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ASSESSMENT OF SOME SELECTED AUTOMATED TELLER MACHINES IN KADUNA METROPOLIS FOR PATHOGENIC BACTERIA CONTAMINATION

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ABSTRACT: *Selected Automated Teller Machines in Kaduna Metropolis were assessed for pathogenic bacteria contamination. Pathogenic bacteria such as Escherichia coli, Pseudomonas aeruginosa, Shigella dysenteriae, Salmonella typhimurium, Staphylococcus aureus and Klebsiella pneumonia were isolated using standard methods. Kano Road and Ahmadu Bello Way had the highest number of isolates as well as sample size because of the concentration of the banks around these roads and the influx of people within and around this area who do business on a daily basis. K. pneumoniae had the largest percentage of isolates with 46 (23.0%), followed by S. dysenteriae with 37 (18.50%). S. aureus, S. tyhimurium, and P. aeruginosa had 33 (16.50%), 32 (16.0%) and 29 (14.5%) respectively while E. coli had the smallest percentage of isolates with 22 (11.0%). The correlation coefficient (r) of 0.60 obtained showed that there is a strong relationship between the isolated pathogenic bacteria and the Automated Teller Machines.*

KEYWORDS: Pathogenic Bacteria, Contamination, Automated Teller Machines

INTRODUCTION

Information and Communication Technology (ICT) is a major driver of improved quality of life, economic growth and development in the countries of the world. It is indisputable that ICT has the potential to continue driving growth for the foreseeable future. Anwana (2010) is of the view that electronic banking is an offshoot of ICT and it provides the classic and current means of banking. Electronic banking (e-banking) has brought colossal transformation into the banking industry and is still having major effects on banking relationships; e-banking is gradually becoming 'an essential to have' than 'a pleasure to have' service. E-banking systems evolved technologies such as Automated Teller Machines (ATMs), Point of Sales Terminals (POS), Electronic Funds Transfer and Telebanking. Out of all these technologies, the Automated Teller Machines or Automatic Teller Machines (ATMs) has the most significant impact on the common man (Folorunsho *et al*., 2010).

Automated Teller Machines (ATMs) services are considered as one of the most essential services offered by the banking industry globally. These services are provided within certain locations, either within the area of the bank branches or outside the area of the bank branches (Okafor and Ezeani, 2012; Mehdi *et al*., 2013). Transition from the traditional monetary instruments of paper and metal based currency to “plastic money” in the form of credit cards and debit cards accelerated the global use of ATM as one of the fastest means of cash dispensing in use (Ndife *et al*., 2013). Mehdi *et al*. (2013) believes that development of the

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ATMs services not only has affected economic status of countries, it has had several deep social and cultural effects on quality of lives of individuals.

The wide acceptance of e-banking technology has created new environmental challenges on publicly used electronics and technological devices; it provides an avenue for high human dermal contact which could be a source of contamination, infection and health hazard to man. The ATM has been perceived as low performing when it is without cash to 'give out' and therefore much resources has been expended to maintain and ensure that it possesses and dispenses cash as quickly as possible; the hygienic, aesthetic and environmental safety conditions have been at the mercies of employed general cleaners.

Most of these cleaners may not have proper training to differentiate between generalised and specialized cleaning; they may use rags for cleaning toilets, tables and chairs to clean ATMs. These types of cleaning regimes overtime could discolour the machine, dispose and disseminate germs which could be transferred between and within the banking premises via ATMs. These machines are sometimes left at the mercies of impulses of different weather and climatic conditions as most of the ATMs are filthy, covered with dust and grime especially after a heavy rain that one may have to cover ones nose to make use of the machines in cities like Lagos, Port Harcourt, Kano, and Abuja (Faroyji, 2013).

An Automatic Teller Machine (ATM) according to Sharma and Rathore (2012) is an electronic unattended banking outlet, which allows customers to complete basic banking transactions without a direct branch interaction or a branch representative or teller. It is connected to a data system and related equipment and activated by a bank customer to obtain cash withdrawals amongst other services such as cell-phone recharge and inter- account transfer. The ATM comprises a computer with a keypad and screen to perform tasks to access bank accounts through telephone networking, a host processor, and a bank computer to authenticate data. This means that a customer must be in physical interaction with the machine to carry out transactions (Sharma and Rathore, 2012).

In addition, there is no restriction as to who has access to the facility, and no guidelines to ensure hygienic usage. But like all surfaces, microbial colonization of these metallic keypads are eminent, particularly so when there are no proper cleaning regimen in place for most of these facilities. Such colonisations and their subsequent biofilm formation have been the theme of research by several investigators (Hood and Zottola, 1997; Sharma and Anand, 2002). Many factors have been shown to influence the bacteria transfers between surfaces, including the source and destination surface features, bacterial species involved, moisture levels, pressure and friction between the contact surfaces and inoculum size on surfaces (Chen *et al.*, 2001; Rusin *et al.*, 2002; Montville and Schaffner, 2003; Whitehead and Verran, 2006).

