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Research Article

Determination of Bacterial Contamination, Occurrence and Antimicrobial Susceptibility of *Staphylococcus aureus* on Commercial Banks Automated Teller Machines (ATMs) in Kaduna Metropolis, Kaduna State, Northwestern Nigeria

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Abstract

The metallic keypads of Automated Teller Machines (ATMs) were examined for bacterial contamination, occurrence and antimicrobial susceptibility of *Staphylococcus aureus*. Surface swabs were collected from 235 Bank ATMs operating in Kaduna metropolis. The laboratory analysis employed were quantification of bacterial and coliform loads, identification of *Staphylococcus* species using biochemical tests and Microgen ID test system, antibiotic sensitivity test was also carried out on the isolates and minimum inhibitory concentration evaluation of Oxacillin and Vancomycin were conducted on the resistant isolates. Furthermore, Penicillin Binding Protein (PBP2a) Latex Agglutination Test was also conducted to detect PBP2a in isolates of *Staphylococcus aureus*. The results indicated the bacterial contamination of the ATM keypads in Kaduna metropolis with mean total aerobic bacterial counts ranged between 3.3 ± 1.04 - 4.4 ± 1.26 mean/log/cfu/cm^2 and mean total coliform counts ranged between 1.0 ± 1.32 - 3.2 ± 1.75 mean/log/cfu/cm^2. ATM keypads were contaminated with *Staphylococcus aureus* (38.3%) and 95.6% of the isolates were Methicillin Resistant *Staphylococcus aureus* (MRSA). The isolates showed high frequency of resistance to front line antibiotics including Ciprofloxacin (91%) and Gentamicin (60%). Hand washing and proper cleaning regimens were suggested to reduce contamination in the course of using ATMs.

Keywords: *ATM; Antimicrobial Susceptibility; Commercial Banks; Kaduna Metropolis; Nigeria; Staphylococcus aureus*

Abbreviation

ABU Zaria: Ahmadu Bello University Zaria; ATM: Automated Teller Machine; FCT: Federal Capital Territory; GTB: Guaranty Trust Bank; Stanbic IBTC Bank: Stanbic Investment Banking and Trust Company Chartered Bank; LGA: Local Government Area; UBA: United Bank for Africa

Introduction

Staphylococci are spherical gram-positive bacteria that divide in several planes to form irregular grape-like clusters. They occur as commensals on skin and mucous membrane, some act as opportunistic pathogens causing pyogenic infections. They affect virtually all warm - blooded animals and they are comparatively stable in the environment. Almost 20% of healthy human population were found to

persistently harbor *Staphylococcus aureus* [1]. Five species are of veterinary/medical importance. They include: *Staphylococcus aureus, S. intermedius, S. epidermidis, S. hyicus and S. scheiferi* spp *coagulans. Staphylococcus aureus* is a common pyogenic agent in human and several animal species. The coagulases in *S. aureus* species subspecies *aureus* and *S. intermedius* and coagulase-variable in *S. hyicus* converts fibrinogen in plasma to fibrin and is a virulence factor of these organisms which correlates with pathogenicity. Some of the virulence factors of *S. aureus* depending on the strains are coagulase, lipase, staphylokinase, hyaluronidase, protein A, leucocidin, alpha toxin (Alpha haemolysin), beta toxin (Beta haemolysin) exfoliative toxins and enterotoxins [2].

Many factors have been shown to influence the bacterial transfer between surfaces, including the source and destination surface features, bacterial species involved, moisture level, pressure and friction between the contact surface and the inoculum size [3]. One of the most commonly touched surfaces in health care setting today is the computer keyboard. So, it should not be surprising that studies have shown typically, 25% of keyboards in hospitals carry pathogens at any given time more than double that of other commonly touched surfaces [4]. Automated Teller Machines (ATMs) are the longest standing and most widely used form of computer-driven public technology. Working as a data terminal communicating through a host processor which links all other such machines operated by a bank across a wide area network, it makes cash withdrawal and other services available to the account holders more convenient [5].

Pathogens spread among people with direct or indirect contact of hands with inanimate objects or surfaces [6]. Isolation of cysts from samples collected on keyboards is an indication that it could be source of transmission of pathogens [7]. These findings correlate with that of Hartmann., *et al.* where it was observed that keyboard harbours a lot of parasites [8]. The use of public telephones installed inside airports, bus stations, malls and commercial centers among other places of great circulation may initiate the disease process as the apparatus may be contaminated with pathogenic fungi [9]. Several studies of the human environment have demonstrated colonization and contamination, of the objects such as door handles, phones, money, fabrics and plastics [4]. Animals and animal products may also be a vehicle for many bacterial pathogens [10]. Food contamination with antibiotic-resistant bacteria is now a major threat to public health, as the antibiotic resistance determinant can easily be transferred to other bacteria of human clinical significance [11].

