rate of bacterial infection [2]. The spread of infectious disease through hand contact has been an area of major concern. Artificial contamination

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of public surfaces with an invisible fluorescent tracer showed that contamination from outside surface was transferred to most hands and a great majority tracked the tracer to their home or personal belonging hours later [3].

According to a study [4], Gram positive *Staphylococcus aureus*, and Gram-negative enteric bacteria such as *Escherichia coli*, Klebsiella species, Citrobacter species were found to contaminate various contact surfaces including tables, chairs, windows, door handles and many other common household fixtures [4]. Some epidemiological studies suggest that contaminated surfaces may play a role in the spread of respiratory viruses [5]. Bacteria that can cause severe gastroenteritis have been found on ATM machine keypads/buttons. Fomites such as ATM machines carry germs and when one touches it and then touches the mouth, nose, eye etc, he is infected. Though majority of these microorganisms are harmless to humans and animals, few are harmful and can lead to death of infected individuals, especially in immune-compromised individuals [6]. Fomites serve as vehicles for cross-infections and recontamination of washed hands [7-9]. People tend not to be aware that microbes are found on many regular objects outdoors, in their workplace, comfortable offices and even in their homes. Such objects contaminated by microorganisms include; playground equipment, kitchen sinks, work desks, PC keyboards, handrails, elevator buttons and Automated Teller Machine (ATM) keypads [10]. The entire above mentioned are objects/places that come in contact mostly with the hands of people who are in various hygienic conditions. It is a general belief amongst the populace that microbes are only present in research laboratories or in hospitals and clinics and thus they have a misleading feeling of safety or security in other places [11]. However, this lack information on where germs prowl could be the cause of health problems.

Automated Teller Machine is a computer driven device that enables its users or clients of a financial institution to perform transaction without the need of cashier. It is probable to be contaminated due to vast majority of users with varying hygiene and the contaminant stays long on the surface ranging from hours to months; hence cross contamination has been established [12]. Due to the ongoing development and expansion of urbanization, as well as the increasing population, people do not have enough time to use traditional banking systems and have accepted new technological advances in e-banking, such as the use of Automated Teller Machines (ATMs) [13]. Today the wide use of electronic technologies is considered a source of bacterial contamination [14]. The increasing incidence of epidemic outbreaks of certain diseases and the rate of spread from one community to the other has become a major public health concern [15]. Possible diseases that can be caused by the isolated bacteria include foodborne diseases (*Staphylococcus aureus* and *Escherichia coli*), urinary tract infections (UTI) (*Escherichia coli* and *Pseudomonas aeruginosa*), pneumonia (Klebsiella sp.), sore throat (*Streptococcus pyogenes*) and diarrhoea (*Escherichia coli*) [16]. *Escherichia coli* has been reported to be the most common cause of UTIs with some clones that may be associated with gastrointestinal infections. *Escherichia coli* serovars, especially the enteropathogenic *Escherichia coli* has been implicated in major food borne disease outbreaks and infections mainly from eating contaminated meat [17]. Bacillus sp. *Staphylococcus aureus*, Klebsiella sp. and *Pseudomonas aeruginosa* are well documented for their high pathogenicity, causing even death in some major outbreaks and infections [17]. Dirty surfaces would harbour more bacteria than clean ones. This makes the process of dusting and removal of soil and dirt by simple cleaning procedures of paramount influence on the reduction of surface contamination. ATM has been seen as low performing when it is without money to dispense and therefore more resources have been allocated to maintain and ensure it works as quickly as possible. The hygiene, aesthetics and environmental safety conditions have been left for employed general cleaners that do not have appropriate training about generalized and specialised cleaning. They may use rags for cleaning the toilets, tables and to clean ATM thereby transmitting germs. ATMS are not sterile; therefore, there is a need to maintain good hygiene practices by users and a need for the bank to provide hand sanitizers after each use [18].

MATERIALS AND METHODS

Collection and Isolation of the Organism

Twenty (20) samples were collected from 10 different user interfaces of 10 commercial banks situated at various parts of Nsukka Metropolis. The samples were collected during the peak periods (that is, when a greater number of people would have used the ATM centres) using sterile swab sticks. Single sterile swab sticks moistened with 1 ml of normal saline was rubbed on the touch screen, and the buttons of the ATM then returned to

its casing, labelled properly, and transported to the Microbiology Laboratory, University of Nigeria, Nsukka. A ten (10) fold serial dilution of the sample was carried out.

The isolation of the bacteria was done on MacConkey agar, Mannitol salt agar, Cetrimide agar and blood agar plates by adding 0.1 ml of sample solution and streaking using a sterile wire loop. It was incubated at 37°C for 24 hours, after which it was observed. Purification of the resultant isolate was done using a sterile loop sterilized by flaming, cooling, and used for subsequent subculturing on dried nutrient agar.

