



ISRG PUBLISHERS

Abbreviated Key Title: isrg j. multidiscip. Stud.

ISSN: 2584-0452 (Online)

Journal homepage: <https://isrgpublishers.com/isrgjms/>

Volume – III, Issue - V (May) 2025

Frequency: Monthly



Antibiotics susceptibility pattern of culturable bacteria species from automated teller machines in Enugu urban, Enugu State, Nigeria.

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| Received: 11.05.2025 | Accepted: 17.05.2025 | Published: 29.05.2025

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Abstract

Automated teller machine (ATM) remains an easy and fast means of financial transaction, yet a reservoir for the dissemination of microbial species. This study is aimed at determining the antibiotics susceptibility pattern of culturable bacteria species from automated teller machines in Enugu urban, Enugu State. Twenty swab samples of metallic keypad of ATM were collected and screened for the presence of culturable bacteria species using standard microbiological procedures. Developed colonies were identified using colonial features, Gram staining and microscopy, and biochemical characteristics. Identified isolates were evaluated for antibiotic susceptibility to ten commonly prescribed antibiotics using the Kirby-Bauer disk diffusion method. The isolates were identified as *Escherichia coli* (45.8%), *Staphylococcus aureus* (37.5%), *Bacillus* spp. (8.3%), *Coliform* bacteria (4.2%), and *Pseudomonas* spp. (4.2%) in the order of occurrence. *E. coli* were resistant to penicillin (100%), norfloxacin (90.9%), erythromycin (81.8%), clindamycin (72.7%), augmentin (72.7%), chloramphenicol (63.6%), ceftazidime (63.6%), and ciprofloxacin (54.6%) except for cefuroxime and vancomycin where sensitivity was above 50%. *S. aureus* showed over 60% sensitivity to the quinolones (ciprofloxacin and norfloxacin) but high resistant rate to the β -lactams (cefuroxime (100%), ceftazidime (88.9%), penicillin (88.9%), and augmentin (77.8%)). The study reveals that ATM serves as a non-human agent for the transmission of multiple drug resistance (MDR) opportunistic bacterial pathogens, especially *E. coli* and *S. aureus*. We recommend the maintenance of adequate personal hygiene, use of alcohol hand sanitizer, and frequent handwashing practices as a means to curb the spread of MDR pathogen from ATM keypads.

Keywords: Automated teller machine, antibiotic susceptibility, resistance, opportunistic pathogen, fomite.

INTRODUCTION

Automated teller machines (ATMs) are the longest standing and most widely used form of computer driven public technology which makes banking and other financial transactions easier (Nworie et al., 2012). It has significantly simplified everyday financial transactions and interactions, facilitated global connectivity and reduced the burden on individuals (Adane et al., 2021). ATMs are known by various other names including ATM machine, automated banking machine, cash dispenser, and various regional variants derived from trademarks on ATM systems held by particular banks. A typical usage of the ATM involves slotting a card into a recipient hole and following on-screen instructions. Punching the keys of the metallic keypads to enter secret codes and commands; thus, instructing the machine as to the kind of service one requires.

Microorganisms are ubiquitous in nature and have an amazing ability to adapt and grow in diverse environmental niches (Marbel et al., 2014; Katzenberger et al., 2021). Their ability to adapt and multiply on various surfaces and in different environments is key to their being found on soil surfaces, acidic hot springs, radioactive waste water, deep in the earth's crust as well as organic matter and surfaces of flora and fauna. Bacterial contamination of environmental objects and surfaces is a common phenomenon and survival rate on fomites can be relatively high (Zhao et al., 2019; Katzenberger et al., 2021). Many factors have been shown to influence bacteria transfers between surfaces, including the human behaviour, source and designated surface features, bacterial species involved, moisture levels, pressure and friction between the contact surfaces and inoculum size on surfaces (Zhao et al., 2019). Human beings have a marked tendency to pick up microorganisms from environmental objects, and the human hand has been shown to play a role in the transmission of organisms from one surface to another (Agu et al., 2018). Further the hand can serve as a means of pathogen transfer and disease dissemination (Ugwu et al., 2024).