The emergence and dissemination of antimicrobial resistance among *Staphylococci* is an important problem in clinical settings and in particular, the increasing prevalence of Methicillin Resistant *Staphylococcus aureus* (MRSA) is of concern to hospitals worldwide [12]. MRSA is also of concern in animals such as dogs, horses and pigs [13]. These animals could act as reservoirs of human infections or could represent an opportunity for the evolution of increasing pathogens and resistant strains [14].

Information on the phenotypes and genotypes of antimicrobial resistance in food-borne pathogens e.g. *Staphylococci* are largely restricted to the developed countries and there is a dearth of information on what is happening in developing countries [15]. Therefore, the study of antibiotic resistance in developing countries is important as this information could enhance prudent use of antibiotics in food production [15]. It is clear that antimicrobial-resistance e.g. MRSA is an excellent example of the "one health" concept as it can reciprocally affect humans and animals [2].

In Vellore city of India, a study was conducted to identify and quantify bacterial contamination on the surface of ATMs. The result revealed that ATMs were highly contaminated with pathogenic organisms especially the numeric keys; the organisms isolated included *S. aureus, S. epidermidis* and *Klebsiella* spp which revealed that ATMs may act as a potential source for transmission of infectious agents [16].

Tekerekoglu., *et al.* surveyed ATMs in Matalya city in Turkey for assessment of microorganisms in which they detected *Bacillus* spp, *Escherichia coli, Staphylococcus aureus* and methicillin resistant *Staphylococcus aureus* [17]. Similarly, survey on bacterial contamination on private and open access user interface (keypad, mouse, ATM) in Ile-ife, Nigeria was also conducted from which *Bacillus* spp. (8.4%), *Klebsiella pneumoniae* (11.1%) and *S. aureus* (16.7%) were detected [18].

Literature search has revealed that very few studies have been carried out in Nigeria on the presence of microbes on ATMs and it failed to reveal previous studies on the contamination of these devices in Kaduna State. This study has updated an existing information on the

contamination of ATMs with *S. aureus* in Kaduna metropolis and will eventually stimulate the interest to intensify efforts on monitoring and minimizing contamination with the bacteria in Kaduna State and Nigeria at large.

Materials and Methods

Study area

The study was carried out in Kaduna Metropolis, which is located between Latitude 10°20N of the equator and longitude of 7°45E east of the Greenwich Meridian. The State occupies an area of 46,053sqkm and has a population of about 6million [19] which is one of the most densely populated States in Nigeria (Figure 1). The State shares boundaries with Niger State to the West, Zamfara, Katsina and Kano to the North, Bauchi and Plateau States to the East, FCT Abuja and Nasarawa States to the South.

