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Bacterial Contamination and Antibiotic Resistance Patterns on POS and ATM Surfaces in Ahmadu Bello University, Zaria

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Abstract

The widespread use of Point of Sale (POS) systems and Automated Teller Machines (ATMs) has raised documented concerns about bacterial contamination and antibiotic resistance. This study investigated bacterial contamination, diversity, and antibiotic resistance profiles of isolates from ATM and POS surfaces at Ahmadu Bello University, Zaria. A total of 40 swab samples (20 from POS terminals and 20 from ATMs) were collected and analyzed using standard microbiological techniques. Results indicated that POS and ATM surfaces were contaminated with pathogenic bacteria, including Staphylococcus aureus and Escherichia coli. Enumeration revealed significantly higher total aerobic mesophilic counts on ATMs (6.94 x 10^5 CFU/mL) compared to POS (3.41 x 10^5 CFU/mL; P-value = 0.000); ATMs also had higher mean total Staphylococcal counts (TSE) and mean total coliform counts (TCE) than POS. The antibiotic susceptibility patterns showed that S. aureus isolates from ATMs were 100% susceptible to ciprofloxacin and tetracycline, and 50% susceptible to trimethoprim, gentamicin, and chloramphenicol, while showing 100% resistance to Amoxicillin and 25% resistance to chloramphenicol. Similarly, POS isolates showed 100% susceptibility to ciprofloxacin, 75% susceptibility to trimethoprim, chloramphenicol, and tetracycline, and 25% susceptibility to gentamicin. *E. coli* isolates from ATMs demonstrated 100% susceptibility to ciprofloxacin and tetracycline, and 75% susceptibility to trimethoprim, gentamicin, and chloramphenicol, with 100% resistance to Amoxicillin and 50% resistance to cefoxitin. Comparative analysis highlighted distinct differences in bacterial contamination, diversity, and antibiotic resistance between POS and ATM surfaces. Given these findings, implementation of routine disinfection protocols and public awareness initiatives is crucial to mitigate the risks of bacterial transmission and promote public health.

INTRODUCTION

Electronic banking involves consumers using the Internet to access their bank accounts and to undertake banking transactions [1]. At the basic level, internet banking can mean the setting up of a web page by a bank to give information about its products and services [1]. At an advanced level, it involves the provision of facilities such as accessing accounts, transferring funds, and buying financial products or services online [2]. In the 1990s, banks realized that the rising popularity of the World Wide Web gave them an added opportunity to advertise their services. Initially, they used the Web as another brochure, without interaction with the customer. Early sites featured pictures of the bank's officers or buildings, and provided customers with maps of branches and ATM locations, phone numbers to call for further information, and simple listings of products [3]. Nigeria does not embrace electronic banking as early as developed countries. Nigeria adopted an electronic banking system in the early 2000s [4].

In the rapidly evolving landscape of financial technology, the assessment of the impact of Automated Teller Machine (ATM) and Point of Sale (POS) transactions on currency circulation in Nigeria has become a topic of paramount importance. POS is a payment method that allows individuals to make transactions like fund transfers and cash withdrawals without visiting banking halls or ATM. However, charges apply depending on transaction volume. Nigeria, as one of the largest

economies in Africa, has experienced a significant surge in the use of electronic payment methods, such as ATM and POS terminals, in recent years [5]. These technologies have transformed the way people conduct transactions, leading to a shift away from traditional cash-based transactions [6]. This transformation raises essential questions about its effects on the circulation of physical currency within the country [6].