LITERATURE REVIEW

History of ATM and Its Introduction To Banking Operation

Milligan (2007) and Miller (2011 maintained that an ATM service was used first in 1967 and became fully integrated in mainstream banking in the 1980s. ATM services have since its development, improved day after day to meet customers' demands. Jegede (2014) noted that the first ATM in Nigeria was installed by National Cash Registers (NCR) for the defunct Societe Generale Bank Nigeria (SGBN) in 1989. Since then, the number of these machines

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installed across the country has increased as it became more popular after the post-consolidation era of 2005 (Ojo, 2010).

The Spread of ATMs in Nigeria

A recent report by Udenze (2013) confirms that as at the end of October 2013, there were about 12,100 active ATMs performing transactions across the country at bank branches, hotels and airports while the nation's banks have so far invested a whopping N390 billion in the acquisition of Automated Teller Machines (ATMs) deployed across the country in a bid to ease payment system. This amount excludes the quarterly technical support from these ATMs suppliers; more billions are spent on this. ATMs have transformed the face of electronic payment in Nigeria.

ATMs in Public Places

ATMs can be regarded as public places considering the number of persons that use them daily especially in metropolitan, cosmopolitan and other urban/peri-urban areas. Public places are spatial locations where large numbers of people meet. They could refer to street, alley, park, public building, any place of business or assembly open to or utilised by the public and any other place which is open to the public view or to which the public has access. These places vary in the number of persons that use them, the amount of time spent there and the type of activities that occur in the area (WHO, 2014). Thus, studies like Folorunsho *et al*. (2010), Abban and Thano Debbra (2011), Sharma and Rathore (2012), Okafor and Ezeani (2012), Al-abedallat (2012) and Saroja *et al*. (2013) reveal that increasing number of persons prefer to use the ATMs than to queue at banking halls for financial transactions especially as most economies of the world are gravitating towards cashless economies.

The days of carrying huge cash around with its attendant risk may have gone as the ICT age has made money virtually plastic. ATMs offer convenience to customers, provide 'round the clock' (twenty four hours by Seven days) banking services, and ensures withdrawals for immediate needs rather than the bulk withdrawals that characterised the past. These conveniences make the ATMs more popular as the number of users increase daily justifying the huge investment by banks. While enormous investment has been made in its acquisition, installation, maintenance and even its security, little has been done in ensuring its sound environmental quality. The ATM is increasingly seen as an open place for financial transactions and may be one of the busiest public places in the world today considering long queues noticed around it in many Nigerian cities.

ATMs As Dispensers of Diseases

The ATMs may not only be cash providers but dispensers of diseases considering the population of pathogenic micro-organisms that may be present as large number of persons assess them on a daily basis without adequate regard for sound environmental quality. Users usually stop over ATMs without the knowledge that the keypad they touch contains a blend of pathogenic bacteria, germs and even viruses which can eventually be transferred between individuals. The poor environmental conditions may even have impact on the quality of service and the level of functionality of the machine apart from the health challenge that it is likely to pose.

The Central Bank of Nigeria appears to focus more on 'important' areas of compliance for instance; the Cashless Policy has been imperceptibly seen as more important than the

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customer's health. Commercial and Microfinance banks have taken high security measures to prevent theft of cash at the ATMs, however they have failed to take preventive, corrective and security initiatives on maintaining safe and clean ATM machines. The technical engineers contracted by these banks also, tend to focus more on the inner parts of the ATMs; as long as the software is up to date and any electro-mechanical part is tested and effectively operational, their business is completed.

Organisations like the National Agency for Food and Drugs Administration and Control (NAFDAC), Standards Organisation of Nigeria (SON), and other Consumer Protection Agencies, have not initiated studies nor have they carried out any proactive measure on these machines which could be disease dispensers. The foremost environmental regulations agency, the National Environmental Standards and Regulation Enforcement Agency (NESREA), a parastatal under the Ministry of environment has not captured the use of ATMs in its twenty four (24) regulations. Very few works have reported on bacterial contamination of ATMs in the banks.

Some scholars have tried to probe the quality and environmental challenges associated with the computers in hospitals and other public places from the standpoint of environmental hygiene in qualitative and quantitative terms. Nothing has been done about the study of ATMs in Kaduna Metropolis especially relating to environmental quality assessment of pathogenic microbial contamination. However, this study aim at assessing some selected ATMs in Kaduna Metropolis for bacterial contamination.

MATERIALS AND METHODS

Study Area

The study area covered the ATMs located within Kaduna Metropolis. A total of two hundred (200) swabbed samples were obtained from seven (7) different locations within Kaduna metropolis. These locations were: Nigerian National Petroleum Corporation (NNPC); Ahmadu Bello Way (ABW); Ali Akilu Way (AAW); Shopping Complex around Station (SCS); Kachia Road/Sabon Tasha (KR/ST); Kano Road (KR) and Nnamdi Azikiwe Way (NAW).

Method of Sample Collection

A total of 200 samples from 7 sampling points were collected between March and April, 2015. The samples were collected using sterile swab sticks. Single sterile swab sticks moistened with sterile distilled water was rubbed on the touch screen and buttons inside the ATM room and then returned back into its casing, labelled appropriately and then transported to the Microbiology Laboratory within 1 hour. This was done to ensure that pathogens contained in the samples do not undergo any form of growth. In the laboratory, the samples were preserved by adding 2 ml of Phosphate Buffer Solution (PBS) to each of the labelled swab sticks under aseptic conditions and stored in a refrigerator at 4^{o}C until they were ready to be used. The samples were collected during the peak periods (that is, when more number of people will be using the ATM centres). Hence, sampling was done between 9am to 11am; 12noon and 2pm.

