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BACTERIAL CONTAMINANTS ASSOCIATED WITH AUTOMATED TELLER MACHINES (ATMS) KEYPADS IN LAFIA METROPOLIS, NASARAWA STATE, NIGERIA

[*1,2]Ya'aba, Y., [2]Chuku, A., [2]Okposhi, U. S., [1]Mohammed, S. B., [1]Adigwe, O. P. and [2]Ramalan, A. S.

[1]Department of Microbiology and Biotechnology, National Institute for Pharmaceutical Research and Development (NIPRD) Abuja, Nigeria.
[2]Department of Microbiology, Federal University of Lafia, Nasarawa State, Nigeria.
*Correspondence: E- mail: yakyabnig@yahoo.com, Phone no: +2348033326544.

ABSTRACT

Microbiological contamination of environmental objects and surfaces is a common phenomenon and of public health significance, because microorganisms are ubiquitous (found everywhere). This research is aimed at evaluating bacterial contaminants associated with Automated Teller Machines (ATMs) keypads in Lafia metropolis, Nasarawa State, Nigeria. Samples from ten different banks situated along Jos road, Lafia were used for the study between August, 2019 and November, 2019 with oral permission obtained from their management. A total of 20 samples were collected using standard microbiological procedures within two sampling periods (morning and afternoon). The results showed that total bacterial count on the ATM keypads ranged from 1.7 x 10^1 ***cfu/mL to 2.3 x*** 10^2 ***cfu/mL in the morning, and 1.1 x*** 10^1 ***cfu/mL to 2.4 x*** 10^2 ***cfu/mL in the afternoon. The bacteria isolated during the study period were mostly pathogenic and were: Escherichia coli, Salmonella sp., Bacillus sp., Pseudomonas sp., Staphylococcus aureus, Klebsiella sp., and Enterobacter sp., which could be transferred from one customer to another. In view of this, it is therefore important for regular hygiene practices before and after usage of the ATMs by customers so as to avoid or reduce cross contamination of pathogenic bacteria.***

Keywords: Automated Teller Machines, Cross contamination, Pathogenic, Staphylococcus aureus, Nasarawa state

INTRODUCTION

Automated Teller Machine or Automatic Teller Machine (ATM) is a computerized telecommunication device that enables customers of a financial institution to carry out financial transactions with ease without the need for a human clerk, cashier or bank teller (Odeyemi *et al*., 2018; Okoro *et al.,* 2018). ATMs are known by other names such as automated banking machine, ATM machine, cash dispenser and some regional variants derived from trademarks on ATM systems advocate by particular banks (Rasiah, 2010; Iquo *et al*., 2015; Osarenmwinda and Blessing, 2020). The use of ATMs involves slotting a card into a recipient hole and following on screen instructions (Iquo *et al*., 2015), by pressing the keys on the metallic keypads to enter secret codes or pins and instructions; thus, instructing the machine as to the sort of service a person needs (Sharma and Anand, 2002; Odeyemi *et al*., 2018). The machine allows for multiples user to perform transactions at different time intervals allowing only a single user at a time (Osarenmwinda and Blessing, 2020). ATMs in banks are majorly localized in strategic points that are easily accessible to costumers without causing any form of congestion. Since accesses to ATMs are not specific to a particular user or group of people with same hygiene practices or financial status, as such, hundreds of people indiscriminately use it (Tekerekoğlu *et al.,* 2013). For that reason, customers with contaminated fingers easily contaminate the keypads/buttons inadvertently and the deposited microorganisms randomly contaminate the hands of subsequent users with infectious pathogens at the point of contact, reverting in cross-contamination of users (Odebisi-Omokanye *et al.,* 2014; Aquino *et al*., 2019).

Microorganisms are ubiquitous and often found on surfaces of animate and inanimate objects including human beings, and are in many instances' indispensable for the continued existence of their host (Iquo *et al*., 2015). Thus, it is not always easy and beneficial to remove them by sterilizing our environments. Infections escalate amongst individual with direct or indirect contact with hands or on inanimate personal belonging (Mathai *et al.,* 2010; Odebisi-Omokanye *et al*., 2014).