Preliminary Characterization of Isolates

Catalase test

Hydrogen peroxide (2.3 ml) were placed on a slide. A Sterile wire loop was used to collect a good growth of the isolated bacteria that was freshly cultured for 24 hours. The isolated bacteria were immersed in the hydrogen peroxide while watching out for immediate bubbling. The above procedure was repeated for the remaining isolates, and results were recorded

Gram staining

A smear of the organism was prepared by putting a drop of normal saline on a grease-free slide, and a small quantity of the organism was emulsified. It was allowed to air-dry, and Fixation was done by passing it three times over the flame then the slide was placed on staining rack and was flooded with crystal violet which act as a primary stain these was allowed to stain for 30-60 seconds. After the staining it was washed off with clean water then the smear was also covered with Lugol's iodine for 30-60 seconds, it was decolourized with acetone alcohol and immediately washed off with clean water then the back of the slide was cleaned and was allowed to air dry. The slide was examined using oil immersion microscope. The above procedure was repeated for the remaining isolates.

Citrate test

Citrate (6.31 g) was suspended in 260 ml of distilled water in a round bottom flask; it was heated to boiling to dissolve the medium and mixed well. 5 ml was dispensed on each of the 52 test tubes and the mouth covered with cotton plug. It was sterilized by autoclave at 121°C under 15 psi pressure for 15 minutes and cooled in a slanted position (long slant and shallow butt), to solidify. A Sterile wire loop was used to collect a good growth of the isolated bacteria that was freshly cultured for 24 hours streaked lightly on the slant and incubated at 37°C for 24 hours and colour change was observed. The remaining isolate was also streaked

Triple sugar iron agar test (TSIA)

TSIA (16.8 g) was suspended in 260 ml of distilled water in a round bottom flask. It was heated to boiling to dissolve the medium, mixed well, 5 ml was dispensed on each of the 52 test tubes and the mouth covered with cotton plug. It was sterilized by autoclave at 121° under 15 psi pressure for 15 minutes and cooled in a slanted position (long slant and shallow butt), to solidify. A sterile wire loop was used to collect a good growth of the isolated bacteria that was freshly cultured for 24 hours and was inoculated by first stabbing through the centre of the medium (Butt) and then streaking on the surface of the agar slant incubated at 37°C for 24 hours and colour change observed and recorded. The remaining isolate was also inoculated

Mannitol fermentation test

Peptone (3.9 g) was dissolved in 260 ml of distilled water. 2.6 g mannitol was dissolved in the peptone water. 0.1g of bromophenol was also added to the preparation and mixed well. 5 ml was dispensed into each of the 52 test tubes, and the mouth covered with cotton plugs; it was sterilized in an autoclave at 121°C under 15 psi pressure for 15 minutes. A Sterile wire loop was used to collect a good growth of the isolated bacteria that was freshly cultured for 24 hours and inoculated on the mannitol broth. It was incubated at 37°C for 24 hours, and colour change was observed and recorded. The remaining isolate was inoculated.

Oxidase test

From the oxidase reagent, 1 g was dissolved in 100 ml of distilled water**;** a strip of filter paper was soaked with a little freshly made 1% solution of the reagent, and a speck of culture was rubbed on it with a loop. A positive reaction was indicated by an intense deep-purple hue appearing for 5-10 seconds, and a negative reaction by absence of colouration or colouration later than 60 seconds. This was done for the remaining isolates

Indole test

A 4 ml of tryptophan broth was added to a sterilized test tube; the tube was inoculated aseptically by taking the growth from a 24 h culture and was incubated at 37°C for 24 h . A 5 ml of Kovac's reagent was added to the broth culture, and the presence of a ring was observed. This was done for other isolates.

Storage of Stock Cultures of Isolate

A 3.9 g of nutrient agar powder was suspended in 140 ml of distilled water contained in a round-bottom flask. It was stirred and heated constantly to make sure it completely dissolved its components. 2.5 ml was dispensed into each of the 52 plain bottles, covered, and sterilized in an autoclave at 121^{o}C for 15 minutes. It was slanted and allowed to cool and solidify. Each isolate was transferred aseptically to the nutrient agar slants by streaking using a wire loop. The slants were incubated at 37^{o} for 24 h after which they were stored in the refrigerator at a temperature of 4^{0}C

Standardization of Isolates

From the stock cultures, viable colonies of each isolate were harvested using sterile wire loop and introduced into test tubes containing 5 ml of sterile normal saline. The volume of the normal saline was adjusted by dilution to obtain a cell population corresponding to Macfarland's 0.5 nephelometer. The standardization was done prior to carrying out the microbiological assays involving antibiotics.