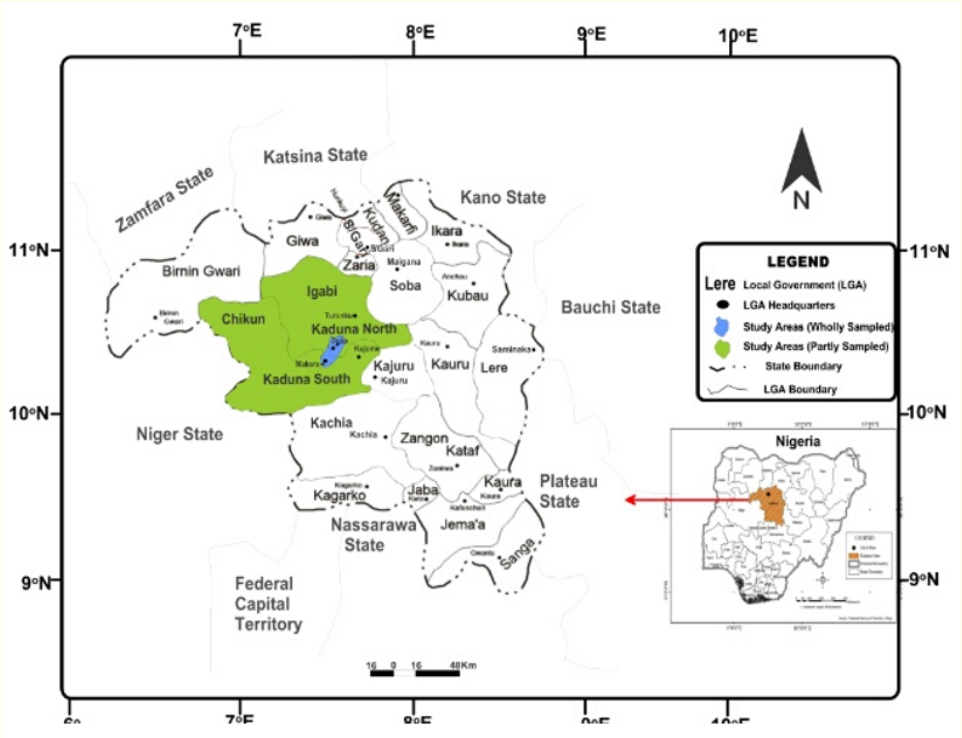

Figure 1: *Map of Kaduna state showing the study area.*
Source: Modified from http//www.thephss.org

There are two marked seasons in the State, the dry (windy season) and the rainy (wet season). The wet season is usually from April through October with great variation. The State has 23 Local Government Areas with four of them making up Kaduna metropolis, Kaduna North, Kaduna South, Part of Igabi and Chikun Local Government Areas. There are 57 languages spoken as first language in Kaduna; Gbagyi and Hausa are major languages. Agriculture including animal and poultry farming are the main stay of the economy of the State with about 80% of the population actively engaged in farming.

It is one of the education centers in Nigeria, with many colleges and the most recognized University in Nigeria (A.B.U. Zaria). It has numerous tourist attractions and comfortable five star hotels. Kaduna State has two distinct seasons.

Sample collection

A cross sectional study was conducted to assess ATMs in four Local Government Areas (Kaduna North, Kaduna South, part of Igabi and Chikun) that make up the Kaduna metropolis. Banks operating in Kaduna with ATMs were used for the study with their different branches

within the metropolis constitute the sampling frame. These are: Access Bank, Diamond Bank, Ecobank, Enterprise Bank, First Bank, Fidelity Bank, FCMB, GTbank, Keystone Bank, Mainstreet Bank, Skye Bank, Stanbic IBTC Bank, Sterling Bank, UBA, Union Bank, Unity Bank and Zenith Bank. A sample size of 235 ATM was determined using the formula [20] and 18.5% prevalence.

Swabs were taken from keypads of ATMs. Sterile swabs were placed in 5ml of Normal Saline diluent in a sample bottle. The swabs were well labeled with location, dates and Bank identity with a full description recorded. A total of 100 cm^2 of each keypad was swabbed. The sterile swab was removed and dipped in the diluent and excess saline was removed by pressing against the inner side of the tube. An area of 20 cm^2 made of 4 X 5 cm was swabbed holding the swab at low angle and rotating backwards. The swab sticks were eluted in the saline diluent by swirling the swab into it; the excess saline was removed by pressing against the inner wall. Swabbing of 20 cm^2 was repeated 5 times (20 X 5) = 100 cm^2. The end of the swab stick that has been held was broken off leaving the swab in the saline which was covered tightly. The samples were taken in cold chain to the Bacterial Zoonoses Laboratory, Department of Veterinary Public Health and Preventive Medicine, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria for analysis.

Sample processing

Quantification of bacteria

Ten-fold Serial dilutions of the swab saline suspension were spread on duplicate nutrient and MacConkey agar plates, for total aerobic and coliform counts respectively. The plates were incubated for 24 hrs at 37℃ under aerobic condition. The number of Colony Forming Units (CFU) on each plate for each sample was counted and recorded.

However, in isolation of *Staphylococcus aureus***,** Brain Heart Infusion Broth was used for enrichment. This was prepared according to Manufacturer's instruction**.** One ml of saline suspension of the swabs was inoculated in 9 ml of Brain Heart Infusion broth supplemented with NaCl (6.5%) and incubated at 35℃ for 24 hours [21]. Enrichment was manifested by increased turbidity of the medium after the incubation period.

Similarly, in morphological identification of the organism Baird Parker-Egg Yolk Agar was prepared according to the manufacturer's instructions. A sterile loop-full of the BHI broth inoculum was streaked onto Baird Parker Agar and incubated at 37℃ for 24 hours. *Staphylococcus aureus* was identified as small (1 - 2 mm in diameter) black shiny convex colonies with a narrow edge surrounded by clear zone ring within the colonies. The colonies suggestive of *Staphylococcus* species were characterized by conventional tests.