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Isolation of Pathogenic Bacteria

Culture Media Preparation

The culture media used for the isolation of the pathogenic bacteria were Cetrimide Agar (for *Pseudomonas aeruginosa*), Mannitol Salt Agar (for *Staphylococcus aureus*), Salmonella Shigella Agar (for *Shigella dysenteriae* and *Samonella typhimurium*) and Eosin Methylene Blue Agar (for *Escherichia coli*). The media were prepared according to the manufacturer's instructions.

Serial Dilutions

Serial dilutions of 1:10, 1:100 and 1:1000 were prepared from each test tube containing the swabbed samples by taking 1ml into 9ml of sterilised buffer peptone using sterile needle and syringe. This gave a dilution factor of 10^{-1} (Collins *et al*., 1995).

Inoculation and Incubation of Culture Media

The sterilised culture media were inoculated with a loopful from the 10^{-1} dilution factor using flamed wire inoculating loop and then incubated at $37^{o}C$ for 24-72 hours (Cheesbrough, 2010).

Enumeration of Pathogenic Bacteria

The enumeration of pathogenic bacteria was done by multiplying the number of viable, visible, separated and distinct colonies with the reciprocal of the dilution factor and expressed as colony-forming unit per millilitre (cfu/ml) (Cheesbrough, 2010).

Gram Staining isolated Pathogenic Bacteria

The Gram staining was carried out as stated by Brooks *et al*. (2007) and Cheesbrough (2010).

Biochemical Tests to identify isolated Pathogenic Bacteria

Biochemical tests such as Catalase Test, Citrate Utilization Test, Methyl Red Test, Indole Test, Triple Sugar Iron (TSI) Test and Urease Test were carried out to confirm the isolates as stated by (Cheesbrough, 2010; MacFaddin, 2000).

Statistical Data Analysis

The experimental data were subjected to statistical analysis of correlation coefficient to determine the relationship between the isolated pathogenic bacteria and the Automated Teller Machines.

RESULTS

Occurrence of Pathogenic Microorganisms in ATMs in the Study Area

Table 1 showed the number (percentage) of isolates obtained from ATMs from various locations within Kaduna Metropolis. A total of two hundred (200) samples were obtained from seven (7) different locations within Kaduna metropolis. These locations were: Nigerian National Petroleum Corporation (NNPC); Ahmadu Bello Way (ABW); Ali Akilu Way (AAW); Shopping Complex around Station (SCS); Kachia Road/Sabon Tasha (KR/ST); Kano

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Road (KR) and Nnamdi Azikiwe Way (NAW) as shown in Table 1 below. Out of the twenty (20) samples obtained from NNPC, the isolates recorded were 3 (15.0%) *Escherichia coli*, 4 (20.0%) *Pseudomonas aeruginosa*, 4 (20.0%) *Shigella dysenteriae*, 3 (15.0%) *Salmonella typhimurium*, 4 (20.0%) *Staphylococcus aureus* and 2 (10.0%) *Klebsiella pneumoniae*. *Escherichia coli* recorded 6 (15.0%), *Pseudomonas aeruginosa* 7 (17.50%), 6 (15.0%) were *Shigella dysenteriae, Salmonella typhimurium* were 6 (15.0%), *Staphylococcus aureus* 7 (17.50%) and 8 (20.0%) *Klebsiella pneumoniae* out of the forty (40) samples obtained from Ahmadu Bello Way (Table 1). Also, the twenty (20) samples obtained from Ali Akilu Way had 2 (10.0%) *Escherichia coli*, 1 (5.0%) *Pseudomonas aeruginosa*, 5 (25.0%) *Shigella dysenteriae*, 2 (10.0%) *Salmonella typhimurium*, 3 (15.0%) *Staphylococcus aureus* and 7 (35.0%) *Klebsiella pneumoniae*.

Furthermore, Table 1 revealed that out of the thirty (30) samples obtained from the ATMs around shopping complex around station (SCS), no *Escherichia coli* was obtained, 5 (16.67%) were *Pseudomonas aeruginosa*, *Shigella dysenteriae* had 7 (23.33%), *Salmonella typhimurium* had 6 (20.0%), 4 (13.33%) were *Staphylococcus aureus* and 8 (26.67%) *Klebsiella pneumoniae*. On the other hand, *Escherichia coli* had 1 (5.0%), 3 (15.0%) were *Pseudomonas aeruginosa*, *Shigella dysenteriae* had 5 (25.0%), *Salmonella typhimurium* had 4 (20.0%), 2 (10.0%) were *Staphylococcus aureus* and 5 (25.0%) *Klebsiella pneumonia*e when twenty (20) samples obtained from Kachia Road/Sabon Tasha were examined (Table 1). The forty (40) samples obtained from the ATMs along Kano Road had 6 (15.0%) *Escherichia coli*, 6 (15.0%) *Pseudomonas aeruginosa*, 7 (17.50%) were *Shigella dysenteriae*, 6 (15.0%) *Salmonella typhimurium*, 6 (15.0%) *Staphylococcus aureus* and 9 (22.50%) *Klebsiella pneumoniae* (Table 1). Table 1 showed that out of the thirty (30) samples obtained from the ATMs along Nnamdi Azikwe Way, *Escherichia coli* had 4 (13.33%), 3 (10.0%) were *Pseudomonas aeruginosa*, *Shigella dysenteriae* had 3 (10.0%), *Salmonella typhimurium* had 5 (16.67%), 8 (26.67%) were *Staphylococcus aureus* and 7 (23.33%) were *Klebsiella pneumoniae* (Table 1).