Microbial contamination of environmental objects and surfaces is a common phenomenon and a source of serious public health concern; due to the ability of the objects within the environment to harbor certain pathogenic microorganisms (Iquo *et al*., 2015). The extensive use of electronic devices such as ATMs is not excluded as a source of bacterial contamination (Saroja *et al.,* 2013). Since microorganisms are ubiquitous, their presence on keypads/buttons of ATMs are inevitable and has been reported by various researchers (Stephen and Kwaku, 2011; Iquo *et al.,* 2015; Agu *et al*., 2018; Aquino *et al*., 2019), and the tendency of these microorganisms to be picked by humans and get infected through oral, nasal or eyes contacts with contaminated fingers are very high (Stanley and Kayode, 2014; Aquino *et al*., 2019). This tendency increases with increase in human population as well as progressive digitization of banking systems abandoning the traditional system (i.e. use of tellers and check books), which is time consuming and exhausting to customers making the ATMs widely used across Nigeria (Saroja *et al.,* 2013; Odeyemi *et al*., 2018; Aquino *et al*., 2019).

With the wide acceptance and extended usage of ATMs across Nigeria, the electronic technologies are considered as sources of bacterial contamination due to public usage (Okoro *et al*., 2018; Adedoyin *et al.,* 2019). The threatening concern is that the amount of bacterial strains which acquire resistance against disinfectants and particularly antibiotics is on the increase faster than expected. This is due to the intermittent threat to human life, obliterate or regulating the development of pathogenic microorganisms specifically bacteria, fungi and viruses on non-living surfaces remain to be a fundamental interest globally (Hamouda and Baker, 2000).

Antimicrobial agents have been used for many years to overcome pathogenic microorganisms in a wide range of actions, in hospitals, home and industrial premises (Odeyemi *et al.,* 2018). Notwithstanding, using them for a long time has resulted in the development of defiant microorganisms (Odeyemi *et al.,* 2018). The quantity of antibiotic resistant bacteria has proliferated in contemporary years due to the abuse or misuse of antibiotics and biocides which in several cases have reverted in the emergence of cross resistance. Accordingly, new, harmless and effective biocides are frequently needed to overcome challenges related with microorganism's remodeling and the emergence of resistant strains (Hamouda and Baker, 2000; Odeyemi *et al.,* 2018).

In view of these, it is imperative that the level of danger caused by the use of ATM metallic keypads used by various individuals under daily situations should be routinely checked. Therefore, this research is aimed at evaluating bacterial contaminants associated with Automated Teller Machines (ATMs) keypads in Lafia metropolis, Nasarawa State, Nigeria.

MATERIALS AND METHODS

Study Area

This study was conducted within the Lafia Metropolis. Lafia is the state capital of Nasarawa state situated in the North central part of Nigeria lying at latitude 8^{o}29'30" North of the equator and longitude 8^{o}31'0"East of Greenwich Meridian (Akwa *et al.,* 2007). Lafia has a total inhabitant of 330, 712 (Census, 2006; Akwa *et al.,* 2007). It is currently reported that Lafia has a population of 127, 236 (WPR, 2019).

Approval for the study

Oral permission was obtained from the management of all the banks used for the study. These banks were coded as A, B, C, D, E, F, G, H, I and J.

Sample Collection

One (1) ATM each from ten different banks situated along Jos road, Lafia were used for the study between August 2019 and November, 2019. A total of 20 samples were collected using standard microbiological procedures within two sampling periods (morning and afternoon).

Double strength nutrient broth (9ml) in screw cap test tubes and nutrient agar (NA; Merck, Darmstadt, Germany) plates were prepared according to manufacturers' instructions. The samples were taken from the surfaces of ATMs keypads on two occasions daily between the hours of 08:00a.m to 10: 00a.m and 02: 00p.m to 04:00p.m. The keypads surfaces were swabbed with sterile swab sticks moistened with sterile distilled water by rolling the swab over the surfaces on each visit. The swabs were then immediately dipped into labeled bijoux bottles containing nutrient broth (NB) and packed into an ice packed container then transported to the Microbiology laboratory, Federal University of Lafia, for microbiological analysis.

Isolation and Identification of Bacterial Isolates

The ATMs swab samples in bijoux bottles containing NB were allowed to stand on the laboratory bench for 30mins to attain room temperature. The microbial load analyses were done based on the techniques described in United States Pharmacopeia (USP, 2003).

