MICROBIAL LOAD AND PUBLIC HEALTH RISK OF CONTAMINATED POS MACHINES RANDOMLY SAMPLED AROUND FIVE JUNCTION TO FIRST EAST CIRCULAR JUNCTION, BENIN CITY, EDO STATE, NIGERIA.

BY

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DEPARTMENT OF SCIENCE LABORATORY TECHNOLOGY

FACULTY OF LIFE SCIENCES

UNIVERSITY OF BENIN

BENIN CITY

OCTOBER, 2025

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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF SCIENCE LABORATORY TECHNOLOGY, FACULTY OF LIFE SCIENCES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE (HONORS) DEGREE (BSC.) IN SCIENCE LABORATORY TECHNOLOGY

OCTOBER, 2025

CERTIFICATION

This is to certify that this project work carried out by **OGUJOR OGHENETEJIRI BLESSING** with the matriculation number **SC2009719** of the department of Science Laboratory Technology (Microbiology Technology), Life Sciences, University of Benin, Benin City, Edo State, Nigerian.

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DEDICATION

This book is dedicated to God Almighty and My lovely parents MR and MRS OGUJOR whose unwavering love, guidance, direction and strength have fueled my journey of discovery.

ACKNOWLEDGMENT

I would like to express my sincere appreciation to my supervisor, Dr. O. C. Udinyiwe, for his invaluable guidance, supportive nature and insightful feedback throughout this research project. His knowledge, encouragement and commitment have been crucial in influencing the direction and quality of this work. I am truly thankful to my Head of Department, Prof. J.O. Osarumwense for creating a supportive academic atmosphere and promoting a culture of excellence within the department. His leadership and vision have served as an inspiration and I appreciate his support and encouragement. I am grateful to my course adviser, Mr. Salokun for his advice, encouragement and mentorship throughout my educational journey, as well as to the other staff members of the Department of Science Laboratory Technology, I express my gratitude. A huge thank you to my project coordinator, Dr. P. O. Alonge, for his patience and guidance during the research phase. I wish to acknowledge my parents, Mr. and Mrs. Ogujor, for their consistent support, love, sacrifices and encouragement throughout my academic pursuits. I love you both so much. This accomplishment is equally yours as it is mine. I also wish to express my appreciation to my dear friends, Miracle, Lydia, Esther and Prosper for their unwavering love and encouragement during my academic journey. I love and celebrate you all.

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ABBREVIATIONS

Acronym	Full Meaning
POS	Point of Sale
ATM	Automated Teller Machine
WHO	World Health Organization
CBN	Central Bank of Nigeria
cfu/ml	Colony Forming Units per millilitre
AMR	Antimicrobial Resistance
MRSA	Methicillin-Resistant Staphylococcus aureus
ESBL	Extended Spectrum Beta-Lactamase
CLSI	Clinical and Laboratory Standard Institute
R	Resistant
I	Intermediate
S	Susceptible
VRE	Vancomycin-Resistant Enterococcus

ABSTRACT

Point-of-sale (POS) machines are widely used for cashless transactions in Nigeria, but frequent handling by multiple users makes their keypads potential fomites for microbial transmission. This research aimed to determine the microbial load, public health risk and antimicrobial resistance patterns present on POS keypads sampled from twenty locations between Five Junction and First East Circular Junction, Benin City. 20 Swab samples were used to swab on the screen or button of the POS machines to collect isolates. The bacterial isolates were identified using morphological, microscopic and biochemical techniques. Antibiotic susceptibility testing was conducted to determine resistance profiles of the bacterial isolates. Analysis of bacterial counts revealed considerable contamination, ranging from 1.5×10^3 cfu/ml to 6.55×10^4cfu/ml. Four bacterial species were identified which were *Staphylococcus* spp. (34.15 %), *Pseudomonas* spp. (26.83 %), *Aeromonas* spp. (24.40 %) and *Enterococcus* spp. (14.63 %). Antibiogram results demonstrated multidrug resistance, particularly in *Pseudomonas sp.* which showed resistance to several antibiotics including streptomycin and chloramphenicol. The presence of pathogenic and multidrug-resistant bacteria on POS keypads indicates their potential role in the transmission of infectious diseases and antimicrobial resistance within the community. Nevertheless, further research is needed to establish effective disinfection practices, determine the frequency of contamination and evaluate the impact of hygiene interventions to reduce cross-contamination and limit the spread of resistant pathogens.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of Study