However, out of the 200 samples, 22(11.0%) were *E. coli*, 29 (14.5%) were *P. aeruginosa*, while *S. dysenteriae* had 37 (18.50%), *S. tyhimurium* had 32 (16.0%), *S. aureus* had 33 (16.50%) and 46 (23.0%) were *K. pneumoniae* (Table 1).

In addition, the stacked bar chart below depicts isolates obtained from various ATMs within Kaduna metropolis. Kano Road and Ahmadu Bello Way had the highest number of isolates as well as sample size because of the concentration of the banks around these roads and the influx of people within and around this area who do business on a daily basis. *K. pneumoniae* had the largest percentage of isolates with 46 (23.0%), followed by *S. dysenteriae* with 37 (18.50%). *S. aureus*, *S. tyhimurium*, and *P. aeruginosa* had 33 (16.50%), 32 (16.0%) and 29 (14.5%) respectively while *E. coli* had the smallest percentage of isolates with 22 (11.0%) (Figure 1).

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Table 1 Number of Isolates obtained from ATM from various locations in Kaduna Metropolis

		Number (%) of Isolates					
Location of ATM	**Number of Samples**	***Escherichia coli***	***Pseudomonas aeruginosa***	***Shigella dysenteriae***	***Salmonella typhimurium***	***Staphylococcus aureus***	***Klebsiella pneumoniae***
NNPC/KRPC	20	3 (15.0%)	4 (20.0%)	4 (20.0%)	3 (15.0%)	4 (20.0%)	2 (10.0%)
ABW	40	6 (15.0%)	7 (17.50%)	6 (15.0%)	6 (15.0%)	7 (17.50%)	8 (20.0%)
AAW	20	2 (10.0%)	1 (5.0%)	5 (25.0%)	2 (10.0%)	3 (15.0%)	7 (35.0%)
SCS	30	0 (0.0%)	5 (16.67%)	7 (23.33%)	6 (20.0%)	4 (13.33%)	8 (26.67%)
KR/ST	20	1 (5.0%)	3 (15.0%)	5 (25.0%)	4 (20.0%)	2 (10.0%)	5 (25.0%)
KR	40	6 (15.0%)	6 (15.0%)	7 (17.50%)	6 (15.0%)	6 (15.0%)	9 (22.50%)
NAW	30	4 (13.33%)	3 (10.0%)	3 (10.0%)	5 (16.67%)	8 (26.67%)	7 (23.33%)
TOTAL	200 (100%)	22(11.0 %)	29 (14.5%)	37 (18.50%)	32 (16.0%)	33 (16.50%)	46 (23.0%)

KEY:

NNPC/ KRPC - Nigerian National Petroleum Corporation/Kaduna Refinery and Petrolchemicals Company
ABW- Ahmadu Bello Way
AAW- Ali Akilu Way
SCS- Shopping Complex around Station
KR/ST- Kachia Road/Sabon Tasha
KR- Kano Road Axis
NAW- Nnamdi Azikiwe W

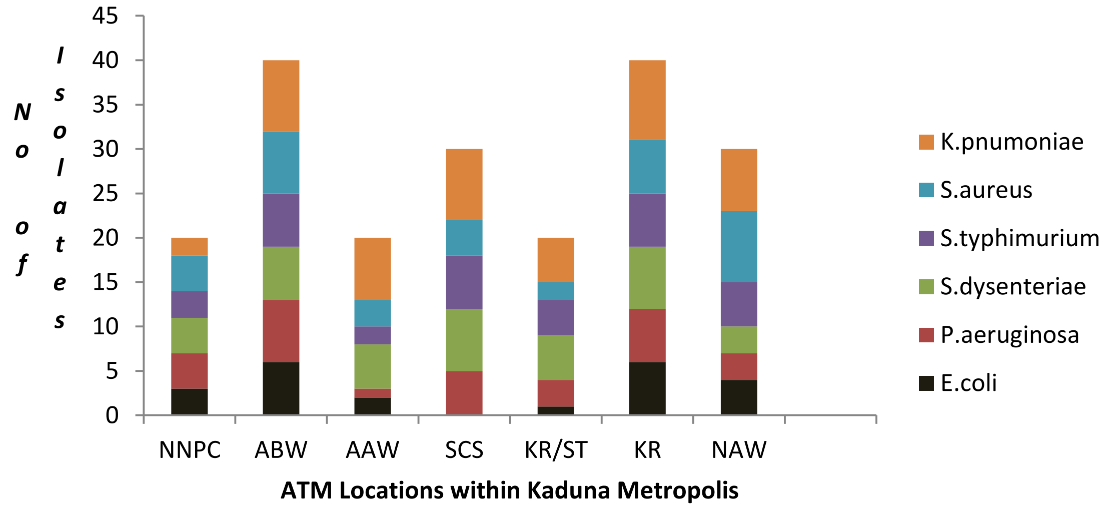

Figure 1: Number of Isolates obtained from ATM from various locations in Kaduna Metropolis