Antibiotic Sensitivity Screening of Isolates

A 39.5 g of Mueller-Hinton agar was suspended in 1040 ml of distilled water contained in a round-bottom flask. It was stirred and heated constantly to make sure it totally dissolved its components .it was autoclaved at 121^{o}C for 15 minutes and was allowed to cool to 45^{o}C. It was poured under aseptic techniques into each of the 52 Petri dishes and allowed to set for 20minutes. 0.1 mL of the standardized bacterial Suspension was put into each Petri dish and spread using a glass spreader. Using a pair of forceps, the antibiotic discs were placed inside each of the plates few centimeters apart. Thereafter, the plates were incubated at 37^{o}C for 24 hours and resultant inhibition zone diameters were measured and recorded.

RESULTS

Prevalence, Characterization and Identification of Bacterial Isolates of ATM Machines in Nsukka

Table 1 presents the cultural and morphological characteristics of bacterial isolates recovered from automated teller machines (ATMs) in Nsukka Metropolis. Four bacterial groups were presumptively identified: *Staphylococcus* spp., *Escherichia coli*, *Salmonella* spp., and *Pseudomonas* spp. The isolates exhibited distinct colonial characteristics on selective media. *Staphylococcus* spp. produced yellow colonies on Mannitol Salt Agar, *E. coli* formed pink colonies on MacConkey agar, while suspected *Salmonella* spp. produced pink colonies with dark centres on Salmonella–Shigella agar. *Pseudomonas* spp. exhibited green colonies on Cetrimide agar.

Figure 1 illustrates the percentage occurrence of bacterial isolates recovered from ATM surfaces. *Staphylococcus* spp. had the highest occurrence (approximately 34%), followed by *Escherichia coli* (31%) and *Salmonella* spp. (29%), while *Pseudomonas* spp. recorded the lowest occurrence (6%).

Figure 3 illustrates the resistance patterns of the bacterial isolates against eight antibiotics. The highest resistance was recorded against vancomycin (approximately 82%) and cefoxitin (79%), followed by erythromycin and cefepime (41% each), amoxicillin (29%), and tetracycline (13%). Gentamicin exhibited relatively low resistance (4%), while no resistance was reported against ciprofloxacin (0%).

Table 1: Cultural and morphological characteristics of bacterial colonies from ATM in Nsukka Metropolis

Bacterial isolates	Agar medium	Size	Form	Pigmentation	Margin	Elevation	Suspected organism
BANK A							
SSA_1	Salmonella shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp.
SSA_2	Salmonella shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp.
MSA_1	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp.
MSA_2	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp.

MA_1	MacConkey	Small	Circular	Pink	Entire	Convex	*E. coli*
BANK B							
MA_1	MacConkey	Small	Circular	Pink	Entire	Raised	*E. coli*
MA_2	MacConkey	Large	Circular	Pink	Entire	Raised	*E. coli*
MSA_1	Mannitol salt	Small	Circular	Yellow	Entire	Convex	Staphylococci spp.
MSA_2	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp.
SSA_1	Salmonella shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp.
SSA_2	Salmonella Shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp.
BANK C							
MA_1	MacConkey	Large	Circular	Pink	Entire	Flat	*E. coli*
MA_2	MacConkey		Circular	Pink	Entire	Raised	*E. coli*
MSA_1	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp.
MSA_2	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp.
SSA_1	Salmonella Shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp.
SSA_2	Salmonella Shigella	Large	Circular	Pink colonies with dark centre	Entire	Raised	Salmonella spp.
BANK D							
SSA_1	Salmonella Shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp.
MA_1	MacConkey	Large	Circular	Pink	Entire	Convex	E coli
MSA_1	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp.
SSA_2	Salmonella Shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp.
MSA_2	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp.
BANK E							
SSA_1	Salmonella Shigella	Large	Circular	Pink colonies with dark centre	Entire	Raised	Salmonella spp.
SSA_2	Salmonella Shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp.
MSA_1	Mannitol salt	Small	Circular	Yellow	Entire	Convex	Staphylococci spp.