The automated teller machine (ATM) and point of sale machine are regarded as a mini bank, as almost all forms of bank transactions can be carried out on them. Its keypads, on which pathogenic microorganisms might survive, represent an often-overlooked reservoir for enteric diseases [7]. A representative number of microbes bear the potential for survival on dry fomites like ATM and POS machines, keypads [8]. They have evolved different physiological resting stages, which give them the advantage of surviving or hibernating due to low water activity. Some Gram-negative bacteria can remain as long as eleven days on surfaces. Important factors for the survival of pathogens on surfaces are the presence of organic matter, solar irradiation, temperature, and humidity. It was reported that many Gram-positive bacteria, such as *Enterococcus* spp., *Staphylococcus aureus*, and *Streptococcus pyogenes*, and Gram-negative bacteria, such as *Acinetobacter* spp., *Escherichia coli*, *Klebsiella* spp., *Pseudomonas aeruginosa,* and *Shigella* spp., can survive for months on surfaces. The survival rate of most pathogens varies, with mycobacteria *and Clostridium difficile* having a monthly lifespan, whereas *Bordetella pertussis, Haemophilus influenzae*, and *Vibrio cholerae* persist only for days (9).

Specific bacteria, such as Salmonella and *Escherichia coli,* have been implicated in being transferred from the hand to raw, processed, and cooked foods, even at minute levels [9]. The most recent research on microbial contamination on ATM and POS devices was conducted in 2020 by a team of researchers led by Farzad Shayeghi from the Medical Department, Islamic Azad University of Medical Sciences, Tehran, Iran. This study aimed to identify pathogens and factors related to microbial contamination on ATM and POS. The study reported that snacks eaten with the fingers can easily be cross-contaminated by bacteria from the hands through constant exchange of dirty currency notes [10]. It has also been reported that fungal microbial contamination is found associated with the use of ATMs. Some studies have found that microbes once in contact with hands and some hard surfaces find an easy habitat with such surfaces and, as a result, are quite challenging to get rid of [7].

Research has consistently shown that ATM and POS machines are prone to harmful microorganisms, posing a significant threat to public health. Despite these findings, no concrete actions have been taken to mitigate the risk of contamination. People frequently use these machines without a second thought about hygiene, unlike after using the restroom, where handwashing is more common [7]. Banks have also been negligent in maintaining cleanliness, circulating old currencies, and failing to implement preventive measures on these devices [7]. The widespread use of POS terminals and ATM has raised public health concerns due to the potential for microbial contamination. These devices are frequently touched by numerous individuals, creating a conduit for the transmission of pathogenic bacteria. Despite their ubiquitous presence in daily transactions, there is a lack of comprehensive understanding regarding the extent of bacterial contamination and the associated health risks [11]. The increasing adoption of electronic payment methods, such as Automated Teller Machines (ATMs) and Point of Sale (POS) terminals, has transformed financial transactions in Nigeria, leading to a shift away from traditional cash-based transactions [5,6]. However, these devices pose a significant public health risk due to potential microbial contamination [7]. Research has shown that ATMs and POS machines can harbor pathogenic microorganisms, including bacteria like *Salmonella, Escherichia coli*, and *Staphylococcus aureus*, which can survive on surfaces for extended periods (8, 9). The transmission of these microorganisms can occur through contact with contaminated surfaces, highlighting the need for proper hygiene practices (7, 10). Studies have reported that microbes can survive on dry fomites like ATM and POS machine keypads, and factors such as organic matter, solar irradiation, temperature, and humidity influence their survival [9]. The widespread use of these devices, frequently touched by numerous individuals, creates a conduit for the transmission of pathogenic bacteria, underscoring the importance of understanding the extent of bacterial contamination and associated health risks [11]. This study aims to investigate the microbial contamination on ATMs and POS machines in Nigeria, with a focus on antibiotic resistance and public health implications.

The advent of electronic banking has revolutionized financial transactions, with Automated Teller Machines (ATMs) and Point of Sale (POS) terminals becoming increasingly popular in Nigeria since the early 2000s [1,2]. These devices allow users to access their accounts, transfer funds, and conduct transactions online or through physical interactions [3]. However, the frequent use of ATMs and POS terminals by numerous individuals creates an often-overlooked reservoir for enteric diseases and pathogenic microorganisms (4). Studies have shown that bacteria like *Escherichia coli*, *Staphylococcus aureus*, Salmonella, and others can survive on dry surfaces, including ATM and POS keypads, for extended periods [5,6]. The transmission of these pathogens can occur through contact with contaminated surfaces, highlighting the risk of cross-contamination, particularly with dirty currency notes [7]. The widespread use of ATMs and POS terminals has raised public health concerns, with research consistently showing that these devices are breeding grounds for harmful microorganisms [7, 8]. Furthermore, the potential for microbial contamination and transmission of antibiotic-resistant bacteria poses a significant threat to public health, underscoring the need for a comprehensive understanding and preventive measures [9-11]. This study aims to investigate the extent of bacterial contamination and antibiotic resistance on ATMs and POS terminals in Ahmadu Bello University, Zaria, Nigeria.