Catalase test

It detects the enzyme Catalase that converts Hydrogen peroxide to water and gaseous oxygen. A loopful of the bacterial growth was placed on a clean grease-free glass slide and a drop of 3% hydrogen peroxide was added. The release of bubbles of oxygen gas within few seconds indicated positive (+ve) reaction and its absence suggests negative (-ve) reaction.

Coagulase test

The test tube method was used using Rabbit plasma. Three test tubes were labelled 'test', 'negative control' and 'positive control'. Each tube was filled with 1 ml of 1 in 10 saline diluted rabbit plasma. 'Test' labelled test tube was added with 0.2 ml of overnight broth culture of test bacteria and 0.2 ml of overnight broth culture of known *S. aureus* was added to the 'positive control' test tube, while 0.2 ml of sterile broth was added to the 'negative control' tube. All the tubes were incubated at 37℃ and the suspension was observed for 4 - 24 hours. Coagulase Positive organisms were indicated by gelling of the plasma which remains in place even after inverting the tube and test tubes were read after 4 hours and left overnight for 24 hours. A negative test did not show clumping within 24 hrs.

Deoxyribonuclease (DNAse) Test

It was conducted where the test organism was aseptically spot-inoculated onto freshly prepared DNAse agar plates which were prepared according to the Manufacturer's manual. The plates were incubated over night at 35 - 37°C after which the surface of the plate was flooded with 0.1 ml dilute HCl and the excess tipped off. Clearing around the colonies indicated a positive result of DNAse, while absence of clearing around the colonies indicated a negative result.

Haemolytic reactions

Blood agar plates were prepared according to the manufacturer's manual and inoculated with the test organism. The plates were incubated at 37°C for 18 hours and examined. Clearing around the colonies indicated lysis of the red blood cells by haemolysis. This reaction was interpreted as α, β and γ - haemolysis representing incomplete, complete and no haemolysis respectively.

Sugar fermentation

Four sugars were used; Mannitol, Maltose, Glucose and Rhamnose. 1% concentration of each sugar was prepared in andrade peptone water in bijoux bottles. These sugar solutions were then inoculated with the organisms from pure culture with gentle agitation for proper mixing and incubated at 37℃ for 24 hrs. A positive sugar fermentation test was manifested by change in colour from colourless to pink to red.

Microgen ID test system

Characterisation of isolates was conducted using Microgen™ STAPH-ID System. The Microgen® Staph ID system is supported by the Microgen® Identification System Software which assist in the interpretation of the results. The isolates suspected to be *Staphylococcus* species were further identified with Microgen™ MID-69 microwell test strips. A single colony each, from 18-24 hours culture was emulsified in suspending medium supplied in the kit. The adhesive tapes sealing the microwell test strips were carefully peeled back to expose the test well. Sterile Pasteur pipette was used to add 3 - 4 drops (approximately 100 µL) of bacterial suspension to each well of the strips, after which wells 10 and 11 were overlaid with 3 - 4 drops of mineral oil. The microwell test strips were then sealed with the adhesive tapes and incubated at 35 - 37 ºC for 18 - 24 hours (Plate 1). The results were read with the aid of the Microgen™ software database (containing the colour chart and substrate reference table) after adding the necessary reagents (PYR and Nitrate A and B). On the Microgen Staph-ID Report form, the isolates were identified as *Staphylococcus aureus* by Microgen test system.

Plate 1: *Microgen ID test system confirming S. aureus.*

Disk diffusion method

The susceptibility of *Staphylococcus aureus* was carried out using a panel of 12 antimicrobial agents by disc diffusion method [22] following guidelines of Clinical and Laboratory Standards Institute and culturing on Mueller Hinton agar. The antimicrobial agents used were: Amikacin (30 µg), Oxacillin (1 µg), Trimethoprim (5 µg), Penicillin (10 units), Chloramphenicol (30 µg), Streptomycin (10 µg), Cefoxitin (30 µg), Amoxycillin (10 µg), Ciprofloxacin (5 µg), Nalidixic acid (30 µg), Gentamicin (30 µg), and Vancomycin (5 µg).