The swabbed ATMs surfaces and control (without swabbing the ATMs) collected samples containing NB were shaken gently to allow for even distribution after which one milli-Litre (1mL) aliquots of each NB culture from swabs in each container were plated in NA and incubated at 37^{o}c after allowing them to stand for 10-15mins on the laboratory bench for total bacteria counts. One millitre (1mL) from each and control sample was also suspended onto Eosine Methylene Blue (EMB; Merck, Darmstadt, Germany) agar and MacConkey agar (Merck, Darmstadt, Germany) and incubated for 37^{o}c after allowing them to stand for 10-15mins to test for the presence of coliforms. All the plates were incubated at 37^{o}C for 24hrs. After the incubation period, the colonies from the NA plates were counted using colony coulter and expressed in colony forming units per millilitres (CFU/mL) (USP, 2003). The colonies were also tested for faecal coliforms on MacConkey broth (Oxoid,) with Durham tubes and on EMB agar.

The method adopted by Mehmet *et al*. (2013) were used to characterize and describe the pure isolates obtained in this study. The cultural characteristics were observed and morphological characterization was ascertained after Gram staining followed by microscopy. The isolates were distinguished into various shapes and Gram's reaction owing to the result obtained from the microscopy. The pure isolates were further characterized biochemically using various biochemical tests including Voges-Proskauer, indole test, citrate utilization, catalase utilization test, coagulase test, methyl red test, urease test, oxidase test, sugar fermentation test, and motility test. All tests were carried out using standard basic media and reagents (Atlas, 1997) and prepared as described by manufacturer's instructions. The isolates were identified following a check on their characteristics and matched with those of existing taxa in standard manuals such as Bergy's Manual of determinative bacteriology and were named according to their matching species.

Statistical Analyses

The quantitative data were analyzed statistically using SPSS (version 20) statistical software. Standard simple statistical tools including means, frequencies and percentages were used to interpret some of the findings.

RESULTS

Seven (7) different bacteria were isolated and found to be associated with ATMs keypads in Lafia metropolis (Table 1). The bacterial isolates were: *Escherichia coli, Salmonella sp., Bacillus sp., Pseudomonas sp., Staphylococcus aureus, Klebisella sp.,* and *Enterobacter sp.*

Table 2 showed the prevalence of the bacterial isolates both in the morning and afternoon. The total prevalence per day had a percentage as follows: *Staphylococcus aureus* (30.70%), *Salmonella sp.* (24.84%), *Esherichia coli* (39.53%), *Bacillus sp.* (25.52%), *Pseudomonas sp.* (36.98%), *Klebisella sp.* (28.47%) and *Enterobacter sp. (13.96%).*

The highest mean bacterial count was observed from ATM keypads from sample point code H with 2.3 x 10^2 cfu/mL followed by sample point code B with 2.2 x 10^2 cfu/mL, sample point code A with 1.9 x 10^2 cfu/mL, then sample point code I with 1.2 x 10^2 cfu/mL. The least bacterial count of less than 10^2 cfu/mL were observed from samples obtained from sample point codes C, D, F, G and J respectively with total bacterial counts of 1.7 x 10^1 cfu/mL, 3.5 x 10^1 cfu/mL, 3.7 x 10^1 cfu/mL, 4.6 x 10^1 cfu/mL and 6.1 x 10^1 cfu/mL in the morning. The total bacterial counts on the ATMs keypads in the afternoon were higher at sample point code I with 2.4 x 10^2 cfu/mL, followed by sample point code B 1.1 x 10^2 cfu/mL while other banks were observed to be less than 10^2 cfu/mL (Table 3).

Table 1: Cultural, morphological and biochemical characteristic

	Isolates						
Characteristics	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Cultural							
Shape	Circular	Circular	Irregular	Circular	Circular	Circular	Circular
Elevation	convex	convex	Flat	Low convex	convex	Convex	convex
Margin	Entire	Entire	Undulate	Entire	Entire	Entire	Entire
Wetness/Dryness	Wet	Wet	Dry	Wet	Wet	Wet	Wet
Transparency	Opaque	Opaque	Opaque	Opaque	Opaque	Opaque	Opaque
Colour	Cream	Yellow	Cream	Cream	Yellow	Cream	Yellow
Size	Small	Small	Large	Medium	Medium	Medium	small
Morphological							
Gram Staining	+						
Cell Type	Rod	Cocci	Rod	Rod	Rod	Rod	Rod
Cell Arrangement	Single	Cluster	Chain	Single	Single	Single	Chain
Biochemical							
Catalase	+	+	+	+	-	+	+
Coagulase	-	-	-	+	-	-	-
Oxidase	-	+	-	-	-	-	-
Urease	-	+	+	-	+	+	-
Indole	+	-	-	-	+	-	-
Citrate	-	+	+	+	-	+	+
Sugar							
Glucose	AG	A	A	A	A	AG	A
Lactose	+	-	-	-	-	+	-
Possible Isolates	*E. coli*	*S. aureus*	*Bacillus sp.*	*Pseudomonas sp.*	*salmonella sp.*	*Klebisella sp.*	*Enterobacter sp.*