MATERIALS AND METHODS

Study Area

This study was carried out in Ahmadu Bello University, Zaria, in the (11.1512° N, 7.6546° E) in Kaduna (10.5036° N, 7.4337° E) State, North-West zone of the Federal Republic of Nigeria [12].

Ethical Clearance and Informed Consent

With an introductory letter from the Department of Microbiology, Ahmadu Bello University, Zaria, Nigeria, formal consent was sought and obtained ethical approval from the University for the use of these ATMs and POS users.

Collection of Samples

A total of 20 ATMs and 20 POS machines were located in Ahmadu Bello University Main Campus. Swab sticks were used to collect samples from the machines' buttons, screens, cash dispensers, and card insertion points. This was done at standard environmental conditions. From each ATM and POS 5 swabs from each area were taken and labelled with appropriate sample codes. They were then transported to the Department of

Microbiology Laboratory immediately for analysis within 2 hours [7].

Sample Analysis (Stock Preparation and Serial Dilution)

Stock Preparation
About 8.6 g NaCl was added to 1000 mL of distilled water. The solution was mixed thoroughly until the NaCl dissolved completely. The solution was then boiled and allowed to cool to room temperature [13].

Serial Dilution
Dilution tubes were labelled according to the dilution series plan (10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, and $10^{-5,}$ respectively), starting from the highest dilution to the lowest. The diluent already prepared (normal saline) in a clean container was used. Using a sterile pipette, 1 mL of the normal saline was pipetted into the first dilution tube containing 9mL of the diluent. The solution added depends on the desired dilution factor. The contents of the first dilution tube were mixed thoroughly to ensure uniform dilution. A clean pipette was used to transfer another 1 mL of the first dilution tube to the second dilution tube containing diluent [14].

Total Aerobic Plate Counts
Each sample was serially diluted. 1 mL of the preparation was added to 9mL of sterile 0.1% peptone water in a test tube, resulting in a 1:10 dilution. 1 mL of 1:10 dilution was then transferred into the second 9 mL diluent with the second pipette. Further serial dilution in the same manner was carried out. 0.1 mL of 10^{-3} dilution of the sample was transferred onto the agar plate. All the plates were incubated at 37 ºC for 24 hours. Colonies on the plates were counted, and results were recorded in colony-forming unit per milliliter (CFU/mL) [15].

Total Staphylococcal Count
Enrichment of the bacteria was done by adding one milliliter (1 mL) of the sample into 9 mL peptone water and incubating for 18 hours at 37 ºC. Isolation of the *Staphylococcus aureus* was achieved by dispensing 0.1 mL of the pre-enriched culture from the peptone water onto a selective differential agar plate of Mannitol Salt Agar (MSA) freshly prepared following the manufacturer's instructions. The plates were then incubated at 37 ºC for 24 hours under aerobic conditions. The bacterial colonies were counted using a colony counter [14].

Total Coliform Count
Each sample was serially diluted. 1 mL of the preparation was diluted into 9mL of sterile 0.1% peptone water in a test tube, resulting in a 1:10 dilution. 1 mL of 1:10 dilution was then transferred into the second 9 mL diluent with the second pipette. Further serial dilution in the same manner was carried out. 0.1 mL of 10^{-3} dilution of the sample was transferred onto the agar plate. All the plates were incubated at 44 ºC for 24 hours. Colonies on the plates were counted and results were recorded in colony-forming unit per milliliter (CFU/mL) [15].

Isolation of Bacteria

Culture on Eosin Methylene Blue Agar for Isolation of *Escherichia coli*
An aliquot of 0.1 mL from 10^{-1} dilution was transferred to the surface of Eosin Methylene Blue (EMB) agar and gently spread across the surface with a bent glass rod to ensure homogeneity. Incubation was done at 37 ºC for 24 to 48 hours, after which the plate was observed [16].