The spread of infectious diseases has remained a pressing public health challenge worldwide and the role of contaminated inanimate objects commonly referred to as fomites has received increasing attention in epidemiology (Kramer *et al.,* 2006). Fomites are surfaces and materials that can serve as reservoirs for pathogenic microorganisms which are later transmitted to humans through direct contact. They include door handles, currency notes, writing pens, mobile phones, computer keyboards, Automated Teller Machines (ATMs) and Point of Sale (POS) machines. As human dependence on electronic and financial technology grows these shared devices are touched by hundreds of individuals daily raising concern about their role in microbial transmission cycles (Reynolds *et al.,* 2005). In recent years, Nigeria has witnessed an exponential increase in the use of POS machines as a result of the Central Bank of Nigeria's drive toward a cashless economy and financial inclusion. These devices are now indispensable in open markets, shops, transport parks, supermarkets, fuel stations and street kiosks where they provide an alternative to bank cash withdrawals (Central Bank of Nigeria, 2019). Unlike personal items such as mobile phones, which are often used by a single individual POS machines are handled by multiple people operators, customers and bystanders creating significant opportunities for microbial transfer. This communal handling combined with frequent placement of POS devices in unhygienic environments makes them potential reservoirs for microbial contamination.

The survival of microorganisms on surfaces has been widely documented. For example, *Staphylococcus aureus* and *Escherichia coli* can survive on plastic and metallic surfaces materials commonly used in the manufacture of POS machines for several hours to days

(Neely and Maley, 2000). These pathogens are of public health concern because they cause a range of infections including diarrhea, urinary tract infections, pneumonia, wound infections and septicemia (Cheesbrough, 2006). Other organisms such as *Klebsiella pneumoniae*, *Proteus spp*., *Pseudomonas aeruginosa*, and *Salmonella typhimurium* have also been consistently reported from fomites in Nigeria (Awua *et al*., 2022). Several studies in Nigeria have confirmed the heavy microbial contamination of frequently touched devices. For instance, (Awua *et al.,* 2022) reported the presence of *staphylococcus aureus* (41.6 %), *E. coli* (34.4 %) and *K. pneumoniae* (24.0 %) on ATM machines in Makurdi metropolis. Similarly, (Otu-Bassey *et al.,* 2021) isolated *S. aureus, E. coli, Bacillus subtilis, P. aeruginosa, Salmonella* spp*. and Shigella* spp. from ATM surfaces in Calabar South and highlighted significant resistance of the isolates to commonly prescribed antibiotics. In Benin City, (Akinnibosun and Adetitun, 2019) investigated ATM keypads and observed multidrug resistance among isolates such as *S. aureus* and *E. coli* with plasmid profiling confirming the genetic basis for resistance.

Studies on POS machines although relatively few show similar outcomes. In the study conducted in Imo state, it was observed that high levels of microbial contamination on POS machines were 3.7×10^5 cfu/ml (Eze and Igwe, 2021) The most common isolates were *S. aureus, Klebsiella* spp*.* and *Proteus* spp., Likewise, (Musa *et al.,* 2022) examined POS and ATM machines within Ahmadu Bello University, Zaria and identified bacteria including *E. coli, Staphylococcus* spp. and *Salmonella* spp., many of which exhibited resistance to ampicillin and tetracycline. These studies confirm that POS machine much like ATMs, act as fomites that could play an important role in the spread of infectious agents within communities. Issue is of particular importance in Nigeria where infectious diseases remain highly prevalent. The burden of diarrheal diseases, typhoid fever, respiratory infections and foodborne illnesses is still high (Okeke *et al.,* 2005). In environments such as open-air

markets where POS devices are widely used, sanitation is often poor hand hygiene is irregular and awareness of microbial risks is limited. The humid tropical climate of southern Nigeria, including Benin City further enhances microbial persistence and growth on shared surfaces (Onifade *et al.,* 2019). The World Health Organization (WHO) has identified antimicrobial resistance as one of the most serious global health threats noting that the misuse and overuse of antibiotics combined with poor infection control, accelerates the spread of resistant organisms (WHO, 2014). When pathogenic bacteria colonize devices such as POS machines they can be transmitted among community members, thereby disseminating resistant strains more widely. In Nigeria, this is particularly dangerous because access to quality healthcare and effective antibiotics is often limited, making the prevention of transmission critical (Iwuafor *et al.,* 2020).