The disk diffusion method was used to determine the antibiotic susceptibility profiles of the *Staphylococcus aureus* isolates. Inoculum was prepared by making a saline suspension of isolated colonies selected from 24h Mannitol Salt Agar plate and the suspension was adjusted to match the 0.5 McFarland's turbidity standards. A sterile cotton swab was dipped into the adjusted suspension and excess inoculum was removed by pressing the swab firmly on the inside wall of the tube. The dried surface of a Mueller-Hinton agar plate was inoculated on the entire surface. This procedure was repeated by streaking two more times, rotating the plate approximately 60º each time to ensure an even spread of inoculum. After about 10 minutes to allow for pre- diffusion, the antimicrobial discs were placed firmly on the surface of the inoculated agar plate by disc dispenser. The plates were incubated at 35 - 37ºC for 16 - 20 hrs. After 16 to 18h of incubation, the plates were examined and the diameters of the zones of inhibition were measured to the nearest millimeter (Plate 2). Results were classified as susceptible, intermediate, or resistant, according to the approved guidelines of the Clinical and Laboratory Standards Institute.

Plate 2: *Antibiotic sensitivity testing on Mueller Hinton agar showing the zone of inhibition.*

The MIC Evaluation strips used were Oxacillin and Vancomycin. Appropriate MacFarland inoculum level was prepared. Several colonies from a pure culture into a suitable suspension medium were emulsified and compared the turbidity to appropriate 0.5 McFarland standards. A sterile cotton swab was dipped into the suspension and the excess liquid removed by pressing against the edge of the tube. The plate was inoculated by swabbing in at least three different directions. The surface of the agar was allowed to dry completely before applying the MIC Evaluation strips, since excess moisture can cause distortion of the gradient (Plate 3a and 3b). The MIC was read according to the recommendation of the Manufacturer (Oxoid, Basingstoke, UK) based on the point of intersection of zone of inhibition and the evaluator strips.

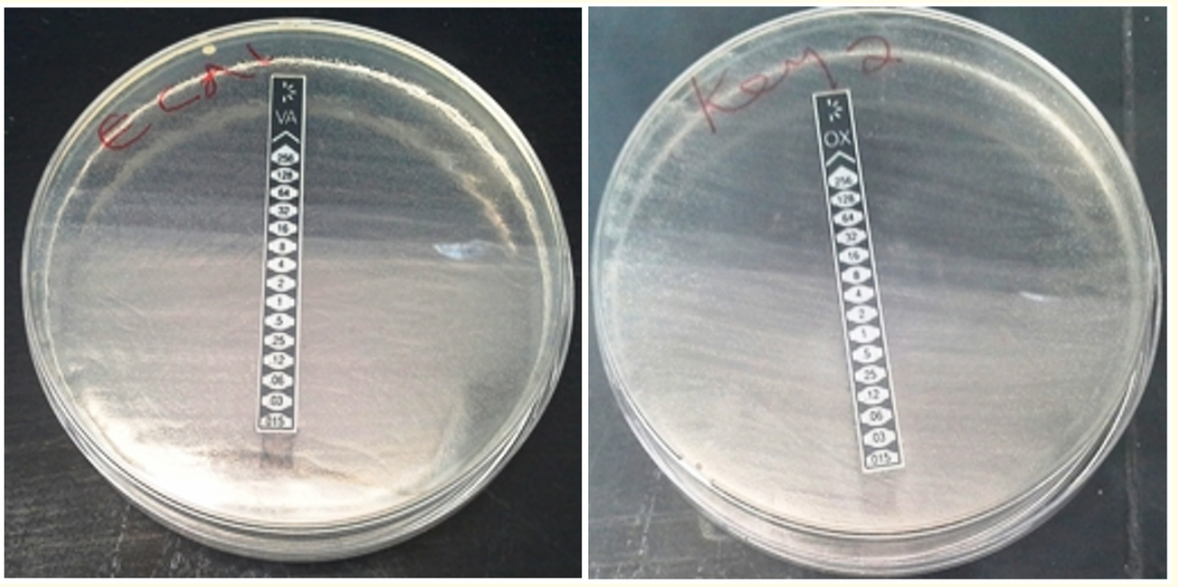

Plate 3a and 3b: *MIC of oxacillin and vancomycin to Staphylococcus aureus isolates.*

Penicillin binding protein (PBP2a) latex agglutination test

PBP2a extraction was conducted by adding four drops of extraction reagent 1 to a microcentrifuge tube. The test culture was suspended in the microcentrifuge tube by vortexing to obtain a very turbid suspension and the tube was placed into boiling water or heating block (over 95ºC) and heated for three minutes. The microcentrifuge tube was removed and allowed to cool to room temperature and one drop of extraction reagent 2 was added into the tube and mixed well. The tube was centrifuged at 1500 × g for five minutes and the supernatant was used for the test.

