# ISOLATION AND IDENTIFICATION OF BACTERIA ON MOBILE PHONES FROM SELECTED MARKET WOMEN IN BENIN CITY EDO STATE.

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**UNIVERSITY OF BENIN**

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**A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF MICROBIOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, IN PARTIAL FUFILLMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF B.Sc. (HONS) IN MICROBIOLOGY, UNIVERSITY OF BENIN, BENIN CITY.**

**FEBRUARY 2025.**

# CERTIFICATION

This is to certify that this project work was successfully carried out by **DAVID OKIEMUTE VIEGBISIE** with matriculation number **LSC2007083,** of the department of Microbiology, Faculty of Life Sciences, University of Benin, Benin City, Edo State, Nigeria, under my supervision.

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**PROF. F.O EKHAISE** **DATE**

(Project Supervisor)

_____ _____

**PROF. Mrs. F.I AKINNIBOSUN** **Date**

(Head of Department)

# DEDICATION

This report is primarily dedicated to the Most High God for His abundant blessings, mercy, and guidance throughout my university journey.

I am also dedicating this project to my parents for their constant love and support.

# ACKNOWLEDGEMENTS

First and foremost, I wish to give my profound gratitude to God Almighty for His faithfulness, goodness and grace throughout my life and academic journey.

I want to sincerely acknowledge my supervisor **PROF F.O EKHIASE** for his encouragement and insight towards the success of this work. I am grateful to the Head of Department, Microbiology, Prof. (Mrs) F. I. Akinnibosun, and also my course adviser, Dr. (Mrs) R. Adams for their support and guidance throughout my academic years.

The lecturers in the Department have provided essential insights and support, for which I am truly grateful. I am grateful to Dr (Mrs) I.B. Idemudia.

I would like to express my deepest gratitude to several individuals and groups whose support and guidance have been instrumental in the completion of this project.

At the top of that list is my immediate family, I am immensely thankful to my parents, MR MONDAY EDEFE VIEGBISIE and MRS ARAMIDE THOMAS VIEGBISIE for their unwavering support and encouragement throughout my academic journey, to my brother, DANIEL OGHENETEGA VIEGBISIE thanks for always supporting me without hesitation.

I am also thankful to my project group members for their collaboration and constructive suggestions, which have greatly enhanced the quality of this work. My friends, The Jiggas, has been a constant source of support and camaraderie from my second year onward, and I am deeply appreciative of their presence in my social and academic life.

Without the collective support of these individuals and groups, I would find it challenging to reach this milestone.

I say, remain blessed by God Almighty, I love you all, you all are the best!

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# ABSTRACT

Mobile phones are frequently exposed to various environmental contaminants and serve as potential reservoirs for bacterial pathogens, particularly among individuals in high-contact occupations such as market women. This study aimed to isolate and identify bacterial contaminants from mobile phones used by selected market women in Benin City, Edo State, to assess potential public health risks. Total bacterial counts (TBC) ranged from $1.70 \pm 0.02 \times 10^4$ cfu/m³ to $3.80 \pm 0.53 \times 10^4$ cfu/m³, indicating significant microbial contamination. Morphological and biochemical characterization identified *Salmonella spp., Escherichia coli, Bacillus spp., Klebsiella* sp., *Streptococcus* sp., *Staphylococcus* sp., and *Enterococcus* sp. Staphylococcus spp. exhibited the highest occurrence (20%), followed by Streptococcus spp. (16%) and *Escherichia coli* (13%), while *Klebsiella* sp. had the lowest occurrence (5%). Antibiotic susceptibility testing revealed varying resistance patterns among isolates. *Escherichia coli* exhibited resistance to cefotaxime and nitrofurantoin, while *Staphylococcus* sp. was resistant to cefotaxime and nitrofurantoin but sensitive to ampicillin, levofloxacin, and imipenem. The multiple antibiotic resistance (MAR) index ranged from 0.3 to 0.5, highlighting the presence of antibiotic-resistant strains with potential public health implications. These findings emphasize the need for improved hygiene practices among market women to minimize bacterial contamination and potential disease transmission.

# CHAPTER ONE

# INTRODUCTION

## 1.1.Background of the study

The global proliferation of mobile phones has revolutionized communication and accessibility, but it has also introduced public health concerns regarding microbial contamination (Simmonds *et al.,* 2020). Mobile phones serve as potential reservoirs for various pathogenic microorganisms due to frequent handling, exposure to different environments, and lack of routine cleaning. Among market women, who operate in high-contact, high-contamination settings, the risk of microbial transfer via mobile phones is particularly significant. Mobile phones are indispensable tools for communication and business transactions, especially in informal markets. However, their frequent usage in environments with high microbial load, such as open markets, increases their susceptibility to contamination. Several studies have documented the presence of bacteria, including *Escherichia coli, Staphylococcus aureus, and Pseudomonas aeruginosa*, on mobile phones (Bhat *et al*., 2011;Tagoe *et al*., 2011). These organisms are capable of causing a wide range of infections, including gastrointestinal diseases, skin infections, and systemic illnesses, particularly in immunocompromised individuals (Brady *et al*., 2009; Ulger *et al*., 2009).