The automated teller machine (ATM) is regarded as a mini bank as almost all forms of bank transactions can be carried out on it (Adane et al., 2021). ATM usage is open to the general public and people from all walks of life visit the ATM gallery for easy financial transaction. Through handling, microorganisms can be deposited on the keypad by users. The transfer rates of bacterial from metal-to-fingers and finger-metal can be high even at unfavourable environmental conditions (Zhao et al., 2019). The keypads of an ATM on which microorganisms thrive represent an often-overlooked reservoir for pathogenic microorganisms. Several microbial types including bacteria, fungi, and viruses have the potentials to survive on dry fomites like ATM machine keypads (Górny et al., 2022). Some have evolved different physiological resting stages, which gives them the advantage for surviving or hibernating during low water activity. For instance, certain gram-negative and gram-positive bacteria, especially enteric and respiratory pathogens can remain on fomites for hours and as long as thirty days (Zhao et al., 2019; Katzenberger et al., 2021). Pathogens' long survival on surfaces are influenced by the type of microorganism, the quantity of microbe deposited, and environmental condition like solar radiation, organic matter, temperature, humidity, and others (Lopez et al., 2013; Zhao et al., 2019).

Previous studies had earlier reported that many Gram-positive bacteria such as *Enterococcus* spp., *Staphylococcus aureus*, and *Streptococcus pyogenes* including Gram-negative bacteria like

Acinetobacter spp., *Escherichia coli*, *Klebsiella* spp., *Pseudomonas aeruginosa*, and *Shigella* spp. can survive for months on surfaces (Okoro et al., 2002; Memmet et al., 2013; Ugwu et al., 2024). Specific bacteria such as *Salmonella* and *Escherichia coli* have been implicated to be transferred from the hand to raw processed and cooked foods, even at minute levels on the fingers (Nworie et al., 2012). In 2002, studies showed that snacks eaten with the fingers can easily be cross-contaminated by bacteria from the hands through constant exchange of dirty currency notes (Lopez et al., 2013). Some studies have found out that microbes once in contact with hand and some hard surfaces find easy habitat with such surfaces and as a result are quite difficult to get rid of (Dawodu and Akanbi, 2021). ATMs in developing countries are particularly vulnerable to microbial contamination and pathogen invasion (Ozkan et al., 2016), thereby constituting a potential public health risk.

Assessing potential microbial pathogens from ATM for antibiotic susceptibility is of public health interest and a necessity to curb infections that might result from unhygienic handling of ATMs. This study aims to determine the antibiotics susceptibility pattern of culturable bacteria species from automated teller machines in Enugu urban, Enugu State.

METHODS

Study Area

The study was carried out in Enugu urban, Enugu State. The State is located in South-Eastern Nigeria and the city has an estimated population of 875,552 according to the National population commission in 2024. The total area of the State is 7,161 km² (2,765 sq. mi) and the State shares borders with Abia State and Imo State to the south, Ebonyi State to the east, Benue State to the northeast, Kogi State to the northwest and Anambra State to the west.

The study focused on ATM gallery of commercial banks within Enugu urban. Functional and frequently used ATM gallery within Enugu urban make up the study population. Non-functional ATM were excluded from the study. Banks that refused to give consent for sample collection were also excluded in the study.

Consent/Ethical Consideration

Permission was gotten from each of the banks before sample collection. During sample collection, bank staff was assigned to accompany the researcher to the ATM gallery. Also, the ATM users at the point of sample collection were properly informed of the intention of the study to avoid unnecessary misconceptions.

Sample Collection

Samples were collected from twenty randomly selected ATMs within the study area. Sample collection involved the use of sterile swab sticks as previously described (Agu et al., 2018). Before sample collection, the swab sticks were moistened with sterile distilled water and then rubbed over the surfaces of the metallic keypads of the ATM in a unilateral direction. Then, the swab sticks were aseptically placed in a screw-capped test tube containing sterile peptone water and labelled appropriately. Collected samples were transported to the Molecular Biology Laboratory of National Arbovirus and Vectors Research Centre (NAVRC), Enugu and analysis within 6 hours of sample collection.