MSA_2	Mannitol salt	Small	Circular	Yellow	Entire	Convex	Staphylococci spp.
MA_1		Large	Circular	Pink	Entire	Convex	*E. coli*
MA_2		Large	Circular	Pink	Entire	Flat	*E coli*
BANK F							
MSA_1	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp.
MA_1	MacConkey	Large	Circular	Pink	Entire	Convex	*E. coli*
MSA_2	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp.
SSA_1	Salmonella Shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp.
SSA_2	Salmonella Shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp.
BANK G							
MA_1	MacConkey	Large	Circular	Pink	Entire	Convex	*E. coli*
MA_2	MacConkey	Large	Circular	Pink	Entire	Convex	*E. coli*
MSA_1	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp.
MSA_2	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp
SSA_1	Salmonella Shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp.
BANK H							
MSA_1	Mannitol salt	Large	Circular	Yellow	Entire	Raised	Staphylococci spp
MSA_2	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp.
MA_1	MacConkey	Large	Circular	Pink	Entire	Convex	*E. coli*
MA_2	MacConkey	Large	Circular	Pink	Entire	Convex	*E coli*
SSA_1	Salmonella Shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp.
BANK I							
MSA_1	Mannitol salt	Large	Circular	Yellow	Entire	Convex	Staphylococci spp
MA_1	MacConkey	Large	Circular	Pink	Entire	Convex	E coli
SSA_1	Salmonella Shigella	Large	Circular	Pink colonies with dark centre	Entire	Convex	Salmonella spp

C_1	Cetrimide	Large	Circular	Green colonies	Entire	Convex	Pseudomonas spp
C_2	Cetrimide	Large	Circular	Green colonies	Entire	Convex	Pseudomonas spp

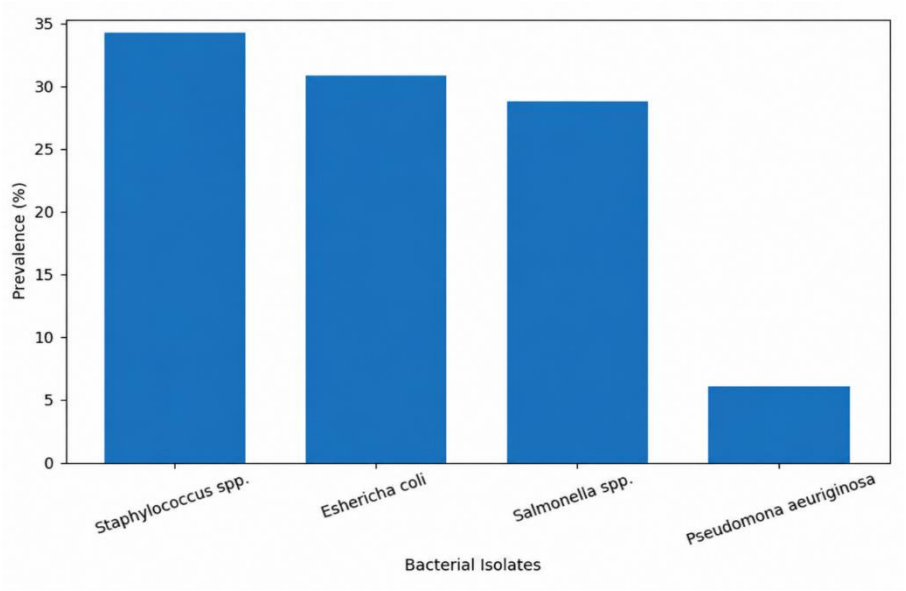


Figure 1: Percentage Occurrence of Bacterial Isolates

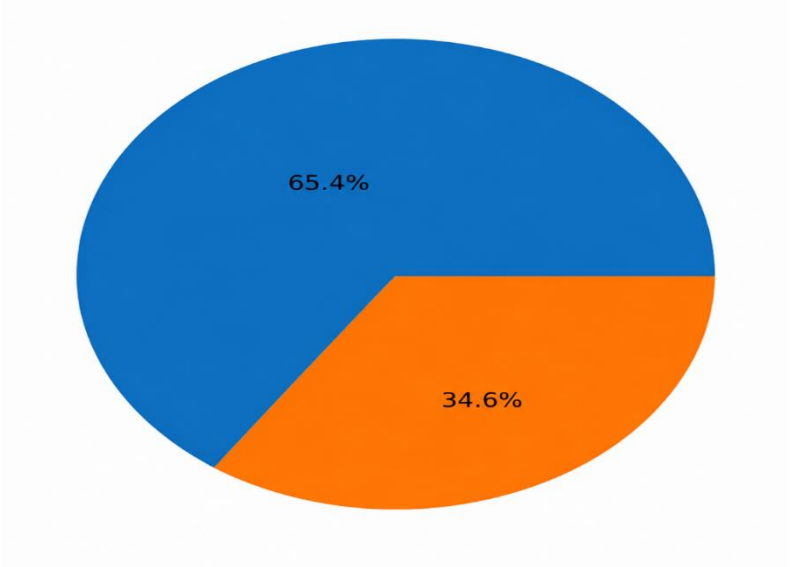


Figure 2: Classification of Bacterial Isolates According to Gram's Reaction. Blue (65.4% for Gram negative bacteria) and Orange (65.4% for Gram positive bacteria)