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KEY:

NNPC- Nigerian National Petroleum Corporation
ABW- Ahmadu Bello Way
AAW- Ali Akilu Way
SCS- Shopping Complex around Station
KR/ST- Kachia Road/Sabon Tasha
KR- Kano Road
NAW- Nnamdi Azikwe Way

Gram Reactions of the isolated Pathogenic Bacteria

The result of the Gram reactions for the isolated pathogenic bacteria subjected to Gram staining is shown in Table 2. *Escherichia coli*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa*, *Salmonella typhimurium* and *Shigella dysenteriae* were Gram negative rods while Staphylococcus *aureus* appeared as Gram positive cocci in clusters (Table 2).

Table 2: Gram Reactions of the isolated Pathogenic Bacteria

Isolated Pathogenic Bacteria	Gram Reactions
Escherichia coli	Gram negative rods
Klebsiella pneumonia	Gram negative rods
Pseudomonas aeruginosa	Gram negative rods
Salmonella typhimurium	Gram negative rods
Shigella dysenteriae	Gram negative rods
Staphylococcus aureus	Gram positive cocci in clusters

Characteristic Colony Appearance of the isolated Pathogenic Bacteria on different culture media

The characteristic colony appearance of the isolated pathogenic bacteria on different culture media is shown in Table 3). The colonies of *Escherichia coli* appeared as green metallic sheen on Eosin Methylene Blue Agar while *Klebsiella pneumoniae* were pinkish colonies on MacCkonkey Agar. On the other hand, *Pseudomonas aeruginosa* appeared greenish on Cetrimide Agar; *Salmonella typhimurium* and *Shigella dysenteriae* showed colonies with black centres and colourless colonies on Salmonella Shigella Agar respectively. The colonies of *Staphylococcus aureus* appeared yellowish on Mannitol Salt Agar (Table 3).

Table 3: Characteristic Colony Appearance of the isolated Pathogenic Bacteria on different culture media

Isolated Pathogenic Bacteria	Media Used	Colony Appearance
Escherichia coli	EMBA	Green metallic sheen colonies
Klebsiella pneumonia	MCA	Pink colonies
Pseudomonas aeruginosa	CMA	Greenish colonies
Salmonella typhimurium	SSA	Colonies with black centres
Shigella dysenteriae	SSA	Colourless colonies
Staphylococcus aureus	MSA	Yellow colonies

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KEY:

EMBA- Eosin Methylene Blue Agar
MCA- MacConkey Agar
CMA- Cetrimide Agar
SSA- Salmonella Shigella Agar
MSA- Mannitol Salt Agar

Biochemical Tests conducted on the isolated Pathogenic Bacteria

The result of the biochemical tests conducted on the isolated pathogenic bacteria (that is, *E.coli*, *P.aeruginosa*, *S.dysenteriae*, *S.typhimurium*, *S.aureus* and *K.pneumoniae*) is presented in Table 4. Six (6) tests which include triple sugar iron (TSI); methyl red; indole; catalase; citrate utilisation and urease were carried out on ten (10) isolates for each of the pathogenic bacteria isolated from the samples for confirmation and identification.

In Table 4, out of the six (6) isolates tested for TSI, only *P.aeruginosa* was negative while others were positive. *E.coli*, *S.dysenteriae*, *S.typhimurium* and *S.aureus* were positive for methyl red while *K.pneumoniae* and *P.aeruginosa* were negative. Table 4 also revealed that *E.coli* and *S.dysenteriae* were indole positive while *S.typhimurium*, *S.aureus*, *S.dysenteriae* and *K.pneumoniae* were indole negative.

However, all the isolates were catalase positive as revealed in Table 4. The citrate utilisation test was positive in *P.aeruginosa*, *S.aureus* and *K.pneumoniae* were positive but *E.coli*, *S.dysenteriae* and *S.typhimurium* were negative (Table 4). The urease test was positive in *E.coli*, *P.aeruginosa*, *S.aureus* and *K.pneumoniae* but negative in *S.dysenteriae* and *S.typhimurium* (Table 4).

Table 4: Biochemical Tests Conducted on the isolated Pathogenic Bacteria (n=10)

Tests	*E.coli*	*P.aeruginosa*	*S.dysenteriae*	*S.typhimurium*	*S.aureus*	*K.pneumoniae*
TSI	+	-	+	+	+	+
Methyl Red	+	-	+	+	+	-
Indole	+	-	+	-	-	-
Catalase	+	+	+	+	+	+
Citrate Utilisation	-	+	-	-	+	+
Urease	+	+	-	-	+	+

KEY:

+ = Positive

- = Negative

n = Number of isolates tested

Testing the relationship between the ATMs and the Contaminants (isolates)

Table 5 showed the result obtained when the relationship between the ATMs and the contaminants (isolated pathogenic bacteria). The correlation coefficient (r) of 0.60 was obtained.