Sample Analysis

Media preparation and bacteriological analysis of the sample

All the media used were prepared following the manufacturer's guide. The constituted media were carefully loaded into the autoclave and sterilized at 121 °C for 15 minutes under 15 pressures. The sterile media were allowed to cool to 40 °C before being poured into a clean sterile petri dish to solidify (Dawodu and Akanbi, 2021). MacConkey agar (LabM, Kent UK) was used for the selective cultivation of Enterobacteriaceae and brain heart infusion (BHI, Merck-KGaA, Germany) and blood agar were used as an enrichment media for the cultivation of other bacteria species. Loopful of the pre-enrichment sample was streaked on the already prepared sterile agar on plate and incubated for 24 hours at 37 °C. After incubation, developed colonies were sub-cultured severally to obtain distinct pure colonies.

Characterization and identification of bacterial isolates

Bacterial pure cultures were observed for colonial morphology, and subsequently characterized using Gram reaction, microscopy. Characterization using some biochemical assays including catalase, coagulase, indole, citrate utilization, urease tests. Identification was based on Bergey's Manual of Determinative Bacteriology as describe in (Acharjee, 2023; Ugwu et al., 2025).

Gram reaction

The Gram reaction of each isolate was determined by staining with Gram stain and observed under a light microscope using oil immersion objective 100x. The bacterial isolates appeared either as Gram positive or Gram negative under the microscope (Acharjee, 2023; Ugwu et al., 2025).

Catalase test

A loopful of the organism in broth culture was placed on a sterile slide, followed by a drop of 3% hydrogen peroxide solution. Positive results are shown by foaming or bubbles.

Coagulase test

A colony of the test organism was emulsified on a sterile slide using sterile distilled water in duplicates to get a milky suspension. A loopful of plasma was placed on one of the suspensions and observed for the formation of clumps within 10 seconds. The presence of agglutination within 10 seconds of adding plasma indicated positive reaction.

Indole test

Discrete colony of the test organism was inoculated into sterile test tubes with 4 ml of sterile tryptophan broth and incubated at 37 °C for 24 hours. Then, 0.5 ml of 4 (p)-dimethylamino-benzaldehyde, also known as Kovac's reagent, was added. Positive test results are shown by the presence of pink or red ring on the surface of the medium. Negative result shows no ring formation.

Citrate utilization test

A small vial was used to create sterile slanted Simmon's citrate agar medium and allow it to set. The test microorganism was inoculated onto the slant medium using a sterile wire loop, then it was incubated at 37 °C for 24 hours. After incubation, visible growth and change of media colour to vivid blue indicates positive result.

Urease test

A colony of the test organism was inoculated on the sterile slant and incubated for 1 or 6 hours. Organisms that hydrolyze urea quickly exhibit strong positive reactions when incubated for 6 hours. Delayed positive organisms create modest positive reactions on the slant that intensify with additional incubation. Urease

negative organism will continue to be yellow and with no colour change on the culture media.

Voges-Proskauer (VP) test

Incubate an MR/VP broth tube for 24 hours at 37 °C after inoculating it with a pure culture of the test organism. Add 1 mL aliquot of broth culture into a clean sterile test tube and then add 0.6 mL of 5% -naphthol and 0.2 mL of 40% KOH. Allow the tube to stand undisturbed for 10 to 15 minutes after giving it a little shake to expose the medium to ambient oxygen. A pink-red surface colour that appears 15 minutes or longer after the addition of the reagents indicates a positive VP test.

Methyl red test

Add methyl red indication to the other aliquot of the MR/VP broth culture and immediately look out for red color. Detection of a red colouration shows a positive methyl red test.

Sugar (Glucose and sucrose) fermentation tests

A 5 ml of peptone water was introduced into 5 sterile test tubes respectively. Thereafter, 2 drops of Andrade indicator were added into each of the test tubes and Durham's tubes were inserted in an inverted position, and sterilized. One gram of glucose and sucrose were added independently into 100 ml of sterile distill water and sterilized using membrane filter. A total of 1 ml of each of sterile sugar was added into each of the sterilized test tubes that contained the peptone water. Thereafter, the cultured organisms were inoculated into each of the tubes respectively. They were then incubated at 37 °C for 24 h. Positive result indicates yellow colour while gas production were seen in the Durham's tube.