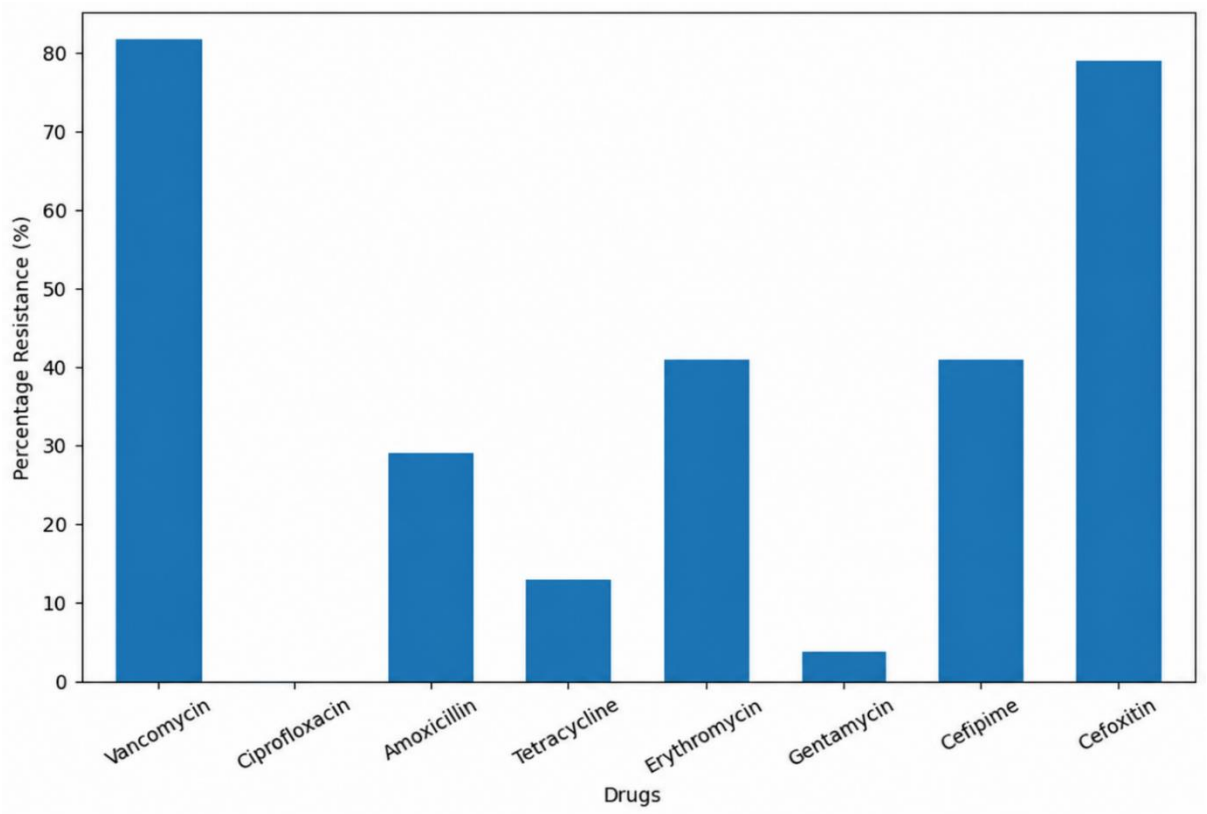


Figure 3: Percentage Resistance of Bacterial Isolates

Table 2 presents the biochemical characteristics used for the presumptive identification of bacterial isolates recovered from ATM surfaces. *Staphylococcus* spp. were characterized mainly by positive catalase reactions and mannitol fermentation, while *E. coli* exhibited positive indole reactions, gas production, and acid reactions on Triple Sugar Iron Agar (TSIA). Suspected *Salmonella* spp. demonstrated hydrogen sulphide production, positive citrate reactions, and alkaline slant/acid butt reactions. *Pseudomonas* spp. exhibited positive oxidase and citrate reactions with alkaline TSIA reactions.

Table 3 presents variations in bacterial counts obtained from ATM surfaces across the sampled banks. On Mannitol Salt Agar, Bank G recorded the highest bacterial count (4.0×10^6 CFU/mL), while Bank C had the lowest (3.0×10^4 CFU/mL). Similarly, Bank G exhibited the highest count on MacConkey agar (2.5×10^6 CFU/mL) and Salmonella–Shigella agar (1.5×10^5 CFU/mL). Growth on Cetrimide agar was recorded only for Bank A (5.0×10^5 CFU/mL), with no growth reported for the remaining banks.