Culture on Mannitol Salt Agar for Isolation of *Staphylococcus aureus*
Isolation of *Staphylococcus aureus* was achieved by pouring 0.1 mL of 10^{-1} dilution onto freshly prepared Mannitol salt Agar (MSA) plates and gently spreading across the surface with a bent glass rod. The plates were incubated at 37 ºC for 24 hours under aerobic conditions. Colonies showing golden yellow were presumed to be *Staphylococcus aureus* (17)

Gram Staining
A sample of the isolates was smeared on a clean, grease-free slide. The smear of suspension was prepared on the clean slide with a loopful of the sample. It was air-dry and heat fixed. Crystal violet was poured over it for 1 minute, and then rinsed with water. It was then flooded with Gram's iodine for 1 minutes and rinsed with water. Safranin was added for about 10-20 seconds and rinsed with water. It was then air-dried and observed using a microscope under the ×100 objective (18).

Biochemical Characterization
Escherichia coli was characterized using the Indole test, Motility test, Methyl red, Voges Proskauer, and citrate utilization tests (IMViC test), and motility, while *Staphylococcus aureus* was characterized using catalase, coagulase, motility, and deoxyribonuclease test.

Indole Test
Tryptic soy agar was prepared according to the manufacturer's instructions. About 5ml of the agar was poured into a test tube and allowed to solidify. The agar was then inoculated with the organism and incubated. The tubes were incubated for 24–28 hrs. After which, 0.5 mL of Kovac's reagent is added. Presence/absence of ring indicates positive/negative test [19].

Motility test
A sterile straight wire needle was used to pick a colony of a young 18-hour culture growing on agar medium. A single stab was made down the center of the tube containing motility agar to about half the depth of the medium. The stab was incubated at 35 – 37 °C and examined daily for 24 to 48 hours [19].

Methyl Red Test
The Methyl Red Voges Proskauer (MR-VP) broth was inoculated with pure cultures of the organisms. It was incubated at 37 ºC for 24 hours. Five drops of methyl red reagents were added per 5 mL of broth. Presence/absence of ring indicates positive/negative test [19].

Voges Proskauer Test
MR-VP broth was inoculated with the culture and incubated at 37 ºC for 24 hours. A zero-point milliliter of 5% alpha-naphthol was added, followed by 0.2 mL of KOH. It was shaken gently, and the tube was exposed to atmospheric oxygen. Development of red color indicates a positive reaction [20].

Citrate Utilization Test
A pure culture of the sample was inoculated on Simon citrate agar. It was then incubated aerobically at 37 ºC for 24 hours. Green to blue color change indicates a positive test [21].

Staphylococcus aureus
Catalase Test
A loop was used to transfer the colony onto the surface of a clean, dry glass slide. A drop of 3% H_2O_2 was dropped on the glass slide for the evolution of oxygen bubbles [22].

Coagulase Test
Two separate drops of saline were placed on a slide using a sterile inoculating loop. One or two colonies of the organisms were emulsified in one drop to make a thick suspension of bacteria. A loopful of plasma was added to both the suspension and the saline drop and then mixed gently. Clumping of the organism was observed within 10-15 seconds [22].

Deoxyribonuclease (DNase Test)
DNase agar was inoculated with 0.1 mL of the organism suspension. The plate was incubated at 35-37 °C for 24 hours. After the incubation period, a solution of iodine was added to cover the colonies for 10 seconds. A clear zone around the colonies indicates a positive DNase test [22].

Standardization of Inoculum
The McFarland standard of 0.5 was prepared by mixing 9.95 mL of 1% sulphuric acid and 0.05mL of barium chloride. The 1% sulphuric acid was prepared by mixing 1 mL of concentrated sulphuric acid with 99 mL of sterile distilled water, while the 1% barium chloride was prepared by dissolving 1g of solid barium chloride in 100 mL of sterile distilled water. Standardization of the test organism was done by emulsifying distinct colonies of the organism in a sterile bottle containing saline water. Their turbidity was compared with that of 0.5 McFarland standards, which is equivalent to 1.5 x 10^8 CFU/mL [22].