Motility Test

Drop of each isolate's suspension was deposited on the hole of a hanging-drop microscopic glass slide then the slide was covered with a cover slip. Afterward, it was examined using a light microscope under 10x and 40x objective lenses.

Antimicrobial Susceptibility Testing (AST)

Antimicrobial susceptibility testing was performed according to Kirby-Bauer disc diffusion method as described by CLSI (2022) using Mueller-Hinton agar (Oxoid, Hampshire, UK) and commercially available antibiotics (Oxoid, Hampshire, UK). The antibiotics class, type, and code used in this study are presented in Table 1.

Table 1: Antibiotics used for susceptibility profile of bacteria from ATM in Enugu urban

Class of antibiotic	Antibiotic type	Code	Disc concentration
Quinolones	Ciprofloxacin	CIP	5 µg
	Norfloxacin	NOR	10 µg
Phenicol	Chloramphenicol	C	30 µg
Lincosamides	Clindamycin	CN	2 µg
β-lactam	Penicillin	P	10 U
	Augumentin	AUG	10 µg
Cephems	Cefuroxime	CXM	30 µg
	Ceftazidime	CAZ	30 µg
Glycopeptides	Vancomycin	VA	30 µg
Macrolides	Erythromycin	ERY	15 µg

Preparation of inoculum for AST

Bacterial inoculum was prepared to 0.5 MacFarland standard using 20 hours growth culture of each bacterial culture. The inoculum was spread over the surface of Mueller-Hinton agar by means of sterile swab sticks. Thereafter, the antibiotic discs were placed on the surface of the inoculated Mueller-Hinton agar plates and allowed to stand for 10 minutes. The plates were then incubated at 37 °C for 24 h after which inhibition zones were observed, measured using a metric rule, and recorded to the nearest millimeter (mm). Susceptibility and resistance profile were accorded based on breakpoint limit as stated in CLSI (2022). Strains that fall under the intermediate category was recorded as resistant (Sidrach-Cardona et al., 2014).

Data Analysis

All the data collected from this study were analyzed statistically using MS Excel 2019. All charts were also plotted using MS Excel 2019. Descriptive statistics and percentages were used to analyze the data.

RESULTS

Bacterial species were detected and isolated from swab samples of ATM in Enugu urban. Based on microscopic and biochemical assay, our study identified five bacterial species including *Escherichia coli*, *Staphylococcus aureus*, *Coliform bacteria*, *Bacillus spp*, and *Pseudomonas spp*. (Table 2). The percentage frequency for the detection of bacterial species ranged from 45.8% to 4.20% with *E. coli* been the most prevalent (Figure 1).

Table 2: Microscopic and biochemical characteristics of isolates from ATM in Enugu urban

S/N	TESTS	Characteristics (reactions)				
1	Gram staining	+ve	-ve	+ve	-ve	-ve
2	Shape	cocci in clusters	short rods	rod	rod	rod
3	Catalase	+ve	-ve	+ve	+ve	+ve
4	Coagulase	+ve	-ve	-ve	-ve	-ve
5	Indole	-ve	+++ve	-ve	-ve	+ve
6	Citrate	+ve	+ve	+ve	+ve	+ve
7	Urease	+ve	-ve	-ve	-ve	-ve
8	Voges Proskaur	+ve	-ve	+ve	-ve	-ve
9	Methyl red	+ve	+ve	-ve	+ve	+ve
10	Glucose test	+ve (A/G)	+ve (A/G)	+ve	-ve	+ve
11	Sucrose test	+ve (A/G)	+ve (A)	-ve	+ve	-ve
12	Motility test	Nm	Nm	M	M	M
Identified bacterial species		<i>Staphylococcus aureus</i>	<i>Escherichia coli</i>	<i>Bacillus cereus</i>	<i>Pseudomonas spp</i>	<i>Coliform bacteria</i>

[Nm: Non-motile, M: motile, +ve: Positive, -ve: Negative, A/G: Acid and gas production, A: acid production only]