In Benin City, markets serve as hubs for diverse activities, including food handling, money exchange, and contact with a variety of goods and customers. These activities contribute significantly to the microbial contamination of surfaces, including mobile phones. Market women often use their phones during transactions or while handling food items, providing multiple avenues for cross-contamination. The presence of high-touch surfaces and unhygienic conditions in these markets further exacerbates the risk of microbial transfer (Kawo and Rogo, 2008).

In Nigeria, there has been an increase in the use of mobile phones among the general population. They are handled frequently, and held to the face (Yusha'u *et al*., 2008; Yusha'u *et al*., 2010) and this constant handling of the mobile phones by users makes it a breeding place for transmission of microorganisms as well as hospitalassociated infections (Glodblatt *et al*., 2007;). The normal microbiota of the skin include among others Staphylococci which are also found regularly on clothes, bed linen and other human environments (Brooks *et al*., 2004). They can produce disease condition if introduced into foreign locations or compromised host (Ekrakene *et al*., 2009). It has been reported that Coagulase negative *Staphylococcus* (CoNS), which constitute part of the normal flora of the skin is among the commonly isolated bacteria on cell phone and automated teller machine (Tunc and Olgun, 2006; Shahaby *et al*., 2012). Also, potentially pathogenic bacteria commonly reported include methicillin sensitive S. aureus (MSSA), coliforms, methicillin resistant *S. aureus* (MRSA), *Corynebacterium* spp., *Enterococcus faecalis, Clostridium perfringens, Klebsiella* spp., *Enterobacter* spp., *Pseudomonas* spp., *Aeromonas* spp., *Acinetobacter* spp., *Stenotrophomonas maltophilia*, *Escherichia coli, Klebsiella* spp. and *Bacillus* spp. (Tunc and Olgun, 2006;Shahaby *et al*., 2012; David *et al*.,2016).

Studies from other regions have shown that mobile phones frequently harbor bacteria that are resistant to antibiotics, raising concerns about the role of these devices in the dissemination of antimicrobial resistance (Akinyemi *et al*., 2009; Kiedrowski *et al*., 2013). Given the increasing reliance on mobile phones in both professional and personal settings, it is imperative to understand the extent of microbial contamination and its public health implications. For instance, studies by Chaka *et al*. (2016) and Jeske *et al*. (2015) highlighted the role of mobile phones in spreading multi-drug resistant pathogens, including methicillin-resistant *Staphylococcus aureus* (MRSA).

Despite the critical role of mobile phones in daily activities, they are often overlooked as fomites for pathogen transmission. Market women in Benin City handle various items, including raw food, money, and personal items, all of which can transfer microbes to their phones. The lack of awareness about proper phone hygiene exacerbates the risk of spreading infections. A study by Pal *et al*. (2015) revealed that mobile phones used in market settings had higher bacterial loads compared to those used in less crowded environments, highlighting the need for targeted interventions. Additionally, research by Shakir *et al*. (2018) indicates that such contamination not only poses risks to the users but also contributes to the broader public health burden by potentially introducing harmful pathogens into households and food supplies. Consequently, there is a pressing need to isolate and identify the pathogenic bacteria present on mobile phones used by market women to develop effective public health interventions.

### 1.2.Aim and Objectives

The aim of this study is to isolate and identify bacterial isolates on mobile phones used by selected market women in Benin City, Nigeria.

The specific objectives of this research were to:

1. isolate and enumerate bacteria from mobile phones used by market women in Benin City.
2. identify the bacteria isolates present in the mobile phones used by market women in Benin City.
3. evaluate the antimicrobial susceptibility patterns of the isolated bacterial pathogens.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 OVERVIEW OF MOBILE PHONES

The mobile phone, a revolutionary communication tool, has undergone significant transformations since its inception. The first mobile phone, introduced by Motorola in 1973, was a bulky device primarily used for voice communication. Over the decades, the mobile phone has evolved into a multifunctional device, incorporating features like text messaging, internet access, photography, gaming, and navigation. The introduction of smartphones in the early 2000s marked a critical turning point, as these devices integrated high-processing power with sophisticated operating systems, enabling users to engage in a wide range of activities beyond communication (Goggin, 2012).

Globally, mobile phone use has expanded rapidly, with mobile subscriptions surpassing the global population. The proliferation of mobile networks, advancements in technology, and lower costs have made mobile phones accessible to diverse demographic groups. In developing countries, mobile phones have become a crucial tool for overcoming barriers to communication and accessing services (Aker and Mbiti, 2010). Locally, in countries like Nigeria, mobile phone penetration has surged in recent years, driven by the affordability of basic mobile phones and the rise of smartphones. The adoption of mobile technology in Nigeria has reshaped how individuals interact socially, economically, and even politically.