Table 4 presents the antibiotic susceptibility profiles of bacterial isolates recovered from different ATM locations. Ciprofloxacin demonstrated consistently large zones of inhibition, ranging from 25 to 39 mm, indicating substantial antibacterial activity against the tested isolates. Gentamicin also exhibited appreciable inhibitory effects, although variations were observed among isolates. Conversely, amoxicillin, erythromycin, cefepime, and cefoxitin exhibited variable inhibition zones, suggesting differences in susceptibility among bacterial groups and sampling locations. Vancomycin showed measurable inhibition predominantly against *Staphylococcus* isolates, while no inhibition zones were reported for most Gram-negative isolates.

Table 2: Biochemical characteristics of the bacterial isolates

Isolates no	Isolates ID	Mannitol fermentation test	Oxidase test	Catalase test	TSIA			Citrate test	Indole test	Gram staining	Suspected organism
					Slant/ Butt	H_2S production	Gas production				
	BANK A										
1	SS_1	+	-	+	R/y	+	-	+	-	- Rod	*Salmonella spp*
2	SS_2	+	-	+	R/y	+	-	+	-	- Rod	*Salmonella spp*
3	MSA_1	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
4	MSA_2	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
5	MA_1	+	-	-	y/y	-	+	-	+	- Rod	*Eschericha coli*
	BANK B										
6	MA_1	+	-	-	y/y	-	+	-	+	- Rod	*Eschericha coli*
7	MA_2	+	-	-	y/y	-	+	-	+	- Rod	*Eschericha coli*
8	MSA_1	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
9	MSA_2	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
10	SSA_1	+	-	+	R/y	+	-	+	-	- Rod	*Salmonella spp*
11	SSA_2	+	–	+	+ R/y	+y/y	-	+	-	- Rod +	*Salmonella spp* Salmo
	BANK C										
12	MA_1	+	-	-	y/y	-	+	-	+	- Rod	*Eschericha coli*
13	MA_2	+	-	-	y/y	-	+	-	+	- Rod	*Eschericha coli*
14	MSA_1	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
15	$_{SSA}1$	+	–	+	+ R/y	+y/y	-	+	-	- Rod +	*PSalmonella spp* Salmo
16	$_{SSA}2$	+	–	+	+ R/y	+y/y	-	+	-	- Rod +	*Salmonella spp* Salmo
17	MSA_2	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
	BANK D										
18	$_{SSA}1$	+	–	+	+ R/y	+y/y	-	+	-	- Rod +	*Salmonella spp* Salmo
19	SSA_2	+	–	+	+ R/y	+y/y	-	+	-	- Rod +	*Salmonella spp* Salmo
20	MSA_1	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
21	MA_1	+	-	-	y/y	-	+	-	+	- Rod	*Eschericha coli*
22	MSA_2	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
	BANK E										
23	SSA_1	+	-	+	R/y	+	-	+	-	- Rod	*Salmonella spp*
24	SSA_2	+	-	+	R/y	+	-	+	-	- Rod	*Salmonella spp*
25	MSA_1	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
26	MSA_2	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
		+	-	-	y/y	-	+	-	+	- Rod	*Eschericha coli*
28	MA_2	+	-	+	y/y	-	+	-	+	- Rod	*Eschericha coli*
	BANK F										
29	MSA_1	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
30	MSA_2	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
31	SSA_1	+	-	+	R/y	+	-	+	-	- Rod	*Salmonella spp*
32	SSA_2	+	-	+	R/y	+	-	+	-	- Rod	*Salmonella spp*
33	MA_1	+	-	-	y/y	-	+	-	+	- Rod	*Eshericha coli*
	BANK G										
34	MSA_1	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
35	MSA_2	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
36	SSA_1	+	-	+	R/y	+	-	+	-	- Rod	*Salmonella spp*
37	SSA_2	+	-	+	R/y	+	-	+	-	- Rod	*Salmonella spp*
	BANK H										
38	MA_1	+	-	-	y/y	-	+	-	+	- Rod	*Eschericha coli*
39	MA_2	+	-	+	y/y	-	+	-	+	- Rod	*Eschericha coli*
40	MSA_1	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*

41	SSA_1	+	-	+	R/y	+	-	+	-	- Rod	*Salmonella spp*
42	MSA_2	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
	BANK I										
43	MSA_1	+	-	-	y/y	-	-	+	-	+	*Staphylococci spp*
44	MSA_2	+	-	-	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
45	MA_1	+	-	-	y/y	-	+	-	+	- Rod	*Eschericha coli*
46	MA_2	+	-	-	y/y	-	+	-	+	- Rod	*Eschericha coli*
	BANK J										
		+	-	+	R/y	+	-	+	-	- Rod	*Salmonella spp*
48	MSA_1	+	-	+	y/y	-	-	+	-	+ cocci	*Staphylococci spp*
49	MA_1	+	-	-	y/y	-	+	-	+	- Rod	*Eschericha coli*
50	C_1	-	+	+	R/R	-	+	+	-	-Rod	*Pseudomonas spp*
51	C_2	-	+	+	R/R	-	+	+	-	-Rod	*Pseudomonas spp*
52	SSA_1	+	-	+	R/y	+	-	+	-	- Rod	*Salmonella spp*