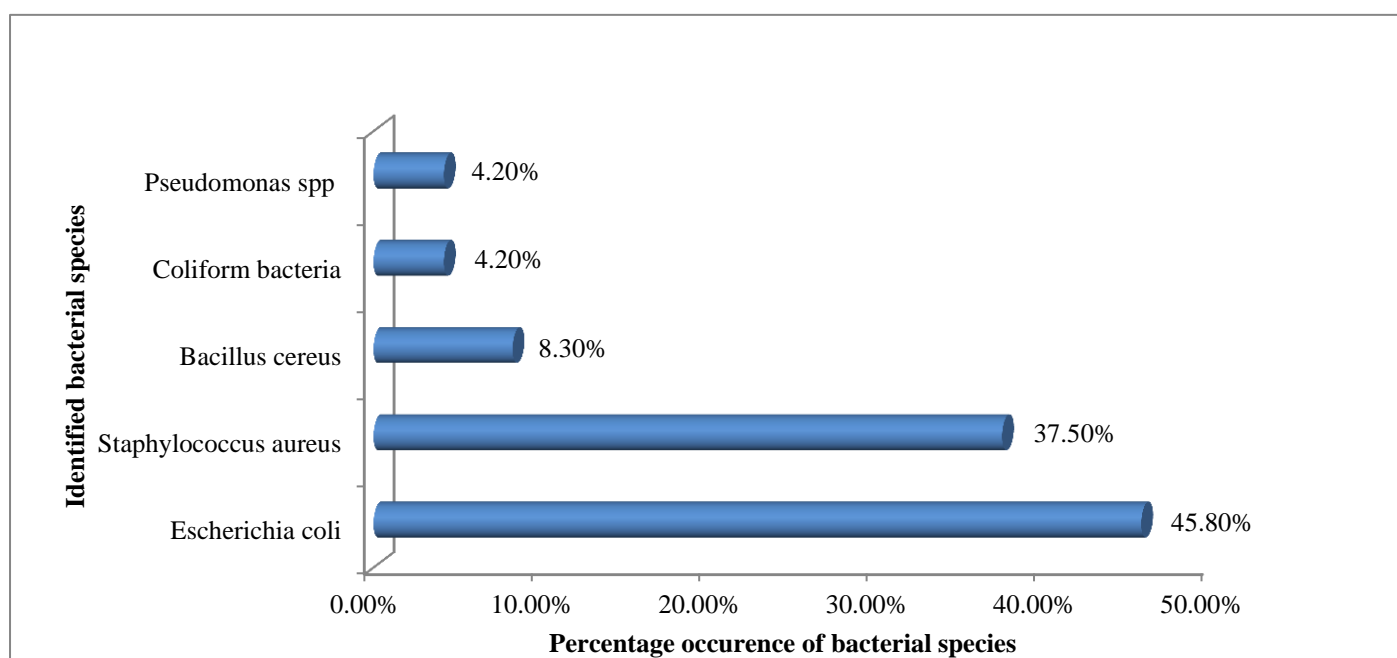


Figure 1: Percentage occurrence of identified bacterial species from ATM in Enugu urban

Screening for susceptibility to ten commonly used antibiotics showed that sensitivity to ciprofloxacin was 50% and above for all the bacterial species except for *E. coli* (45.45%). Similarly, all bacterial species in this study recorded more than 50% sensitivity to vancomycin. On the contrary, resistance to erythromycin, and ceftazidime was above 60% for all the bacterial species in this study (Table 3).

E. coli were resistant to penicillin (100%), norfloxacin (90.9%), erythromycin (81.8%), clindamycin (72.7%), augmentin (72.7%), chloramphenicol (63.6%), ceftazidime (63.6%), and ciprofloxacin (54.6%). On the other hand, *E. coli* showed sensitivity to cefuroxime (63.6%), and vancomycin (54.5%) (Table 3).

S. aureus showed over 60% sensitivity to the quinolones (ciprofloxacin and norfloxacin)

but higher resistant rate (above 70%) to the β -lactams (penicillin, augmentin, ceftazidime, and cefuroxime) (Table 3).