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Table 5: Testing the relationship between the ATMs and the Contaminants (isolates)

Number of ATM (X)	Number of Isolates (Y)	X_1	Y_1	X_1Y_1	X_1^2	Y_1^2
10	20	-2.4	-8.6	20.64	5.76	73.96
30	40	17.6	11.4	200.64	309.76	129.96
10	20	-2.4	-8.6	20.64	5.76	73.96
5	30	-7.4	1.4	-10.36	54.76	1.96
11	20	-1.4	-8.6	12.04	1.96	73.96
13	40	0.6	11.4	6.84	0.36	129.96
8	30	-4.4	1.4	6.16	19.36	1.96
ΣX=87	**ΣY=200**			**ΣX_1Y_1=256.6**	**ΣX_1^2=397.72**	**ΣY_1^2=485.72**

Using Correlation Coefficient, r:

$$r = \frac{\Sigma X_1Y_1}{\sqrt{(\Sigma X_1^2)(\Sigma Y_1^2)}}$$

Where:

n = Number of locations of ATMS (which is equal to 7)

$$\overline{X} = \frac{\Sigma X}{n}$$

$$\overline{Y} = \frac{\Sigma Y}{n}$$

$$X_1 = X - \overline{X}$$

$$Y_1 = Y - \overline{Y}$$

$$r = \frac{\Sigma X_1Y_1}{\sqrt{(\Sigma X_1^2)(\Sigma Y_1^2)}} = \frac{256.6}{\sqrt{(397.72)(485.72)}} = 0.583814 = 0.60 \text{ (1 d.p)}$$

DISCUSSION

Occurrence of Pathogenic Microorganisms in ATMs in the Study Area

The result obtained in Table 1 showed that pathogenic bacteria such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Shigella dysenteriae*, *Salmonella typhimurium*, *Staphylococcus aureus* and *Klebsiella pneumonia* were isolated from the Automated Teller Machines (ATMs) located in NNPC/KRPC (Nigerian National Petroleum Corporation/Kaduna Refinery and Petrochemicals Company); ABW (Ahmadu Bello Way); AAW (Ali Akilu Way); SCS (Shopping Complex around Station); KR/ST (Kachia Road/Sabon Tasha); KR (Kano Road

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Axis) and NAW (Nnamdi Azikiwe Way) within Kaduna Metropolis. This result is in agreement with the results obtained by Hendley *et al*., 1997; Nworie *et al*., 2012 and Noble (2001). The isolated pathogenic bacteria which are members of the family *Enterobacteriaceae* can cause hand-to-mouth infections in man if hands are not sanitized after using ATM. There is also a possibility of them causing nosocomial infections through medical personnel that used an ATM without thorough sanitation of hands used on ATM in the hospital and its environments (Rusin *et al*., 2002). The pathogenic bacteria isolated from the ATMs located within Kaduna Metropolis as shown in Table 1 have the possibility of being harboured under the finger-tips of the users and as a result of this, they can cause finger-tips to mouth infections which can impaired the lives of the infected (Rusin *et al*., 2002).

Furthermore, out of the 200 (100%) samples, *K. pneumoniae* had the highest number (percentage) of 46 (23.0%) followed by *S. dysenteriae* with 37 (18.50%); 33 (16.50%) in *S. aureus*; 32 (16.0%) in *S. typhimurium*; 29 (14.5%) in *P. aeruginosa* and the lowest number (percentage) of 22(11.0%) was recorded in *E. coli* as revealed in Table 1 and Figure 1. The highest number (percentage) recorded in *K. pneumoniae* could possibility expose the users of ATMs in the study area to pneumonia if good and personal hygiene practices (especially that of hand washing after using ATMs) are not adhered to by the users. Despite the fact that the lowest number (percentage) of 22 (11.0%) was recorded in *E. coli*, there is still a high possibility of infections caused by *E. coli* that could affect the users if there is poor hand washing practices. Some kinds of *E. coli* can cause diarrhoea, while others cause urinary tract infections, respiratory illness and pneumonia, and other illnesses. *E. coli* is one of the most frequent causes of many common bacterial infections including cholecystitis, bacteremia, cholangitis, urinary tract infection (UTI), and traveler's diarrhoea and other clinical infections such as neonatal meningitis and pneumonia (Tarun, 2014).

In addition, *E. coli* recorded the highest number (percentage) of 6 (15.0%) at Ahmadu Bello Way and Kano Road Axis and the lowest number (percentage) of 1 (5.0%) along Kachia Road/Sabon Tasha (Table 1). The highest number (percentage) obtained might be due to high population along Ahmadu Bello Way and Kano Road Axis and the lowest number (percentage) recorded Kachia Road/Sabon Tasha might be due to less population in those areas. Poor hygienic practices coupled with unsanitized hands after leaving the toilets might be responsible for the highest number (percentage) of 6 (15.0%) of *E. coli* recorded along Ahmadu Bello Way and Kano Road Axis.