Key: + = Positive, - = Negative

Table 2: Prevalence of Bacteria Isolated from ATMs Keypads

Isolates	Prevalence (%) Morning	Prevalence (%) Afternoon	Total Prevalence (%)
Staphylococcus aureus	11.55	19.15	30.70
Salmonella sp.	14.66	10.18	24.84
Esherichia coli	21.06	18.47	39.53
Bacillus sp.	10.66	14.86	25.52
Pseudomonas sp.	18.25	18.73	36.98
Klebsiella sp.	16.47	12.0	28.47
Enterobacter sp.	7.35	6.61	13.96
Total	100	100	

Table 3: Total Bacterial Counts (cfu/mL) on the ATMs Keypads

Sampling Point Codes	Morning (cfu/mL)	Afternoon (cfu/mL)
A	1.9×10^2	3.1×10^1
B	2.2×10^2	1.1×10^2
C	1.7×10^1	1.1×10^1
D	3.5×10^1	6.5×10^1
E	1.3×10^2	3.7×10^1
F	3.7×10^1	2.2×10^1
G	4.6×10^1	4.3×10^1
H	2.3×10^2	3.6×10^1
I	1.2×10^2	2.4×10^2
J	6.1×10^1	4.7×10^1

DISCUSSION

Microorganisms are ubiquitous; their presence in the environment could cause various health challenges especially to people with underlining health conditions and weakened immune systems.

Their abundance and distributions on inanimate objects such as ATMs may vary from one species to another as well as some environment conditions and hygienic practices employed. The result of this study revealed bacterial contaminations on the surfaces of the keypads of ATMs in Lafia. A total of seven bacterial isolates were recovered from ATMs interface in this study. Qualitative analysis of the bacterial isolates revealed the abundance of skin flora belonging to Coagulase negative (–) *Staphylococcus aureus, Escherichia coli, Salmonella sp., Pseudomonas sp.,* and *Enterobacter sp.,* which is quite similar to the ones obtained by Osarenmwinda and Blessing, (2020). However, the percentage distribution of the bacterial isolates showed that *Staphylococcus aureus* was the one of the commonest isolate with percentage occurrence of *Staphylococcus aureus* (30.70%), *Salmonella* sp., (24.84%), *Esherichia coli* (39.53%), *Bacillus* sp. (25.52%), *Pseudomonas* sp. (36.98%), *Klebisella* sp. (28.47%) and *Enterobacter* sp. (13.96%) in this study (Table 2).

The bacterial loads on the ATMs keypads sampled in the mornings ranged from 1.7×10^1 cfu/mL to 2.3×10^2 cfu/mL, while that from the afternoon ranged from 1.1×10^1 cfu/mL to 2.4×10^2 cfu/mL (Table 3). Bacterial load was higher in samples from the keypads of ATMs obtained from sample point code H having bacterial count of 2.3×10^2 cfu/mL in the morning while higher bacterial count was observed at sample code I with 2.4×10^2 cfu/mL respectively (Table 3). Generally, the bacterial counts in the mornings were higher than in the afternoon. This may be attributed to the fact that more shoppers/traders who patronize the ATMs to withdraw money for morning transactions are in large number, thus increasing the number of microbes on the metallic keypads. It could also be attributed to the fact that transactions (withdrawals or bank transfers) lower than fifty thousand naira were mostly pushed to the ATMs. Therefore, it could be seen that it is associated with poor individuals who are either farmers or petty traders who are not keen about their personal hygiene. The proximity of these ATMs to the main roads may also be a contributing factor. The more bacterial count found on the ATMs keypads in the morning than in the afternoon may also be because of milder temperature and higher relative humidity in the morning which favour bacterial growth.

The bacterial isolates from this research work was similar to the findings of Stephen and Kwaku (2011), which also worked on ATMs machine keypads sampled in Ghana. This study is also in accordance with the study by Abban and Tano-Derah, (2011) who documented the presence of *Staphylococcus* sp., *Escherichia* sp., *and Klebsiella* sp., on the keypads of ATMs machines. The result from this study is in agreement with study carried out in England comparing the bacteria isolated from metallic ATM keypads with those isolated from toilets seats and found that the ATM machines that had comparable levels of bacteria described as heavily contaminated with both *Pseudomonads* sp. and *Bacillus* species (Allwell, 2011). This could be as a result of their visitation to the toilets without observing proper hygiene's.