The study area, Five Junction to First East Circular Junction in Benin City, Edo State is a major commercial zone where financial activities are intense. The area is characterized by high human traffic, dense population and widespread use of POS operators for daily transactions. The constant handling of POS keypads by multiple customers and operators in this environment creates fertile ground for microbial colonization. Yet, no detailed research has previously focused on the microbial contamination of POS devices in this part of Benin City, despite its relevance for community health. The epidemiological role of fomites like POS machines cannot be overlooked. In Port Harcourt (Okerentugba *et al.,* 2015). documented the presence of *S. aureus, E. coli, Salmonella* spp. and *Proteus* spp. on ATM keypads while (Adegboyega *et al*., 2016). Yield *S. aureus, S. epidermidis, K. pneumoniae* and *E. coli* on ATM machines in Ilorin metropolis. These consistent findings across Nigerian cities suggest that POS devices are also highly likely to act as reservoirs of similar pathogens. Despite this evidence, awareness of microbial risks associated with POS machines remains very low. Unlike hospital equipment, which is regularly disinfected POS devices are rarely

cleaned or sanitized. Operators and customers often handle them immediately after exchanging cash, handling food or touching contaminated surfaces thereby facilitating continuous microbial transfer. The public health implications of this cycle are significant especially for immunocompromised individuals and vulnerable populations. Thus, the microbial contamination of POS machines represents a silent but critical public health issue. This research will contribute evidence to guide preventive measures such as routine sanitization, improved hand hygiene and awareness campaigns. Ultimately, addressing this overlooked source of microbial transmission will help reduce the burden of infectious diseases and slow the spread of antimicrobial resistance within the community.

1.2 Aim of Study

The aim of this study was to determine the microbial load and public health of contaminated POS machines randomly sampled around five junction to east circular junction, Benin City, Edo State.

1.3 Specific Objectives

The specific objectives of this research were to:

- determination of the total heterotrophic bacterial count of POS machines across the several locations.
- isolate, enumerate and identify the bacterial isolate present from the POS machines.
- determine the frequency distribution of the bacterial isolated from different POS location.
- determine the susceptibility pattern of the bacterial isolate against some antibiotics.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Fomites and Public Health

Fomites are inanimate objects that can become contaminated with infectious agents and subsequently act as vehicles for their transmission to humans. Everyday items such as door handles, money, computer keyboards, mobile phones, ATMs and point-of-sale (POS) keypads have been identified as potential fomites (Mbim *et al.,* 2016). The World Health Organization (WHO, 2014) has consistently emphasized the importance of understanding non-human reservoirs of pathogens in controlling infectious diseases, particularly in low- and middle-income countries where hygiene and sanitation infrastructure may be suboptimal. The persistence of pathogens on environmental surfaces has been well documented. (Kramer *et al.,* 2006) reviewed more than 80 studies and demonstrated that common bacteria such as *Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa* and *Enterococcus faecalis* can survive for days to months on inanimate surfaces depending on environmental conditions. Similarly, viral pathogens such as i*nfluenza, rotavirus* and SARS-CoV have been shown to persist for hours to weeks on fomites (Boone and Gerba, 2007). The survival of pathogens on fomites poses a considerable risk of cross-contamination especially in crowded urban settings.

2.2 Importance of Studying Fomites

The role of fomites in the spread of infectious diseases is increasingly gaining attention. In healthcare settings contaminated surfaces have been associated with nosocomial infections (Hota, 2004). Outside hospitals, shared objects such as currency notes, coins and communal devices serve as reservoirs for pathogenic microorganisms (Tagoe *et al.,* 2011). The study of fomites has particular relevance in urban centers in developing countries, where population

density, frequent cash handling and high use of shared public devices coincide (Nwankwo and Offiah, 2016). Microorganisms recovered from fomites often include multidrug-resistant strains underscoring their potential as reservoirs and vehicles for antimicrobial resistance dissemination (Iwuafor *et al.,* 2020). POS devices due to their widespread usage and constant contact with multiple individuals daily represent a critical but understudied for Nigeria, where cashless policies have promoted the proliferation of POS transactions (CBN, 2019), the microbial risk associated with POS machines has become an emerging public health issue.

2.3 Microbial Contamination of Surfaces and Devices

Several studies have highlighted that high-touch surfaces are consistently contaminated with pathogenic microorganisms. (Reynolds *et al.,* 2005) demonstrated that up to 60 % of public surfaces in the United States tested positive for bacteria of potential health concern. In Nigeria, (Enemuor *et al.,* 2012) reported that computer keyboards and mice used in universities harboured a variety of microorganisms including coliforms and *Staphylococcus species*. ATMs which share operational similarities with POS machines have also been widely studied. (Okerentugba *et al.,* 2015) reported bacterial contamination of ATMs in Port Harcourt, Nigeria, with isolates including *E. coli*, *Klebsiella pneumoniae* and *S. aureus*. Similarly, (Adegboyega *et al.,* 2016) observed antibiotic-resistant bacteria on ATMs in Ilorin metropolis. These findings provide compelling evidence that shared devices function as microbial reservoirs in the community. The survival and transmission of pathogens through these devices are influenced by environmental factors such as humidity, temperature, frequency of cleaning and intensity of use (Neely and Maley, 2000). The high frequency of POS keypad use coupled with inadequate sanitation practices makes them particularly vulnerable to microbial colonization.