More so, *P. aeruginosa* had the highest number (percentage) of 6 (17.50%) from the ATMs along Ahmadu Bello Way and the lowest number (percentage) of (5.0%) from the ATMs along Ali Akilu Way (Table 1). High number of users of ATMs along Ahmadu Bello Way might be responsible for the numbers of *P. aeruginosa* obtained. On the other hand, fewer users of ATMs along Ali Akilu Way might be responsible for the number of *P. aeruginosa* recorded (Table 1). As opined by Bodey *et al*. (1983), *P. aeruginosa* has emerged as an important pathogen during the past two decades. It causes between 10% and 20% of infections in most hospitals. Pseudomonas infection is especially prevalent among patients with burn wounds, cystic fibrosis, acute leukemia, organ transplants, and intravenous-drug addiction. *P. aeruginosa* is a common nosocomial contaminant, and epidemics have been traced to many items in the hospital environment. Patients who are hospitalized for extended periods are frequently colonized by this organism and are at increased risk of developing infection. The most serious infections include malignant external otitis, endophthalmitis, endocarditis, meningitis, pneumonia, and septicemia. The likelihood of recovery from pseudomonas infection is related

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to the severity of the patient's underlying disease process (Bodey *et al*., 1983). The introduction of the antipseudomonal aminoglycosides and penicillins has improved substantially the prognosis of these infections. Ticarcillin and carbenicillin have been especially beneficial in neutropenic patients; however, prompt institution of therapy is mandatory for optimal benefit. Many new drugs with antipseudomonal activity, including penicillins, cephalosporins, and other beta-lactams, have been introduced in recent years and offer the potential for new approaches to therapy for these infections (Bodey *et al*., 1983).

However, 7 (23.33%) and 7 (17.50%) were recorded for *S. dysenteriae* from ATMs located along Shopping Complex around Station and Kano Road Axis while the lowest number (percentage) was recorded from the ATMs along Nnamdi Azikiwe Way (Table 1). High numbers of ATMs users, Poor hygienic practices coupled other unwholesome behavioural and cultural activities might be responsible for these results. The few users of ATMs along Nnamdi Azikiwe Way and coupled with the indifference attitude of people in using the ATMs must have accounted for the numbers of *S. dysenteriae* obtained. Shigella infection (also known as shigellosis) is an infection of the digestive tract (or gut) caused by Shigella bacteria. Symptoms start between 1 to 7 days (usually 1 to 3 days) after the ingestion of the bacteria and this typically last for between 4 to 7 days. The symptoms include: dysentery (diarrhoea containing mucus and/or blood), nausea and vomiting, fever and stomach cramps (Yabuuchi, 2002).

The highest number (percentage) of 6 (15.0%) obtained for *S. typhimurium* from the ATMs along Ahmadu Bello Way and Kano Road Axis respectively was similar to the result obtained for *E.coli* from the same study areas (Table 1). High frequency of visiting the ATMs by users coupled with the population might be responsible for this result. Less population patronizing the ATMs along Ali Akilu Way might be responsible for recording 2 (10.0%) (Table 1). The ingestion of *S. typhimurium* from contaminated hands causes Salmonellosis. Salmonellosis is a foodborne illness caused by infection with Salmonella bacteria. Most infections are spread to people through consumption of contaminated food (usually meat, poultry, eggs, or milk). Salmonella infections affect the intestines and cause vomiting, fever, and cramping, which usually clear up without medical treatment. Salmonella infections can be prevented by not serving any raw meat or eggs and by not keeping reptiles as pets (particularly for young children). Hand washing is a powerful way to guard against Salmonella infections (Winfield and Eduardo, 2003; Goldrick, 2003).

The highest number (percentage) of 8 (26.67%) of *S. aureus* obtained from the ATMs located along Nnamdi Azikiwe Way might probably be due to change of attitude of the users which must have contributed to the use of ATMs. On the other hand, 2 (10.0%) *S. aureus* recorded from the ATMs along Kachia Road/Sabon Tasha might be due to less patronage by the users of ATMs (Table 1). Although *S. aureus* is not always pathogenic, it is a common cause of skin infections such as abscesses, respiratory infections such as sinusitis and food poisoning. *S. aureus* is responsible for many infections but it may also occur as a commensal (Cimolai, 2008).

The presence of *S. aureus* does not always indicate infection. It can survive from hours to weeks or even months on dry environmental surfaces, depending on strain (Cimolai, 2008).

S. aureus can infect tissues when the skin or mucosal barriers have been breached. This can lead to many different types of infections, including boils and carbuncles (a collection of boils) (Cimolai, 2008). *S. aureus* infections can spread through contact with pus from an infected wound, skin-to-skin contact with an infected person by producing hyaluronidase that destroys

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tissues, and contact with objects such as towels, sheets, clothing, or athletic equipment used by an infected person. Deeply penetrating *S. aureus* infections can be severe. Prosthetic joints put a person at particular risk of septic arthritis, and staphylococcal endocarditis (infection of the heart valves) and pneumonia. Strains of *S. aureus* can host phages, such as Φ-PVL (produces Panton-Valentine leukocidin), that increase virulence (Cimolai, 2008).