The latex agglutination test was conducted for each supernatant, one circle of the test card for testing with test latex was labelled and another for testing with control latex. The latex reagents were mixed well by inversion several times and one drop of test latex added or control to each labelled circle. The card was rocked for up to three minutes and observes for agglutination. The results of the test and control reactions were recorded. The reaction card was disposed off safely into disinfectant or infectious waste.

Agglutination seen with test latex, but not control latex within 3 minutes is PBP2a positive (MRSA). No agglutination in either test latex or control latex within 3 minutes is PBP2a negative (MSSA) and agglutination seen with the control latex within 3 minutes means indeterminate.

Plate 4: *PBP2a latex agglutination test.*

Results

Of the 235 ATMs sampled, the mean total bacterial counts of the ATMs keypads was determined, with the ATMs in Kaduna Metropolis having the bacterial counts ranging from 3.3 to 4.4 log/cfu/cm^2. ATMs in Kaduna North had the highest counts of 4.4 log/cfu/cm^2, while the ATMs in Chikun had the lowest mean counts with 3.3 mean/log/cfu/cm^2 (Table 1).

Location	Number of ATMs	log/cfu/cm^2 ± SD
Kaduna North	133	4.4 ± 1.26
Kaduna South	75	4.0 ± 1.94
Chikun	19	3.3 ± 1.04
Igabi	8	3.8 ± 0.44
Total	235	4.1 *± 1.49*

Table 1*: Mean Log of total aerobic bacterial counts from ATMs in kaduna metropolis.*

The mean total coliform counts of ATMs keypads in Kaduna metropolis ranged from 1.0 - 3.2 log/cfu/cm^2, ATMs in Igabi had the highest counts of 3.2 mean/log/cfu/cm^2, while ATMs in Chikun had the lowest counts of 1.0 log/cfu/cm^2 (Table 2).

Location	Number of ATMs	log/cfu/cm^2 ± SD
Kaduna North	133	2.4 ± 2.31
Kaduna South	75	2.0 ± 2.15
Chikun	19	1.0 ± 1.32
Igabi	8	3.2 ± 1.75
Total	235	2.1 *± 2.22*

Table 2: *Mean Log of total coliform counts from ATMs in kaduna metropolis.*

Isolation and identification of *S. aureus* and other *Staphylococcus* species from ATMs in Kaduna metropolis revealed a total of 25.5% (60/235) *Staphylococcus* species isolated from the ATMs using standard microbiological methods. 38.3% (23/60) were confirmed as *S. aureus*, *S. haemolyticus* is 10.0% (6/60), *S. hominis* is 1.6% (1/60), *S. hyicus* is 8.3% (5/60), *S. simulans* is 5.0% (3/60), *S. warneri* is 1.6% (1/60), and *S. xylosus* is 35.0% (21/60) (Table 3).

Staphylococcal species	Number of isolates	Percentage (%)
S. aureus	23	38.3
S. haemolyticus	6	10.0
S. hominis	1	1.7
S. hyicus	5	8.3
S. silmulans	3	5.0
S. warneri	1	1.7
S. xylosus	21	35.0
S. xylosus	60	100

A prevalence of 23.3% (14/60) was found for *S. aureus* in Kaduna North, 10.0% (6/60) in Kaduna South and Chikun 5.0% (3/60) was obtained (Table 4).

Location	n	S. aureus	Percentage	Odd ratio	95% CI
Kaduna North	31	14	60.9	0.2414	0.0107 - 5.44
Kaduna South	16	6	26.1	0.3231	0.013 - 7.854
Igabi	2	0	0	Ref.	
Chikun	11	3	13.0	2.059	0.077 - 54.85
Total	60	23	100		

Table 4: *Prevalence of S. aureus isolates obtained from ATMs Kaduna metropolis based on location (n = 23).*

P-Value = 0.4883

Fishers = 2.429

The antibiotic susceptibility of *S. aureus* isolates from ATMs in Kaduna metropolis shows that of the 60 *Staphylococcus* species isolates, 38.3% (23/60) showed high frequency of resistance to nalidixic acid (96%) followed by oxacillin, (85%), penicillin (81%), trimethoprim (71%) and amoxicillin (70%); but showed high frequency of susceptibility to ciprofloxacin (91%), amikacin (83%), chloramphenicol (69%), streptomycin (67%), while gentamicin and vancomycin were (60%) and cefoxitin (49%) respectively (Table 5). Table 6 shows the prevalence antibiotic resistance patterns and MAR index of *S. aureus* isolates from ATMs in Kaduna Metropolis.