The health risks associated with the majority of these bacteria isolated in this study are well reported (Precott *et al.,* 2002). The bacterial contaminants observed in this study were comparable to bacteria that have been recovered from surfaces and objects by other researchers Oluduro *et al.,* (2011) which documented that keypads of ATMs harbored more bacteria than computer keyboards and this may attribute to the fact that ATMs are usually located in the open, exposed to wind and rain. However, the bacterial isolates from this research work was in contrast to that obtained from Oluduro *et al*. (2011) which isolated *Klebsiella pneumonia, Proteus sp., Aeromonas viridians, Bacillus sp.,* among others from Electronic hardware interfaces in Ile-Ife, Oyo State, Nigeria. Although, high rates of microbial contamination were found on the mobile phones and computer's keypad which has comparable features with ATMs according to their physical and operational aspects. Tekerekoghu *et al*. (2011) documented that cell phones of patients, visitors and Health care workers carried multidrug – resistant pathogens including *Acinetobacter* sp., *S. aureus* and extend-spectrum β-lactamase ESBL-positive Enterobacteriaceae. It was documented by some researchers that *Staphylococcus aureus* were more prevalent on computer keypad and mouse (Anastasiade *et al.,* 2009; Anderson and Palombo, 2009). Interestingly, this study revealed comparable finding where *S. aureus* was observed as one of highest prevalence among other isolates. *S. aureus* is the major component of the normal flora of the skin and nostril, which probably explains its high prevalence as contaminant, and can be easily be discharged by several human activities, like sneezing, talking and contact with moist skin (Itah and Ben, 2004). The isolation of enteric bacteria such as *Escherichia coli, Enterobacter* sp., and *Klebsiella* sp. in this study,

despite, these bacteria reside normally in the intestinal tracts of animals including humans and some are pathogenic, causing disease and food poisoning in humans, improper hand washing could be adduced to why enteric organism were isolated from the sample ATM keypads machines. Several studies (Mehmet *et al.,* 2013; Stanley and Kayode, 2014; Odebisi-Omokanye *et al.,* 2014) have revealed that Automated Teller Machine (ATM) can become contaminated with pathogenic bacteria. In health care settings, it is perhaps not unexpected that such microbes would contaminate these common public devices. A particularly interesting finding was that multiple-user ATM machine had significantly more numbers of microbes, as well as greater numbers of potentially pathogenic species, compared with ATM machine used by predominantly few persons.

The isolation of *S. aureus* from most of ATM keypads in this study is not too surprising as they are known habitant microflora of the skin (Hardy *et al.,* 2006) and *S. aureus* is carried by healthy individuals between 20 - 40% at any given time. However, because *S. aureus* is the most important human staphylococcus pathogen and causes boils, abscesses, wound infections, pneumonia, in addition to the rise in Methicillin Resistant Staphylococcus aureus (MRSA) incidence, the presence of this microbe in most machines should not necessarily be taken with levity. Although, it is a common skin habitant that is most times responsible for endocarditis and diseases of patients with lowered resistance (Willey *et al.,* 2008).

Enterobacter sp. were the least frequent bacterial contaminants, their presence on environmental surfaces such as ATM keypads is a cause for some alarm, because they have been proven to possess the potential to cause diseases, mostly in a hospital setting (Ducel *et al.,* 2002). In several studies, each of these organisms has been implicated either as a main contaminant or as the most prevalent pathogenic bacteria recovered (Rutala and David, 2004; Fraser and Girling 2009; Oluduro *et al.,* 2011).

It is therefore, recommended that the same disease prevention measures employed during direct contact with patients such as hand washing and use of gloves, and should be enforced when handling computer hardware (Anderson and Palombo, 2009).

CONCLUSION

This study of the bacterial contaminants associated with ATMs keypads in Lafia, Nasarawa State revealed the presence of pathogenic microorganisms such as *Escherichia coli, Salmonella* sp., *Bacillus sp., Pseudomonas* sp., *Staphylococcus aureus, Klebisella* sp., and *Enterobacter* sp. The finding of this study is of public health significance, ATMs keypads are potential surface for pathogen collection.

Recommendation

Cleaning solution aimed at downgrading the population and presence of these microbes on the ATMs surfaces should be developed using correct sanitizers and strictly adhered to by operators of such financial institutions and their customers. Further research is needed to evaluate the status of ATMs according to fungi and viruses which were not studied in this research.

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