Table 1 also revealed that the highest number (percentage) of 9 (22.50%) of *K. pneumoniae* was recorded from the ATMs along Kano Road Axis. This result might be due to high numbers of users especially the buyers and sellers in the Central Market and the shopping complexes along Kano Road Axis. The high level of literacy coupled with good hygienic practices especially hand washing after using the ATMs might be responsible for the lowest number (percentage) of 2 (10.0%) of *K. pneumoniae* obtained from the ATMs located at Nigerian National Petroleum Corporation/Kaduna Refinery and Petrolchemicals Company (Table 1). Despite the fact that *K. pneumoniae* is found in the normal flora of the mouth, skin, and intestines, it can cause destructive changes to human lungs if aspirated (inhaled), specifically to the alveoli (in the lungs) resulting in bloody sputum (Ryan and Ray, 2004). In the clinical setting, it is the most significant member of the Klebsiella genus of *Enterobacteriaceae*. *K oxytoca* and *K rhinoscleromatis* have also been demonstrated in human clinical specimens. In recent years, klebsiellae have become important pathogens in nosocomial infections (Ryan and Ray, 2004).

Gram Reactions of the isolated Pathogenic Bacteria

The result obtained for Gram's reactions of the isolated pathogenic bacteria in Table 2 is in agreement with Bergey's Manual of Determinative Bacteriology (Holt *et al*., 1994). The result is also in line with the work of Abban and Tano-Debrah (2011) and Brooks *et al*. (2007). The result in Table 2 also suggests that the isolated pathogenic bacteria are associated with the ATMs as stated in the work of Nworie *et al*. (2012). This infers that users of ATMs should always maintain a good hand washing practice after visiting an ATMs to prevent hands-to-mouth infections which may have serious health implications on the infected ATMs users.

Characteristic Colony Appearance of the isolated Pathogenic Bacteria on different culture media

The result obtained in Table 3 confirmed the characteristic colony appearance of the isolated pathogenic bacteria on the different culture media they were cultured. This further authenticates the presence of pathogenic bacteria (such as *E. coli*; *S. dysenteriae*; *S. typhimurium*; *P. aeruginosa*; *K. pneumonia*e and *S. aureus*) on the ATMs as stated in the work of Abban and Tano-Debrah (2011). The confirmation of the presence of these pathogenic bacteria suggests that users should always key into good and frequent hand washing practices after using the ATMs in order to prevent infections. The result in Table 3 also indicates that ATMs are not sterile hence the need to maintain good hygienic practices by the users.

Biochemical Tests conducted on the isolated Pathogenic Bacteria

The biochemical tests conducted on the isolates confirmed them to be *E. coli*; *S. dysenteriae*; *S. typhimurium*; *P. aeruginosa*; *K. pneumonia*e and *S. aureus* (Table 4). This result is in line with the Bergey's Manual of Determinative Bacteriology (Holt *et al*., 1994). The authenticity of the presence of *E. coli*; *S. dysenteriae*; *S. typhimurium*; *P. aeruginosa*; *K. pneumonia*e and *S. aureus* on the ATMs was also validated by these results (Table 4). Thus, this result suggests

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that ATMs can be potential media for the transmission of pathogenic bacteria that could have serious public health implications on the users.

Testing the relationship between the ATMs and the Pathogenic Bacterial

The correlation coefficient (r) of 0.60 obtained showed that there is a relationship between the ATMs and the contaminants (isolated pathogenic bacteria) (Table 5). This result is in agreement with the findings of Abban and Tano-Debrah (2011) and this suggests that contaminated ATMs has the potential of transmitting infections to the users of ATMs if the users have poor hygienic and hand washing practices.

Implication to research and practice

Pathogenic bacteria such as *E. coli*; *S. dysenteriae*; *S. typhimurium*; *P. aeruginosa*; *K. pneumonia*e and *S. aureus* on the ATMs were isolated from the selected Automated Teller Machines located within Kaduna Metropolis. The implication of the results is that the users of the ATMs are at the risk of being infected with these bacteria if good hygienic practices especially regular hand washing practices are not sustained by them. The awareness of the presence of these pathogenic bacteria on the keyboards of these ATMs by the users will also help to safeguard public health. The banks that own these ATMs are also expected to regularly sanitize the keyboards of the ATMs with compatible sanitizers.

CONCLUSION

Pathogenic bacteria such as *E. coli*; *S. dysenteriae*; *S. typhimurium*; *P. aeruginosa*; *K. pneumonia*e and *S. aureus* on the ATMs were isolated from the Automated Teller Machines (ATMs) located in NNPC/KRPC (Nigerian National Petroleum Corporation/Kaduna Refinery and Petrochemicals Company); ABW (Ahmadu Bello Way); AAW (Ali Akilu Way); SCS (Shopping Complex around Station); KR/ST (Kachia Road/Sabon Tasha); KR (Kano Road Axis) and NAW (Nnamdi Azikiwe Way) within Kaduna Metropolis. They were confirmed culturally, Gram stained and biochemically tested. The research work established that there is a relationship between the Automated Teller Machines (ATMs) and the isolated pathogenic bacteria.

RECOMMENDATIONS

As a result of the relationship that exists between the Automated Teller Machines (ATMs) and the isolated pathogenic bacteria, the following recommendations will be made:

1. Good hand washing and other hygienic practices should be observed by the users of ATMs.

2. A bowl containing sanitizer should be provided by the bank management at every ATM location so that users can disinfect their hands after using the ATMs.

3. ATM Cleaners should be employed by the bank management so that they can disinfect the metallic buttons at intervals using compatible disinfectants.

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Future Research

The future research that will be carried out will be to compare the microbial load between the ATMs and Electronic Calculators used within a locality and subsequent implications on the users.

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