Antibiotic Susceptibility Testing
A sterile, non-toxic cotton swab was dipped into the standardized inoculum and used to spread the entire surface of Mueller-Hinton Agar (MHA). The antibiotic disc was placed aseptically on the surface of the agar plates, and all plates were incubated at 37 °C for 24 hours. The antibiotics to be used are tetracycline 30 µg, chloramphenicol 10µg, trimethoprim 5 µg, gentamicin 10 µg, ciprofloxacin 10 µg, Amoxicillin 10µg, and cefoxitin 30 µg [23]. Isolates were classified as resistant, intermediate, or sensitive based on the definition of the Clinical and Laboratory Standard Institute and in accordance with WHO requirements [24].

Data Analysis
Microbial counts of the POS machines and ATM were subjected to Analysis of Variance (ANOVA) at 95% confidence interval on IBM SPSS version 20. Factor(s) that had a statistical P-value ≤ 0.05 were considered significant. Final results were simplified on a chart and tables.

RESULTS

The mean total aerobic mesophilic counts (TAMC) of POS machines and ATM in Ahmadu Bello University (ABU), Zaria are presented in **Table 1**. There was a higher mean TAMC of $6.940\times10^5 \pm 6.358\times10^4$ CFU/mL on ATM than on POS machines ($3.410\times10^5 \pm 2.508\times10^4$ CFU/mL). The difference in mean total aerobic mesophilic counts of the machines was statistically significant (P = 0.000). **Table 2** presents the mean total staphylococcal counts (STC) of POS machines and ATM in ABU, Zaria. There was a higher mean STC of $7.0\times10^4 \pm 3.41\times10^3$ CFU/mL on ATM than on POS machines ($6.0\times10^4 \pm 3.36\times10^3$ CFU/mL). However, the difference in the mean STC between the two machines was not statistically significant (P = 0.836). The mean total coliform counts (TCC) of POS machines and ATM in ABU, Zaria are presented in **Table 3**. There was a higher mean TCC on ATM with $4.5\times10^3 \pm 2.56\times10^3$ CFU/mL than on the POS machines, which had $2.5\times103 \pm 1.76\times103$ CFU/mL. The difference was not statistically significant (P = 0.524).

Isolates that grew on Mannitol Salt Agar (MSA) were round, raised, and large golden-yellow colonies. They were characterized to be Gram-positive rods, non-motile, indole and methyl red negative, Voges Proskauer positive, but did not utilize citrate as the sole source of carbon; however, they possessed coagulase, Deoxyribonuclease, and catalase. These characteristics were confirmatory of *Staphylococcus aureus* (**Table 4**).

On the other hand, isolates that grew on Eosin Methylene Blue (EMB) agar were small, purple, round, raised colonies with a green metallic sheen. They were Gram-negative short rods, motile, positive on indole and methyl red tests, but negative on Voges-Proskauer test, and utilized citrate as the sole source of carbon. These characteristics were indicative of *E. coli,* as shown in **Table 4**. The overall occurrences of *Staphylococcus aureus* and *Escherichia coli* on POS machines in ABU Zaria were 15.0% and 10.0% respectively; while their respective occurrences on ATM were 20% and 15.0%. Occurrences of the pathogens were higher on ATM than on POS machines as shown in **Fig.1**.

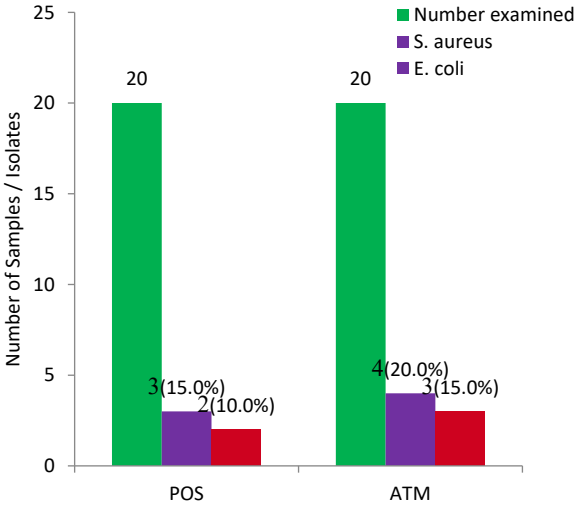

Fig. 1. Overall occurrences of *Staphylococcus aureus* and *Escherichia coli* on point of sales machines and automated teller machines in Ahmadu Bello University, Zaria.