Table 3: Antibiotic susceptibility profile of bacterial species from ATM in Enugu urban

Antibiotics codes	Antibiotic class	<i>E. coli</i> (N=11)		<i>S. aureus</i> (N=9)		<i>Bacillus sp.</i> (N=2)		Coliform bacteria (N=1)		<i>Pseudomonas sp.</i> (N=1)	
		Sensitive	Resistant	Sensitive	Resistant	Sensitive	Resistant	Sensitive	Resistant	Sensitive	Resistant
		N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
CIP	Quinolones	5 (45.45)	6 (54.64)	6 (66.66)	3 (33.33)	1 (50.00)	1 (50.00)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)
NOR		1 (9.09)	10 (90.90)	7 (77.77)	2 (22.22)	0 (0.00)	2 (100.00)	0 (0.00)	1 (100.00)	1 (100.00)	0 (0.00)
C	Phenicol	4 (36.36)	7 (63.63)	4 (44.44)	5 (55.55)	1 (50.00)	1 (50.00)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)
CN	Lincosamides	3 (27.27)	8 (72.72)	0 (0.00)	9 (100.00)	0 (0.00)	2 (100.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)
P	β -lactam	0 (0.00)	11 (100.00)	1 (11.11)	8 (88.88)	0 (0.00)	2 (100.00)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)
AUG		3 (27.27)	8 (72.72)	2 (22.22)	7 (77.77)	2 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)
CXM	Cephems	7 (63.63)	4 (36.36)	0 (0.00)	9 (100.00)	1 (50.00)	1 (50.00)	0 (0.00)	1 (100.00)	1 (100.00)	0 (0.00)
CAZ		4 (36.36)	7 (63.63)	1 (11.11)	8 (88.88)	0 (0.00)	1 (50.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)
VA	Glycopeptides	6 (54.54)	5 (45.45)	5 (55.55)	4 (44.44)	2 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)
ERY	Macrolides	2 (18.18)	9 (81.81)	3 (33.33)	6 (66.66)	0 (0.00)	2 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)

[S: sensitive, R: Resistance]; [CIP: Ciprofloxacin, NOR: Norfloxacin, C: Chloramphenicol, CN: Clindamycin, P: Penicillin, AUG: Augmentin, CXM: Cefuroxime, CAZ: Ceftazidime, VA: Vancomycin, ERY: Erythromycin]

DISCUSSION

Potential pathogenic bacterial species are ubiquitous in the environment and can be transferred from one surface to another by human hands. Bacteria deposited on fomites remains a source of infection transfer (Ugwu et al., 2024) and the transfer of bacterial from contaminated surfaces to human hand through touch plays a vital role in disease spread.

Our study revealed that opportunistic pathogens, *E. coli*, *S. aureus*, *Bacillus* and *Pseudomonas* were the major bacteria that colonized ATM keypad surfaces within Enugu urban. This finding indicates that ATM keypads can be considered a reservoir of potential pathogens and a major source of bacterial dissemination from fomite to hands and vice versa. Our findings agree with several studies that isolated similar opportunistic pathogens from ATM keypads beyond Africa (Górny et al., 2022; Mahmoudi et al., 2017), in Africa (Shayo et al., 2023), and in Nigeria (Nworie et al., 2012; Adedeji, 2019; Dawodu and Akanbi, 2021).

The ATM is available to the public and are frequently used by different people with varying degree of hygiene and health conditions. Poor hygiene and poor hand washing practices aids the dissemination enteric organism from fecal matter to oral and other surfaces. Zhao et al (2019) reported that the transfer rate of bacterial from metal to finger-tip is above 35% and can increase if the donor is rough and exhibits forceful rubbing during handling. Further, transfer efficiency of bacteria from fomite including currency notes can be relatively high under humid condition (Lopez et al., 2013).