2.4 Antimicrobial Resistance and Public Health Risks

The contamination of fomites is not only a concern because of microbial presence but also because of the potential spread of antimicrobial resistance (AMR). The WHO (2014, 2023) has identified AMR as one of the top ten global public health threats exacerbated by the overuse and misuse of antibiotics. Resistant pathogens on fomites can serve as reservoirs for horizontal gene transfer facilitating the spread of resistance determinants (Okeke *et al.,* 2005). (Prestinaci *et al.,* 2015) highlighted the growing challenge posed by multidrug-resistant bacteria such as methicillin-resistant *Staphylococcus aureus* (MRSA) and extended-spectrum beta-lactamase (ESBL)-producing *Enterobacteriaceae*. In Nigeria, reports show increasing resistance among community-acquired infections raising concerns about the potential contribution of environmental fomites (Iwuafor *et al.,* 2020). The risk is particularly acute in public devices like POS machines because they are handled by large diverse populations making them potential "super-spreaders" of resistant microbes.

2.5 POS Keypads as Emerging Fomites

Point-of-sale (POS) machines have become integral to financial transactions in Nigeria, particularly following the Central Bank of Nigeria's cashless policy initiative (CBN, 2019). They are used across urban and rural areas often in environments with poor sanitation, minimal regulation and high human traffic. Studies have shown that POS keypads can harbour a wide variety of microorganisms. Eze and Igwe (2021) reported microbial contamination of POS machines in Owerri, Nigeria with isolates including *Staphylococcus aureus, E. coli* and P*seudomonas* species. Similarly, (Musa *et al.,* 2022) found both bacterial and fungal contaminants on POS and ATM devices within Ahmadu Bello University Zaria, noting that many isolates were resistant to commonly used antibiotics. Despite these findings research into POS keypad contamination remains limited compared to ATMs and mobile

phones. This gap highlights the need for comprehensive investigations into the microbial risks associated with POS devices, especially in areas with high transaction volumes such as Benin City, Edo State.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Sample location

The study was carried out within the commercial areas stretching from Five Junction to First East Circular Junction, Benin City, Edo State, Nigeria.

3.2 Sample Collection

POS keypads were randomly selected within the study area 20 Sterile cotton swab sticks moistened with sterile physiological peptone water were used to swab the surface of the keypads. Each swab sample was introduced into sterile swab tubes, properly labelled and immediately transported to the microbiology laboratory of for further microbiological analysis within two hours of collection.

3.3 Serial Dilution of Swab Samples

The swab stick samples collected from the POS keypads were subjected to serial dilution to obtain countable microbial colonies. Each swab stick was first immersed in a sterile test tube containing 9 ml of normal saline and allowed to soak for a few minutes to ensure proper release of microorganisms into the solution. This stepwise dilution helped to reduce microbial load systematically, thereby facilitating accurate isolation, enumeration and characterization of bacteria during subsequent plating on appropriate culture media.

3.4 Preparation of media

3.4.1 Nutrient Agar

Twenty-eight grams (28 g) of dehydrated nutrient agar powder was weighed and dissolved in 1 Liter of distilled water. The mixture was gently heated with continuous stirring until completely dissolved. The prepared medium was dispensed into clean conical flasks and sterilized by autoclaving at 121°C for 15 minutes. After sterilization, the medium was allowed to cool to 45–50°C before being aseptically poured into sterile Petri dishes at a uniform depth of about 20 ml per plate. The plates were allowed to solidify inverted to prevent condensation and stored at 4°C until required for inoculation.

3.4.2 MacConkey Agar

Fifty grams (50 g) of dehydrated MacConkey agar powder was weighed and dissolved in 1 liter of distilled water. The solution was heated gently with constant agitation until fully dissolved. The medium was then dispensed into sterile conical flasks and sterilized by autoclaving at 121°C for 15 minutes. After sterilization, the agar was allowed to cool to 45–50°C and aseptically poured into sterile Petri dishes at a depth of about 20 ml per plate. The plates were left to solidify on a level surface inverted to avoid condensation.

3.5 Isolation of Samples Using the Pour Plate Method

A total of twenty (20) swab samples collected from POS keypads were processed for microbial isolation using the pour plate technique. From each serially diluted sample, 1.0 ml aliquots were aseptically transferred into sterile Petri dishes in duplicates. About 15–20 ml of sterile molten nutrient agar cooled to 45–50°C, was poured into each plate, gently mixed with the inoculum by swirling to ensure uniform distribution, and allowed to solidify. The plates were then inverted and incubated at 35–37°C for 24–48 hours under aerobic conditions.