The comparative antibiotic susceptibility pattern of *Staphylococcus aureus* isolated from POS machines and ATM in ABU Zaria is presented in **Table 5**. From the POS machines, the isolates (n=3) were 100.0% susceptible to ciprofloxacin and tetracycline. This was followed by 66.7% susceptibility to trimethoprim, gentamicin, and chloramphenicol. There was 33.3% intermediate susceptibility to each of trimethoprim, gentamicin, and cefoxitin. Isolates from the POS machines are mostly resistant to ampicillin (100.0%), cefoxitin (66.7%), and tetracycline (33.3%).

Table 1. Mean total aerobic mesophilic count of point of sales machines and automated teller Machines in Ahmadu Bello University, Zaria.

Machine	Number examined	TAMC (CFU/mL)	±SEM	ANOVA (F)	df	P
POS	20	$3.410\times10^5 \pm 2.508\times10^4$		26.676	39	0.000
ATM	20	$6.940\times10^5 \pm 6.358\times10^4$				
Total	40	$5.175\times10^5 \pm 4.401\times10^4$				

Key: POS = Point of Sale machine; ATM = Automated teller machine; TAMC = Total aerobic mesophilic count; SEM = Standard error; Analysis of variance

Table 2. Mean Total Staphylococcal counts of point of sales machines and automated teller machines in Ahmadu Bello University, Zaria.

Machine	Number examined	TSC ± SEM (CFU/mL)	ANOVA (F)	df	P
POS	20	$6.0\times10^4 \pm 3.36\times10^3$	0.044	39	0.836
ATM	20	$7.0\times10^4 \pm 3.41\times10^3$			
Total	40	$6.5\times10^4 \pm 2.36\times10^3$			

Key: POS = Point of Sale machine; ATM = Automated teller machine; TSC = Total staphylococcal count; SEM = Standard error; Analysis of variance

Table 3. Total coliform counts of point of sales machines and automated teller machines in Ahmadu Bello University, Zaria.

Machine	Number examined	TCC ± SEM (CFU/mL)	ANOVA (F)	df	P
POS	20	$2.5\times10^3 \pm 1.76\times10^3$	0.414	39	0.524
ATM	20	$4.5\times10^3 \pm 2.56\times10^3$			
Total	40	$3.5\times10^3 \pm 1.54\times10^3$			

Key: POS = Point of Sale machine; ATM = Automated teller machine; TCC = Total coliform count; SEM = Standard error; Analysis of variance

Table 4. Gram reaction, biochemical and cultural characteristics of *Staphylococcus aureus* and *Escherichia coli* from point of sales machines and automated teller machines in Ahmadu Bello University, Zaria.

Number of isolates	Gram reaction	Motility	Indole	MR	VP	CU	Coa	DNase	Ca	Inference
7	Gram cocci	+	-	-	-	+	-	+	+	+	*Staphylococcus aureus*
5	Gram short rods	-	+	+	+	-	+	**	**	**	*Escherichia coli*

Key: MR = Methyl red; VP = Voges Proskauer; Citrate utilization; Coa= Coagulase; Ca = Catalase; Negative (-); Positive (+); Not applicable (**), Dnase= Deoxyribonuclease

On the other hand, the *Staphylococcus aureus* isolated from ATM was 100.0% susceptible to ciprofloxacin, followed by 75% susceptibility to each of trimethoprim, chloramphenicol, and tetracycline. Also, 50.0% and 25.0% were susceptible to gentamicin and cefoxitin, respectively. However, there was 25.0% intermediate susceptibility to each of trimethoprim, gentamicin, and cefoxitin. Similarly, *Staphylococcus aureus* isolated from the ATM was 100.0% resistant to ampicillin, followed by 50.0% resistance to cefoxitin. There was 25.0% resistance to each of gentamicin and chloramphenicol (**Table 5**).