The prevalent bacteria species detected in our study were *E. coli* and *S. aureus* with frequency of occurrence at 45.8% and 37.5%, respectively. This is not surprising as study showed high survival rate for *E. coli* and *S. aureus* on metal surfaces (Zhao et al., 2019) and currency notes (Lopez et al., 2013; Sivalingam and Dola, 2021). The works of Nworie et al., (2012) in Abakalliki, Ebonyi State revealed an occurrence rate of 16.7% and 50% for *E. coli* and *S. aureus* from ATM. In the same vein, several other studies reported that *E. coli* and *S. aureus* were among the most prevalent bacterial species isolated from ATM (Mahmoudi et al., 2017; Adedeji, 2019; Dawodu and Akanbi, 2021). Other bacterial species isolated from ATM include *Bacillus*, *Pseudomonas*, *Enterobacter* and *Klebsiella* (Nworie et al., 2012; Mahmoudi et al., 2017; Shayo et al., 2023). These reports are in affirmation with our findings which showed the *Bacillus* and *Pseudomonas* were among the bacterial species that colonize ATM keypads.

Although the isolated bacterial species are normal flora of man, they are equally pathogenic, especially when transferred to vulnerable sites. Most pathogenic *E. coli* are transmitted by faecal oral route while *S. aureus* are easily transferred via dermal contact (Akinola et al., 2022). Poor personal and environmental hygiene by users of ATM especially, those who operate the ATM with contaminated hands could be the major reason why these contaminants are present on the keypads of the ATM. Infections from opportunistic pathogens can be difficult to treat if the bacterial species are multiple drug resistance (MDR): resistance to three or more antibiotics.

Multiple drug resistance remains a global issue and a major public health concern. In our study the isolates recorded high resistance to commonly prescribed antibiotics. All bacterial species in this study were resistant to more than three antibiotics, and across three antibiotic classes. Hence, the isolates from this study can be referred to as MDR bacterial strains. Infections from MDR bacterial strains can cause treatment failure, increased morbidity and mortality, and contributes to the spread of super bugs.

In this study, ciprofloxacin and vancomycin showed better activity to all test bacteria species but the isolates were generally resistant to erythromycin, and ceftazidime. This result is comparable to findings from other studies where isolates from ATM showed increased sensitivity for ciprofloxacin and resistance to erythromycin (Nworie et al., 2012). This may explain the reason for the choice of these antibiotic as therapeutic agent in the treatment of common bacterial infections within the study area.

E. coli in this study showed resistance to virtually all classes of antibiotics tested. It was particularly resistant to all β -lactams including the cepheims. This could be as a result of the production of extended-spectrum beta-lactamases (ESBL) by the *E. coli* species. ESBL are enzymes that are responsible for MDR against the β -lactam antibiotics including penicillin and derivatives, cepheims and new generation cephalosporins (Rupp and Fey, 2003). Reports of ESBL-producing *E. coli* are growing worldwide and are fast becoming endemic with opportunistic pathogens (Castanheira et al., 2021).

S. aureus showed appreciable level of sensitivity to the quinolones but high resistant rate to the β -lactams. This finding is in concordance with reports of Akinola et al., (2022), where *S. aureus* from ATM showed 100% resistance to the β -lactams including augmentin, ceftazidime, ceftriaxone, cloxacillin and cefuroxime.

The misuse and abuse of antibiotic cannot be overruled as a predisposing factor to the MDR status of these bacterial species. Within the study location, antibiotics are commonly purchased over the counter and self-prescribed for the treatment of infections in human and animals without diagnosis (Chad et al., 2022). The indiscriminate use of antibiotics could be responsible for the rise in antibiotics resistance and the existence of MDR among the bacterial species. Further, constituting great risk to the users of ATM.

CONCLUSION AND RECOMMENDATION

The study revealed that automated teller machine can serve as a non-human agent for the transmission of opportunistic bacterial pathogens and a vehicle for disease transmission. The prevalent opportunistic pathogen isolated from ATM in Enugu urban include *E. coli* and *S. aureus*. Many of the isolated bacterial strains were MDR and displayed high level of resistance against some commonly used antibiotics.

The researchers therefore advice ATM users to observe high level of personal hygiene such as hand washing with detergent before and after using the ATM. Where possible, managers of the ATM are advised to provide hand washing materials beside every functional machine, such that users can wash their hands before and after using the ATM. This practice if enforced in all ATM stations will go a long way to curb pathogen dissemination and infections spread from the use of ATM.

ACKNOWLEDGEMENT

The funds for this research was solely provided by the Tertiary Education Trust Fund (TETFUND). We wish to thank TETFUND immensely for sponsoring this research.

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