3.6 Enumeration of Microorganisms

Microbial enumeration was carried out on plates containing colonies to ensure accuracy and reliability of counts. The number of colonies on each plate was recorded and the average count from duplicates was calculated. The colony-forming units per milliliter (CFU/ml) of the original sample were determined using the formula:

$$CFU/ml = \frac{\text{Mean number of colonies x Dilution factor}}{\text{Volume plated (ml)}}$$

3.7 Morphological Characteristics of Isolates

Preliminary characterization of the bacterial isolates was based on their observable macroscopic morphology. Features noted included colony shape (circular, irregular, round), margin/edge (entire, undulate, lobate, filamentous), elevation (flat, raised, convex), colour (milky, pale green), colony consistency (dry, wet) and opacity (transparent, translucent, or opaque). Representative colonies with distinct morphological differences were subsequently sub-cultured onto fresh nutrient agar plates to obtain pure cultures for further microscopic and biochemical identification.

3.8 Gram staining test

The Gram staining technique was used for differentiation between gram positive and gram negative bacterial strains. A drop of sterile distilled water was placed on a neat and clean glass slide and a single isolated colony of 24 hours old culture was mixed in it. The smear was made by spreading the culture. This smear was air dried and fixed by rapidly passing the slide three times over the flame. It was then flooded with crystal violet for 1 minute and then washed off with distilled water. Then gram's iodine solution was added to the smear and the glass slide was left for one minute and rinsed with distilled water. This step was followed by the application of decolorizing agent (ethanol) for 30 seconds. Decolorizing agent was immediately washed with distilled water and the smear was counter stained with safaranine for one minute. The slide was washed with distilled water; air dried and was observed under the microscope.

3.9 Biochemical Tests

3.9.1 Catalase Test

A small amount of a pure bacterial colony was transferred onto a clean glass slide using a sterile loop. A drop of 3% hydrogen peroxide (H_2O_2) was added to the colony. The appearance of immediate effervescence (bubbling) indicated a positive catalase reaction while the absence of bubbles indicated a negative result.

3.9.2 Indole Test

Sterile test tubes containing 5 ml of peptone water were inoculated with pure bacterial isolates and incubated at 37°C for 24–48 hours. After incubation, 0.5 ml of Kovac's reagent was gently added to each culture tube. The formation of a red-coloured layer at the surface indicated a positive indole reaction, while a yellow layer indicated a negative result.

3.9.3 Citrate Utilization Test

Simmons citrate agar slants were inoculated by streaking the slope with a sterile loop containing the test organism. The tubes were incubated at 37°C for 24–48 hours. A colour change from green to blue indicated a positive citrate utilization test while no colour change (medium remaining green) indicated a negative result.

3.9.4 Oxidase Test

A piece of filter paper was soaked in freshly prepared oxidase reagent (1% tetramethyl-p-phenylenediamine dihydrochloride). Using a sterile loop, a portion of the bacterial colony was smeared on the filter paper. The appearance of a deep purple colour within 30 seconds indicated a positive oxidase reaction while no colour change indicated a negative result.

3.9.5 Glucose Fermentation Test

Test tubes containing glucose broth supplemented with phenol red as a pH indicator and inverted Durham tubes were inoculated with the test organism and incubated at 37 °C for 24–48 hours. A colour change from red to yellow indicated acid production (positive glucose fermentation). The presence of gas bubbles in the Durham tube indicated gas production.

3.9.6 Mannitol Fermentation Test

Test tubes containing mannitol broth with phenol red indicator and inverted Durham tubes were inoculated with the isolates and incubated at 37 °C for 24–48 hours. A colour change from red to yellow indicated acid production due to mannitol fermentation, while the presence of gas in the Durham tube confirmed gas production. A negative result was indicated by no colour change (medium remaining red) and absence of gas.

3.10 Antimicrobial sensitivity bioassay

The antibiotic susceptibility of the bacterial isolates was determined using the Kirby–Bauer disk diffusion technique on Mueller Hinton agar, prepared following Clinical and Laboratory Standards Institute (CLSI, 2021) guidelines. Each pure bacterial isolate was standardized by suspending colonies in sterile normal saline to match 0.5 McFarland turbidity standard. Using the pour plate method 1 ml of the standardized inoculum was introduced into sterile Petri dishes and approximately 20 ml of molten Mueller Hinton agar (cooled to 45–50°C) was poured and mixed to ensure even distribution of the inoculum. After the agar solidified Gram-positive and Gram negative antibiotics sensitivity disc was bought from the pharmaceutical shopping store. Antibiotic disc used and their concentrations were as follows: Gram positive discs contained; Ciprofloxacin (10 µg), Norfloxacin (10 µg),

Gentamycin (10 µg), Lincocin (20 µg), Streptomycin (30µg), Riflampicin (20 µg), Erythromycin (30 µg), chloramphenicol (30µg), Ampiclox (20 µg) and Floxapen (20 µg). The Gram negative discs contain, Tarivid (10 µg), Peflacine (10 µg), ciproflox (10 µg), Augumentin (30 µg), Gentamycin (10 µg), Stretomycin (30 µg), ceporex