Mobile phones play an essential role in modern market environments, acting as tools for communication, commerce, and information access. In markets, mobile phones facilitate communication between vendors, suppliers, and customers, thus enhancing the efficiency of transactions. These devices allow for real-time exchange of information, enabling market

participants to keep track of stock levels, negotiate prices, and receive customer orders. In some markets, mobile phones have even replaced traditional methods of payment, with mobile money platforms enabling cashless transactions, which is particularly beneficial in areas with limited access to banking services (Mbiti and Weil, 2011).

Moreover, mobile phones provide market women with access to a wealth of information that can influence their business operations. For instance, mobile phones can help them access market prices, weather forecasts, and supply chain updates, allowing for better decision-making in terms of inventory and pricing (Chavula, 2013). The use of mobile phones is also linked to improved market access, as it allows vendors to connect with a larger customer base beyond their immediate locality, thereby expanding their market reach.

Market women, particularly in developing economies, exhibit specific behavioral patterns regarding mobile phone usage, often shaped by their socio-economic roles and access to technology. These women utilize their mobile phones not just for communication, but also as tools for improving business practices. For example, they may use mobile phones to stay in contact with wholesalers, check for price fluctuations, or receive updates on supply chains. In addition, many market women rely on their phones for personal matters, such as staying connected with family members or using social media to engage with their communities.

In terms of mobile commerce, many market women have adopted mobile payment systems, such as mobile wallets or cash transfer services, as a way to handle transactions efficiently and securely. However, the level of mobile phone usage and the adoption of these services can vary depending on factors such as age, education, and economic status (Chavula, 2013). Studies have also shown that while mobile phone use is widespread, there are significant disparities in how effectively different groups utilize mobile technology for business purposes. Older market

women, for instance, may rely more on basic phones for voice communication, while younger vendors tend to use smartphones for more sophisticated functions (Mbiti and Weil, 2011).

Overall, mobile phones have become indispensable in the lives of market women, facilitating both personal and business activities. As mobile technology continues to evolve, it is expected that its impact on market environments will only deepen, providing new opportunities for economic growth and social interaction.

## 2.2 MOBILE PHONES AS RESERVOIRS FOR PATHOGENIC MICROORGANISMS

Mobile phones are ubiquitous in daily life, offering convenience for communication, work, and entertainment. However, they are also becoming increasingly recognized as potential reservoirs for pathogenic microorganisms. Given the frequent handling and exposure to various surfaces, mobile phones can harbor and transmit a variety of pathogens, making them a source of concern in terms of public health (Shahaby *et al*., 2012).

Mobile phones possess several characteristics that make them suitable for microbial colonization. These devices often have warm, moist environments, especially after prolonged use, which are conducive to the growth of microbes. Additionally, the frequent contact of mobile phones with various surfaces, such as hands, clothing, and public spaces, exposes them to a wide range of microorganisms. The presence of crevices, touch screens, and keypads also provides niches for microbial accumulation. Studies have shown that the touchscreen of a phone, in particular, can accumulate microbial biofilms due to its smooth surface and the oil and sweat from human skin (Olsen *et al*., 2020). Moreover, the small size and portability of mobile phones mean they are frequently used in diverse environments, including kitchens, toilets, and healthcare settings, where microbial contamination is common (Sadeeq *et al*., 2021).

Mobile phones are increasingly recognized as fomites, objects that carry and transfer pathogens. As mobile phones come into frequent contact with surfaces, they pick up microorganisms such as bacteria, fungi, and viruses. These pathogens can remain viable on the phone's surface for hours to days, depending on environmental conditions, and can be transferred when the phone is used by an individual or shared between multiple users. A study by Selim and Abaza, (2015) demonstrated that mobile phones can act as vectors for the transmission of nosocomial infections, especially in healthcare settings, where the risk of exposure to antibiotic-resistant bacteria is higher. In addition, mobile phones are often used in food handling and public areas, where contamination with foodborne pathogens such as *Salmonella* or *E. coli* may occur, leading to potential transmission (Sadeeq *et al*., 2021). The ability of mobile phones to retain and transfer microorganisms underscores their role as an important vector in the transmission of infectious diseases.

Several studies have highlighted the types of microorganisms commonly found on mobile phones. Bacterial contaminants, in particular, have been frequently identified. *Staphylococcus aureus*, including Methicillin-resistant *Staphylococcus aureus* (MRSA), has been a common isolate from mobile phone surfaces, posing significant health risks due to its association with skin and wound infections (Tunc and Olgun, 2006 ; Shahaby *et al*., 2012; David *et al*.,2016).