Antibiotic susceptibility pattern of *Escherichia coli* is presented in **Table 6**. The isolates from POS machines (n=2) were 100.0% susceptible to each of ciprofloxacin, trimethoprim, gentamicin, chloramphenicol, and tetracycline. However, 50.0% were intermediately susceptible to cefoxitin. The highest resistance of the *Escherichia coli* from the POS machines was observed against ampicillin (100.0%) followed by 50.0% resistance to cefoxitin. Similarly, the *Escherichia coli* isolates from ATM in ABU, Zaria, were found to be 100.0% susceptible to ciprofloxacin and tetracycline. However, 66.7% were each susceptible to trimethoprim, gentamicin, and chloramphenicol. There was 33.3% intermediate susceptibility to each of trimethoprim, gentamicin, and cefoxitin. The highest resistance of the *Escherichia coli* isolates was recorded against ampicillin (100.0%) and cefoxitin (66.7%); while the least resistance was 33.3% against chloramphenicol, as presented in **Table 6**.

Table 5. Antibiotic Susceptibility Patterns of *Staphylococcus aureus* isolated from Point of Sales Machines and Automated Teller Machines in Ahmadu Bello University, Zaria.

Antibiotic (µg)	POS n=3			ATM n=4			Total n=7		
	S (%)	I (%)	R (%)	S (%)	I (%)	R (%)	S (%)	I (%)	R (%)
AMX (10)	0(0.0)	0(0.0)	3(100.0)	0(0.0)	0(0.0)	4(100.0)	0(0.0)	0(0.0)	7(100.0)
CIP (5)	3(100.0)	0(0.0)	0(0.0)	4(100.0)	0(0.0)	0(0.0)	7(100.0)	0(0.0)	0(0.0)
TMP (5)	2(66.7)	1(33.3)	0(0.0)	3(75.0)	1(25.0)	0(0.0)	5(71.4)	2(28.6)	0(0.0)
GEN (10)	2(66.7)	1(33.3)	0(0.0)	2(50.0)	1(25.0)	1(25.0)	4(57.1)	2(28.6)	1(14.3)
CHL (30)	2(66.7)	0(0.0)	1(33.3)	3(75.0)	0(0.0)	1(25.0)	5(71.4)	0(0.0)	2(28.6)
TET (30)	3(100.0)	0(0.0)	0(0.0)	3(75.0)	1(25.0)	0(0.0)	6(85.7)	1(14.3)	0(0.0)
CTX (30)	0(0.0)	1(33.3)	2(66.7)	1(25.0)	1(25.0)	2(50.0)	1(14.3)	2(28.6)	4(57.1)

Key: AMX= Amoxicillin; CIP= ciprofloxacin; TMP= trimethoprim; GEN= gentamicin; CHL= chloramphenicol; TET= tetracycline; CTX= cefoxitin

Table 6. Antibiotic Susceptibility Patterns of *Escherichia coli* isolated from Point of Sales Machines and Automated Teller Machines in Ahmadu Bello University, Zaria.

Antibiotic (µg)	POS n=2			ATM n=3			Total N=5		
	S (%)	I (%)	R (%)	S (%)	I (%)	R (%)	S (%)	I (%)	R (%)
AMX (10)	0(0.0)	0(0.0)	2(100.0)	0(0.0)	0(0.0)	3(100.0)	0(0.0)	0(0.0)	5(100.0)
CIP (5)	2(100.0)	0(0.0)	0(0.0)	3(100.0)	0(0.0)	0(0.0)	5(100.0)	0(0.0)	0(0.0)
TMP (5)	2(100.0)	0(0.0)	0(0.0)	2(66.7)	1(33.3)	0(0.0)	4(80.0)	1(20.0)	0(0.0)
GEN (10)	2(100.0)	0(0.0)	0(0.0)	2(66.7)	1(33.3)	0(0.0)	4(80.0)	1(20.0)	0(0.0)
CHL (30)	2(100.0)	0(0.0)	0(0.0)	2(66.7)	0(0.0)	1(33.3)	4(80.0)	0(0.0)	1(20.0)
TET (30)	2(100.0)	0(0.0)	0(0.0)	3(100.0)	0(0.0)	0(0.0)	5(100.0)	0(0.0)	0(0.0)
CTX (30)	0(0.0)	1(50.0)	1(50.0	0(0.0)	1(33.3)	2(66.7)	0(0.0)	2(40.0)	3(60.0)