(10 µg), Nalidixic acid (30 µg), Septrin (30 µg) and Ampicilin (30 µg). Commercially prepared antibiotic-impregnated discs were aseptically placed on the surface using sterile forceps. Plates were incubated in an inverted position at 35–37 °C for 18–24 hours. Following incubation, the diameter of the inhibition zones around each antibiotic disc was measured in millimeters using a transparent ruler. The results were interpreted as Resistant (R), Intermediate (I), or Susceptible (S) based on CLSI interpretive criteria. A clear inhibition zone of sufficient diameter indicated susceptibility, reduced zone size indicated intermediate response and absence or very small inhibition zones indicated resistance. Resistance implied the organism could grow and multiply despite the presence of the antibiotic intermediate suggested a borderline effect where higher doses or specific body sites may still achieve efficacy while susceptibility indicated the antibiotic would likely be effective in treatment.

CHAPTER FOUR

4.0 RESULT

The microbial load of swab samples collected from POS keypads was analysed. Table 4.1 displays the bacterial counts (cfu/ml) obtained from the twenty samples. The results revealed variable levels of microbial contamination ranging from 1.5×10^3 cfu/ml to 6.55×10^4 cfu/ml, with some samples such as 7 (3.85×10^4 cfu/ml) and 14 (6.55×10^4 cfu/ml) showing high bacterial counts, while others such as 8 (1.5×10^3 cfu/ml) and 18 (2.0×10^3 cfu/ml) recorded lower counts. This variation suggests differences in frequent handling, hygiene practices and environmental exposure of the POS machines.

In Table 4.2, four bacterial isolates were identified: *Staphylococcus* species, *Aeromonas* species, *Enterococcus* species and *Pseudomonas* species. The identification was based on features such as colony shape, colour, margin, opacity, Gram reaction, arrangement and results of biochemical tests (catalase, indole, citrate, oxidase, glucose, mannitol).

In Table 4.3 - 4.4 showed the frequency and distribution and bacterial percentage occurrence. *Staphylococcus* spp. had the highest occurred as 14, with 34.15 % occurrence, while *Enterococcus* spp. was the lowest with 6 and 14.63 % percentage occurrence.

Table 4.5. results were interpreted as Resistant (R), Susceptible (S) or Intermediate (I) according to CLSI guidelines. *Aeromonas* spp. was more susceptible to the antibiotics, while, *Pseudomonas* spp. showed more resistance to the antibiotics.

Table 4.1: Result for Bacterial Count (cfu/ml)

Location	Bacterial count (cfu/ml)
1	2.0×10^4
2	5.1×10^4
3	2.5×10^4
4	3.5×10^4
5	4.0×10^4
6	3.3×10^4
7	3.5×10^4
8	1.5×10^4
9	1.8×10^4
10	7.5×10^4
11	2.1×10^4
12	4.5×10^4
13	6.2×10^4
14	6.55×10^4
15	1.5×10^4
16	3.2×10^4
17	2.5×10^4
18	2.0×10^4
19	3.3×10^4
20	1.6×10^4

Table 4.2: Result for Cultural, Microscopic, Morphological and Biochemical test

	A	B	C	D
Shape	Round	Circular	Round	Irregular
Colour	Milky	Milky	Pale green	Milky
Margin	Entire	Entire	Entire	Entire
Opacity	Opaque	Opaque	Translucent	Opaque
Elevation	Flat	Flat	Flat	Flat
Wet / Dry	Wet	Wet	Wet	Wet
Gram Reaction	+ve	–ve	+ve	–ve
Cell Shape	Cocci	Cocci	Cocci	Rod
Arrangement	Cluster	Single	Single	Single
Catalase	+	+	-	+
Indole	-	+	-	-
Citrate	-	+	-	+
Oxidase	-	+	+	-
Glucose	+	-	-	-
Mannitol	-	+	-	+
Suspected isolate	*Staphylococcus* spp.	*Aeromonas* spp.	*Enterococcus* spp.	*Pseudomonas* spp.

Key: + = Present - = Absent

Table 4.3: Result of bacterial frequency distribution

Sample No.	A	B	C	D
1	-	+	+	+
2	+	+	+	+
3	+	+	+	-
4	-	-	-	+
5	-	-	-	+
6	+	-	-	-
7	+	+	+	+
8	+	-	-	+
9	+	+	-	-
10	-	+	+	+
11	+	+	-	-
12	-	+	-	-
13	+	-	-	-
14	-	-	-	+
15	+	-	-	+
16	+	-	-	+
17	+	-	-	-
18	+	-	-	-
19	+	+	-	-
20	+	+	+	+
Isolates bacteria	*Staphylococcus* spp.	*Aeromonas* spp.	*Enterococcus* spp.	*Pseudomonas* spp.