Keys: y- acidic (yellow), R- red (alkaline), +(positive), -(negative). MA-MacConkey agar; MSA-Mannitol salt agar; SSA–Salmonella–Shigella agar; C-Cetrimide agar

Table 3: Bacterial counts from various banks of each ATM button (Cfu/ml)

S/No	Sample	Colony-forming units (cfu/ml)
1	Mannitol Salt agar	
	Bank A	2.0×10^6
	Bank B	1.0×10^6
	Bank C	3×10^4
	Bank D	8×10^4
	Bank E	8×10^4
	Bank F	7×10^4
	Bank G	4.0×10^6
	Bank H	9×10^4
	Bank I	8×10^4
	Bank J	1.0×10^6
2	MacConkey agar	
	Bank A	1.5×10^6
	Bank B	1.2×10^6
	Bank C	1.2×10^6
	Bank D	8×10^4
	Bank E	1.0×10^6
	Bank F	7.6×10^4
	Bank G	2.5×10^6
	Bank H	8×10^4
	Bank I	6×10^4
	Bank J	7×10^4
3	Salmonella-Shigella agar	
	Bank A	$1.0 \times 10_5$
	Bank B	1.0×10^5
	Bank C	5×10^4
	Bank D	5.6×10^4
	Bank E	8×10^4
	Bank F	8×10^4
	Bank G	1.5×10^5
	Bank H	8×10^4
	Bank I	8×10^4
	Bank J	5×10^4
4	Cetrimide agar	
	Bank A	5.0×10^5
	Bank B	Nil
	Bank C	Nil
	Bank D	Nil
	Bank E	Nil
	Bank F	Nil

Bank G	Nil
Bank H	Nil
Bank I	Nil
Bank J	Nil

Table 4: Antibiotic susceptibility test of the bacterial isolates from various Banks of each ATM

ISOLATES	Antibiotics (IZD (mm)							
	VA (30µg)	CIP (5µG)	AMOX (10µg)	TET (30µg)	ERY (15µg)	GENT (10µg)	CEF (30µg)	FOX (30µg)
BANK A								
SS_1	-	34	17	22	17	25	16	18
SS_2	-	30	15	24	12	27	15	16
MSA_1	26	38	12	20	13	27	18	12
MSA_2	24	35	13	20	15	20	16	15
MA_1	-	39	10	30	10	25	18	15
BANK B								
MA_1	-	35	20	25	28	25	18	15
MA_2	-	34	26	33	12	26	16	15
MSA_1	20	35	27	37	12	25	18	12
MSA_2	23	32	20	30	10	25	15	12
SSA_1	-	35	26	20	12	27	20	16
SSA_2	-	38	21	25	17	28	16	15
BANK C								
MA_1	-	35	20	30	27	20	21	20
MA_2	-	30	20	20	22	25	19	18
MSA_1	20	30	20	30	15	25	20	20
SSA_1	-	34	22	25	27	25	19	18
SSA_2	-	35	28	27	10	28	22	16
MSA_2	15	30	11	20	21	11	15	15
BANK D								
SSA_1	-	33	15	25	20	29	20	15
SSA_2	-	30	15	20	21	28	17	15
MSA_1	20	30	20	25	25	15	20	15
MA_1	-	33	11	21	30	27	23	22
MSA_2	-	31	22	28	10	26	25	15
BANK E								
SSA_1	-	32	18	25	33	22	22	15
SSA_2	-	30	20	21	30	14	14	15
MSA_1	20	30	17	25	25	13	13	17
MSA_2	20	33	12	20	25	16	16	12
MA_1	-	31	20	28	20	30	17	11
MA_2	-	32	11	12	30	30	19	12
BANK F								
MSA_1	20	30	16	20	15	25	18	15
MSA_2	15	32	15	15	15	28	15	20
SSA_1	-	30	16	20	15	25	19	20
SSA_2	-	30	20	20	28	25	18	22
MA_1	-	30	20	20	28	25	15	20
BANK G								
MSA_1	15	33	12	15	20	16	15	20
MSA_2	20	35	11	25	10	20	11	10
SSA_1	-	26	6	22	27	23	18	10
SSA_2	-	26	10	20	25	25	18	12
BANK H								
MA_1	-	25	17	20	28	28	19	10