Key: AMX= Amoxicillin; CIP= ciprofloxacin; TMP= trimethoprim; GEN= gentamicin; CHL= chloramphenicol; TET= tetracycline; CTX= cefoxitin

DISCUSSION

The widespread use of ATMs and POS devices at Ahmadu Bello University presents a significant risk of disease transmission due to their frequent public access. As people with varying health statuses interact with these devices, microorganisms, especially bacteria, can easily transfer from the environment or individuals to the devices. This study assessed the bacterial load and susceptibility of some bacteria on ATM and POS machines in Ahmadu Bello University, Zaria. The sample size was limited to 40 because of the number of ATMs and POS that are available within the University. This study revealed that the surfaces of these machines are colonized and highly contaminated by *Staphylococcus aureus* and *Escherichia coli,* among other bacteria. It also indicated a significant difference ($p < 0.05$) in the total aerobic mesophilic counts, Staphylococal and coliform counts between ATMs and POS devices, with mean values of 3.410×10^5 $\pm2.508\times10^4$ and 6.940×10^5 $\pm6.358\times10^4$ CFU/mL; 6.0×10^4 $\pm3.36\times10^3$ and 7.0×10^4 $\pm3.41\times10^3$ CFU/mL; 2.5×10^3 $\pm1.76\times10^3$ and 4.5×10^3 $\pm2.56\times10^3$ CFU/mL, respectively.

These counts are very significant and high, as found in similar studies conducted by (7), who revealed that ATMs and POS machines had high total aerobic mesophilic, staphylococcal, and coliform counts. These may serve as reservoirs for bacterial transmission. *Staphylococcus aureus* and *Escherichia coli* isolated from these machines were resistant to ampicillin and cefoxitin but showed susceptibility to ciprofloxacin, trimethoprim, chloramphenicol, and tetracycline. This is in tandem with the findings of (8). To compare the level of bacterial contamination of ATMs and POS machines based on this study, it can be deduced that ATMs are more contaminated than POS machines. This is likely due to their presence in open areas, whereas POS machines are usually handled by individuals in closed environments. More so, ATMs are used more frequently and for longer periods, increasing hand contact and bacterial transfer, while POS transactions are generally quicker and less interactive. In order to mitigate the public health risks associated with ATMs and POS devices implementation of sanitizing methods is crucial, where strategies such as periodic ultraviolet (UV) light irradiation for specific durations daily, regular cleaning of monitors and keypads with antiseptic materials or alcohol, frequent disinfection of devices, ideally after each use especially for POS machines are recommended (25)

CONCLUSION

The total aerobic mesophilic, total Staphylococcal, and total coliform counts of Point of Sale (POS) and Automated Teller Machine (ATM) surfaces were successfully determined. The total aerobic mesophilic count on these devices was significantly higher on ATM than on POS machines. Pathogenic bacteria, including *Staphylococcus aureus* and *Escherichia coli*, were isolated from both machines, with higher occurrences on the ATM. This presents a significant public health issue, as these devices are heavily used in public spaces; they serve as potential vectors for microbial transmission, especially in high-traffic areas. The antibiotic susceptibility tests revealed alarming rates of these bacteria to ampicillin and cefoxitin, with sensitivity to ciprofloxacin, trimethoprim, chloramphenicol, and tetracycline. The frequent detection of antibiotic-resistant bacteria from these surfaces could contribute to the growing global health threat of antimicrobial resistance.

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