Key: + = Present - = Absent

Table 4.4: Result of percentage distribution of bacterial isolates

Isolates	Frequency	Percentage (%)
Staphylococcus spp.	14	34.15
Aeromonas spp.	10	24.40
Enterococcus spp.	6	14.63
Pseudomonas spp.	11	26.83

Table 4.5: Result for Anti-biogram Susceptibility Test for bacterial isolate

Antibiotic	A	B	C	D
AZ	S	R	R	R
LEV	R	S	S	S
PEF	S	S	S	S
CN	S	S	S	R
APX	R	N.D	R	N.D
Z	R	N.D	R	N.D
AM	R	R	R	R
RA	R	N.D	R	N.D
CPX	S	S	S	S
E	S	N.D	S	N.D
AU	N.D	S	N.D	R
OFX	N.D	S	N.D	S
CF	N.D	R	N.D	R
S.P	N.D	S	N.D	R
Bacteria isolates	*Staphylococcus* spp.	*Aeromonas* spp.	*Enterococcus* spp.	*Pseudomonas* spp.

Key: S = Susceptible, R = Resistant, ND = Not Determined

CHAPTER FIVE

5.0: DISCUSSION

This study investigated the microbial contamination of Point of Sale (POS) keypads within the commercial area spanning from Five Junction to First East Circular Junction in Benin City, Edo State, Nigeria. In Table 4.1, the total bacterial load ranged from 1.5×10^3 cfu/ml to 6.55×10^4 cfu/ml indicating a high level of microbial contamination. Such elevated microbial loads on frequently touched surfaces are comparable to those reported by (Chukwuedo *et al.,* 2020) and (Otalu *et al*., 2020) who observed similar contamination levels on Automated Teller Machines (ATMs), door handles and mobile phones. The variation in bacterial counts among different POS samples suggests that microbial load is influenced by factors such as the hygiene practices of users, environmental exposure, frequency of device use and cleaning routines as similarly observed by (Kumar *et al.,* 2017). The result in Table 4.4 revealed isolates which include *Staphylococcus* spp., *Pseudomonas* spp., *Aeromonas* spp. and *Enterococcus* spp. with *Staphylococcus* spp. being the most prevalent (34.15 %). This predominance agrees with findings by (Otalu *et al.,* 2020) who identified *Staphylococcus aureus* as the most common organism on public-use devices. The high prevalence of *Staphylococcus* species is not unexpected as these bacteria are part of the normal flora of human skin and mucous membranes (Kluytmans *et al.,* 1997). Their abundance on POS keypads, as observed in Table 4.2, indicates contamination primarily due to frequent hand contact reinforcing the view that public touch surfaces can act as vehicles for microbial transmission. Although *Staphylococcus* species are often commensal pathogenic strains such as a *Staphylococcus aureus* can cause a wide range of infections from minor skin lesions to serious systemic diseases particularly in immunocompromised individuals (Lowy, 1998). The distribution of bacterial isolates across the different POS samples as presented in Table 4.3, revealed that several keypads harboured more than one bacterial species indicating mixed

microbial populations. This observation aligns with the report of (Otalu *et al.,* 2020), who detected multiple bacterial species coexisting on ATM keypads. The coexistence of diverse bacterial species on the same surface may facilitate horizontal gene transfer thereby promoting the spread of antimicrobial resistance genes in community environments (Davies and Davies, 2010). As shown in Table 4.4, *Pseudomonas* spp. constituted (26.83 %) of the isolates which is concerning due to its well-documented ability to resist multiple classes of antibiotics and persist in moist environments (Moradali *et al.,* 2017). This finding supports the observation by (Davies and Davies 2010), who described *Pseudomonas aeruginosa* as a key model organism for antibiotic resistance studies. *Aeromonas* spp. (24.40 %) and *Enterococcus* spp. (14.63 %) were also frequently isolated further emphasizing the public health risks associated with contaminated POS devices. Both genera are known opportunistic pathogens capable of causing gastrointestinal disorders, urinary tract infections and wound infections particularly among vulnerable populations (Janda *et al.,* 1990). Their presence on POS keypads suggests faecal or environmental contamination and reflects poor hygiene among handlers consistent with the findings of (Olowe *et al.,* 2013) regarding microbial contamination of public surfaces. The antibiotic susceptibility patterns of the isolates in Table 4.5, revealed variable resistance profiles across species. *Staphylococcus* spp. exhibited resistance to β-lactam antibiotics such as ampicillin and augmentin but remained sensitive to fluoroquinolones such as ciprofloxacin and ofloxacin. This resistance pattern aligns with global reports on the increasing prevalence of β-lactam-resistant *Staphylococcus* strains, including methicillin-resistant *Staphylococcus aureus* (MRSA) (Enright *et al.,* 2002). *Pseudomonas* spp. displayed multidrug resistance consistent with its intrinsic resistance mechanisms including efflux pumps, β-lactamase production and biofilm formation (Moradali *et al.,* 2017). Furthermore, *Enterococcus* spp. demonstrated resistance to several antibiotics consistent with global reports on the emergence of vancomycin-resistant