Antibiotic	Concentration (µg)	Number (%) Resistant
NA	30	58 (96.7)
OX	1	51 (85.0)
P	10	49 (81.7)
W	5	43 (71.7)
AML	10	42 (70.0)
FOX	30	31 (51.7)
CN	30	24 (40.0)
VA	5	24 (40.0)
S	10	20 (33.3)
C	30	19 (31.7)
AK	30	10 (16.7)
CIP	5	5 (8.3)

Table 5: *Frequency of resistance by 60 isolates of Staphylococcus species to 12 antibiotics.*

Resistance Pattern	Frequency	MAR Index
1. OXA; NA	2	0.1
2. OXA; NA; PEN	1	0.2
3. OXA; NA; AML	1	0.2
4. OXA; NA; AML; PEN	1	0.3
5. OXA; NA; STR; GEN	1	0.3
6. OXA; PEN; FOX; AML; VAN	1	0.4
7. OXA; PEN; FOX; AML; NA	2	0.4
8. OXA; PEN; AML; VAN; NA	1	0.4
9. OXA; PEN; TRI; CHL; NA	1	0.4
10. OXA; PEN; AML; CHL; VAN; NA	1	0.5
11. OXA; PEN; AML; VAN; TRI; GEN; NA	1	0.5
12. OXA; PEN; AML; CHL; TRI; GEN; NA	1	0.5
13. OXA; PEN; AML; FOX; TRI; GEN; NA	1	0.5
14. OXA; PEN; AML; FOX; TRI; VAN; NA	1	0.5
15. OXA; PEN; AML; FOX; TRI; VAN; NA; GEN	2	0.6
16. OXA; PEN; AMK; FOX; TRI; CHL; NA; STR	1	0.6
17. OXA; PEN; AML; FOX; TRI; VAN; NA; GEN; STR	1	0.7
18. OXA; PEN; CHL; FOX; TRI; VAN; NA; GEN; STR	1	0.7
19. OXA; PEN; AML; CHL; TRI; AMK; NA; GEN; STR	1	0.7
20. OXA; PEN; AML; FOX; TRI; AMK; NA; GEN; STR; CIP	1	0.8

Table 6: *Antibiotic resistance patterns and MAR index of S. aureus isolates from ATMs in Kaduna metropolis (n = 23).*

Minimum Inhibitory Concentration (MIC) of Oxacillin and Vancomycin against *Staphylococcus aureus* isolates from ATMs in Kaduna metropolis shows MIC values of > 256 μg/ml.

The PBP2a latex agglutination test confirmed 22 of 23 (95.6%) methicillin resistances in *Staphylococcus aureus* isolates as MRSA.

Discussion

Banks ATMs continue to have an increased presence in the environment. They are frequently localized in the city centres, trade areas and within institutions. Customers make hand contact with the surfaces of the keypad or screen of these ATMs. The contribution of hands contaminated with pathogenic and non-pathogenic microorganisms to the spread of infectious disease has been recognized for many years [23]. Studies have documented colonization of keyboards in healthcare settings [4]. There are few reports on the nature and extent of colonization of micro-organisms on keyboards in non-hospital settings such as banking facility. The present study showed that microbial contamination occurs on ATMs in Kaduna metropolis. The bacterial load and occurrence of *Staphylococcus aureus* of this study showed bacterial contamination of the keypads of ATMs, with mean total aerobic plate counts and total coliform counts ranging from 3.3 to 4.4 log/cfu/cm^2 and 1.0 to 3.2 respectively. The contamination varied between the banks and location of the banks within Kaduna metropolis. Bank ATMs in Kaduna North and Kaduna South LGAs had the highest bacterial loads. This may be due to the fact that the areas are located in the city centre with high population, and ATMs are usually located in busy areas where people of different hygienic status use the ATMs on daily basis. Therefore, the high turnover of users may increase the likelihood of contamination. The ability of laboratories

to simply and accurately identify the individual species of CoNS enables laboratories to investigate the incidence and significance of these species more effectively.