MA_2	-	30	10	22	28	27	25	10
MSA_1	15	30	18	20	25	25	15	18
SSA_1	-	30	35	15	20	28	20	25
MSA_2	17	31	10	16	22	27	18	16
BANK I								
MSA_1	20	30	23	25	26	20	20	28
MSA_2	20	31	10	16	22	27	18	16
MA_1	-	30	23	25	26	20	20	22
MA_2	-	30	20	20	29	28	20	25
SSA_1	-	35	17	20	25	29	17	26
BANK J								
MSA_1	18	33	24	21	20	23	19	22
MA_1	-	35	12	20	22	28	18	20
C_1	-	37	14	20	24	29	16	22
SSA	-	38	13	22	24	28	15	10

Keys: Van-vancomycin, Ip - ciprofloxacin, fox - cefoxitin, cef - cefepime, amox-amoxicillin, TET-Tetracycline, ERY-Erythromycin, Gent-gentamicin. MA-MacConkey agar MSA-Mannitol salt agar SSA-Salmonella – shigella agar
C-Cetrimide agar.

DISCUSSION

The result obtained (Tables 1- 3 and Figures 1-2) showed that pathogenic bacteria such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhimurium* and *Staphylococcus aureus* were isolated from Automated Teller Machines located at university market road and Enugu Road, respectively within Nsukka Metropolis. A total of 52 isolates were collected. Among the 52 Isolates, 34 were Gram-negative rods, and 18 were Gram-positive cocci in clusters. The Gram-negative organisms include *Escherichia coli*, Salmonella spp., and Pseudomonas spp. The Gram-positive organism includes Staphylococcus spp. Of 52 isolates, 18 were staphylococcal spp, 16 were *Escherichia coli*, 15 were *Salmonella* spp., and 3 were Pseudomonas spp.; *Serratia* was also identified. Of the 18 staphylococcal spp. 16 were *S. aureus*. The major tests considered were those that differentiated the different isolates. These tests include catalase, indole, citrate, mannitol fermentation, oxidase and Triple sugar test. Findings from this study reveal Staphylococcus to be the most frequently occurring isolate with a high percentage occurrence, followed by *E.coli*, Salmonella, and *Pseudomonas aeruginosa*. The various test and results of characterization is shown in Table 1. The highest incidence of *S. typhimurium* was in ATMs of Bank H this could be as a result of high frequency of visit to the ATM by vast population of market women and other business people. Staphylococcus is a normal flora of the body which can easily be picked from door handles, in a society where there is low hygiene. This explains its prevalence .it is also associated with numerous infectious disease conditions. Furthermore Figure 1 revealed that of the fifty-two (52) isolates from ATMs the following organism were prevalent *S. aureus* 18(34.6%), *Escherichia coli* (30.8%), *S. typhimurium* (28.8%), *Pseudomonas aeruginosa* (5.76 %). The predominance of *Staphylococcus* spp. may be associated with their common occurrence on human skin and frequent transfer through hand contact. The recovery of *E. coli* and *Salmonella* spp. further suggests possible faecal contamination and inadequate hand hygiene among ATM users. These findings highlight the potential role of ATM surfaces as reservoirs of bacterial contaminants.

The results in Figure 3 show that the isolates were most sensitive to ciprofloxacin (100%), then gentamycin (96.2%), tetracycline (86.6%), amoxicillin (71.2%), erythromycin (59.7%) and cefepime (59.7%). They are highly resistant to vancomycin (80.7%) and cefoxitin (78.8%). This study contrasted with the result of antibiogram data obtained by Oluduro *et al*. [19], where susceptibility of *Escherichia coli to erythromycin* and ciprofloxacin was 93% and 35 %, respectively. The variation might be because of variation in geographical locations, environmental conditions and genetic background of the organism and the abuse of drugs in a location which leads to drug resistance [20]. These findings suggest that ciprofloxacin and gentamicin exhibited the most favourable antibacterial activity against the tested isolates. However, resistance classifications require confirmation using appropriate organism-specific interpretive standards, particularly because vancomycin is not clinically effective against Gram-

negative bacteria. Overall, the findings demonstrate heterogeneous antibiotic susceptibility patterns among bacteria recovered from ATM surfaces, emphasizing the importance of antimicrobial susceptibility testing for characterizing environmental bacterial isolates.

CONCLUSION

Pathogenic bacteria such as *Escherichia coli*, *S.typhimurium*, *P aeruginosa* and *Staphylococcus aureus* were isolated from the selected Auto Teller Machines located within Nsukka Metropolis. The research work established that there is a connection between the Automated Teller Machine and the isolated pathogenic bacteria.

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AUTHORS' CONTRIBUTION

CVM, DPB and ECI conceived and designed the study. CVM, JUA, and OOO carried out the research under the supervision of ECI. CVM, DPB and SAE drafted the original manuscript and analysis. Manuscript proofreading: RCO, CAO, OFU, CAA, IFU. All authors read and approved the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare that there are no known financial or personal conflicts of interest that could have influenced the work reported in this manuscript.

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