enterococci (VRE) as major nosocomial pathogens (Murray, 1990). These results mirror the observations of (Chukwuedo *et al.,* 2020) who also reported the presence of antibiotic-resistant bacteria on public-use ATMs in Nigeria. From a public health perspective, the findings from Tables 4.1–4.5 underscore the potential role of POS machines as fomites in the transmission of pathogenic and multidrug-resistant microorganisms. With the widespread adoption of cashless transactions in Nigeria, POS terminals have become high-contact public surfaces. Their frequent use by multiple individuals daily combined with poor sanitation practices provides an ideal environment for microbial survival and transmission. The presence of multidrug-resistant organisms on POS keypads therefore suggests that these devices may serve as reservoirs for antimicrobial resistance dissemination within the community (Chukwuedo *et al.,* 2020). Consequently, this study highlights the urgent need for routine disinfection of POS terminals and improved public awareness on hand hygiene especially after handling shared devices. Public health authorities should implement environmental surveillance programs to monitor microbial contamination of public surfaces and track antimicrobial resistance patterns over time. Such measures, as recommended by the World Health Organization (2021) are essential to curb the spread of infectious agents and antibiotic-resistant bacteria in community and healthcare settings. Overall, the findings from this study emphasize the importance of integrating hygiene education and microbial monitoring into public health policies aimed at reducing environmental transmission of pathogens.

5.2 CONCLUSION

This study examined the microbial contamination of Point of Sale (POS) keypads within the commercial corridor extending from Five Junction to First East Circular Junction in Benin City, Edo State, Nigeria. The findings revealed that the POS keypads harboured diverse bacterial species including *Staphylococcus* spp., *Pseudomonas* spp., *Aeromonas* spp. and *Enterococcus* spp. with total bacterial loads ranging from 1.5×10^3 cfu/ml to 6.55×10^4 cfu/ml. These results confirm that POS machines are potential reservoirs for pathogenic and opportunistic microorganisms capable of spreading infectious diseases among users. The predominance of *Staphylococcus* spp. indicates contamination primarily through human contact, while the detection of *Pseudomonas* spp., *Aeromonas* spp. and *Enterococcus* spp. underscores possible environmental and fecal sources of contamination. The presence of multidrug-resistant isolates particularly among *Pseudomonas* and *Enterococcus* species, further highlights the potential risk of antimicrobial resistance dissemination in the community. Overall, this study demonstrates that POS keypads like other frequently touched public surfaces can serve as fomites for microbial transmission and reservoirs for antibiotic-resistant bacteria. The implications for public health are significant especially in densely populated urban centres where the use of POS devices has become an essential part of daily financial transactions. Therefore, it is concluded that regular cleaning and disinfection of POS devices, strict adherence to personal hygiene practices and public education on hand hygiene are critical measures to minimize microbial contamination and reduce infection risks. Additionally, continuous surveillance of environmental surfaces for microbial and antimicrobial resistance patterns is recommended to support preventive strategies and safeguard community health.

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APPENDIX I

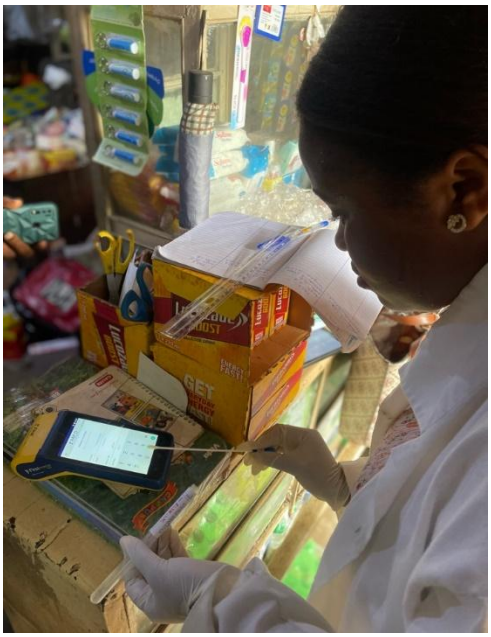

Plate 1: Sample Collection (Field Work, 2025)

Plate 2: Experimental procedure (Field Work, 2025)

Plate 3: Bacterial isolate in plates and McCartney (Field work, 2025)