The *Staphylococcus* species isolated in this study have been documented as the causative pathogen in infections in immunocompromised patients [24]. Several studies on human environment have documented colonization and contamination of public facility [4]. The level of bacterial contamination seen in this study is in line with the study of Oluduro., *et al.* who reported that keypads of ATMs harboured high bacterial counts [18]. This study is also in agreement with the study of Abban and Tano-Debrah who reported the presence of *Staphylococcus* spp (18%) on the keypads of ATM machines [25]. In the same vein, Anastasiades., *et al.* reported that *Staphylococcus aureus* are prevalent on computer keyboards and mouse [26]. This study is also in agreement with the study conducted by Okoro., *et al.* who reported high prevalence of *Staphylococcus aureus* among other isolates on ATMs in Abakaliki metropolis [27]. The highest prevalence (23.3%) of *S. aureus* in this study based on location was seen in Kaduna North. This may be attributed to the area being densely populated with a social setting where people move in timely to engage in multiple activities with frequent utilization of ATMs. Kaduna South had a prevalence rate of 10.0% which is lower than Kaduna North. Conversely, Chikun LGA had a prevalence rate of 5.0% while no isolate was obtained from any of the ATMs in Igabi LGA. Parts of Chikun and Igabi Local Government Areas sampled do not have many ATMs, and it was observed that people residing in these areas who patronise ATMs move to the city centre for transactions due to the availability and conveniences in the city. However, considering the nature of the environment there were no adequate banks and social amenities to make people have dealing with the banks on daily basis.

The frequency of resistance of the *Staphylococcus aureus* isolates was (96%) for nalidixic acid, followed by oxacillin, (85%), penicillin (81%), trimethoprim (71%) and amoxicillin (70%); but showed susceptibility to ciprofloxacin (91%), amikacin (83%), chloramphenicol (69%), streptomycin (67%), while gentamicin and vancomycin were (60%) and cefoxitin (49%). Almost all the isolates tested were resistant to various antimicrobials. It has been observed that antibiotic susceptibility of bacterial isolates is not constant but dynamic and varies with time and environment [29]. This therefore demands the need for periodic screening for common bacterial pathogens for their antibiotic susceptibility profiles in different communities [29]. Occurrence of resistance in pathogens may reduce the effectiveness of previously useful antibiotics [30].

This result agrees with the study of Okoro *et al.* reported multiple drug resistance in *S. aureus* isolated from ATM machines where they showed resistance to a panel of 10 antibiotics [27]. This study is also similar to the study of Issmat., *et al.* who isolated multi-drug resistant bacteria from public interfaces (computer surfaces) [31]. This study disagrees with the result of the antibiogram data obtained by Okoro., *et al.* where the susceptibility of *S. aureus* to ciprofloxacin and gentamicin were (91%) and (60%) respectively [27]. The variation in the results might be because of variation in geographical locations, environmental conditions and genetic background of the organisms and the abuse of drugs in various locations which lead to drug resistance [32].

In this study, 95.6% (22/23) of *S. aureus* isolates were confirmed as MRSA based on PBP2a production. Even though, MRSA reservoirs have been identified in hospital settings, few studies have investigated MRSA on frequently touched public surfaces such as ATMs. In one study Kassem., *et al.* found 8% of computer keyboards at a metropolitan university harboured MRSA [31]. In another study, the hand rails of public transport vehicles had 30% MRCoNS and no MRSA [33]. The high prevalence rate of MRSA on ATMs in this study may be due to the increasing number of hospitals in the metropolis with ATMs being placed everywhere even at the hospital gate, therefore some people use ATMs before entering or coming out of the hospital. Results from this study on the presence of MRSA on frequently touched public surfaces suggest significant concern for the community spread of MRSA. The result of this study is of public health concern especially for residents of Kaduna Metropolis and visitors to the city.

Conclusion

This study established the presence of *Staphylococcus aureus* and other species on ATM keypads with an overall prevalence of 38.3%. The bank ATMs in Kaduna North had the highest frequency of isolation 23.3%, followed by Kaduna south 10.0%, while Chikun had 5.0%

and no isolate was obtained in Igabi. The contact time of the customers' fingers with the surfaces of these devices may be considered to be short, but microbial transmission could occur from the ATMs contaminated by users and user's hands can also be contaminated with *S. aureus* from ATMs. Based on the results of this study, ATM devices might serve as potential sources for transmission of pathogens. Since ATM keypads are providing a surface for colonization, infection control guidelines must target appropriate surfaces.

Based on the findings of this study, disinfection of the keypads and screen parts of ATMs using appropriate disinfectants may be of benefit in limiting the bacterial accumulation and transmission with cash machines. ATM users should always wash hands thoroughly especially after using ATM. Molecular typing of MRSA isolates from ATMs in order to determine their possible human or animal origin and further investigations are required to determine the status of ATMs with regards to contamination with other bacterial species, parasites, fungi and viruses which were not included in this investigation.

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