Other bacterial pathogens such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Enterococcus faecalis* have also been reported on mobile phones, with some of these species being linked to urinary tract infections, respiratory infections, and sepsis (Shahaby *et al*., 2012; David *et al*.,2016).

In addition to bacteria, fungal species such as *Candida albicans* have been identified, particularly in environments where humidity levels are higher. Viruses, including those responsible for respiratory infections, have also been detected on mobile phones, though less

frequently. The diversity of microbial contaminants on mobile phones emphasizes their role as significant reservoirs for a range of pathogens (Olsen *et al*., 2020).

## 2.3. BACTERIA CONTAMINATION OF MOBILE PHONES

Bacteria contamination is a situation which occurs when bacteria end up in a location where they are not supposed to be. It is often used to refer to contamination of food by bacteria which can cause disease, but can also occur in other settings. This situation is not desirable because it can pose a health threat and cause other problems. As a result of this, steps are taken to avoid contamination in settings where it can become as issue.

In the case of cell phones, bacterial contamination can happen at many steps along from contact of hands to hands. The microbial contamination is most commonly found on the mouthpiece, although the earpiece and the handles of cell phones can also harbour bacterial species. Cell phones with buttons and keyboards and other personal mobile phones in general have been found to be even more conducive to bacterial contamination. The majority of bacterial species that have been found on phone surfaces are those that are part of the normal flora of the skin and body, due to the constant contact with the hands and face. (Visvanathan *et al.,* 2011). The reason for the potentially harmful bacteria festering on so many gadgets is people failing to wash their hands properly with soap after going to the toilet. Although 95% of people said they washed their hands with soap where possible, 92% of cell phones and 80% of hands had bacteria on them. Worryingly, 16% of phones and 16% of hands were found to harbour *E. coli* – bacteria of a faecal origin. Harmful *E. coli* (*Escherichia coli*) is associated with stomach upsets and has been implicated in serious cases of food poisoning such as the fatal 0157 outbreak in Germany. Studies provide evidence that some people still don`t wash their hands properly, especially after going to toilet. Faecal bacteria can survive on hands and surfaces for hours at a time, especially in warmer temperatures away from sunlight; it is easily transferred by touch to

door handles, food and cell phones. From there, the germs can be picked up by other people and cause disease to them. The simple action of washing hands with soap is one of the most effective ways of preventing these illnesses. (Visvanathan *et al.,* 2011).

### 2.3.1. Bacteria Associated With The Use Of Mobile Phones

According to Okpalla *et al.* (2011), the following microorganisms were isolated which are *Staphylococcus* spp*., E. coli, Proteus* spp*., Streptococcus* spp., etc. while Ekrakene and Igeleke, (2007) was able to isolate microorganism like *Staphylococcus aureus, Enterobacter aerogenes, Bacillus subtilis.* (Yush`u *et al.,* 2010) isolated *Staphylococcus aureus, Streptococcus* spp*.* (Kabir *et al.*, 2009) isolated *Staphylococcus aureus, Enterococcus fecalis, Pseudomonas aeroginosa, E.coli and Klebsiella* spp. The following are bacteria associated with cell phones:

#### 2.3.1.1. *Escherichia coli*

E. *coli* is a Gram negative rod shaped bacterium that is normally found in the intestine of warm blooded organism (endoderm). Some serotype causes serious food poisoning in human as a result of food contamination whereas there are those which are harmless and are part of the normal flora of the gut and can benefit their host by preventing the establishment of pathogenic bacteria within the intestine. Faecal-oral transmission is the major route in which pathogenic strains of the bacterium cause disease. *E. coli* has been used as an indicator organism for long time now because they can survive outside the body for limited period of time and they can be used to test environmental sample for faecal contamination. *E. coli* can be easily grown in the Laboratory and it is very cheap to do so. It can live on a wide variety of substrates. *E. coli* uses mixed acid fermentation in anaerobic condition producing lactose, succinate, ethanol, acetone and carbon dioxide. Optimal growth occurs $37^0$C but some laboratory strains can multiply at temperature of up to $49^0$C. Young ones and adults are usually immunocompromised when

infected with *E. coli* and develop some fatal haemolytic Uremic Syndrome (HUS), pains, diarrhoea, nausea, fever, fatigue and dehydration (Vogt and Dippold, 2005).

An experiment conducted by Pommerville, (2004) at London school of hygiene and tropical medicine and Queens Mary university of London, they swabbed 780 samples of cell phones which 390 of the swabbed samples were from hands, and they found out that 16% of both hands and cell phones were contaminated with *E. coli* because people don`t wash their hands after using the toilet which implies that people are spreading faecal bacteria not just to their cell phones but also to everything they come in contact with.

#### 2.3.1.2. *Staphylococcus aureus*

*Staphylococcus aureus* is a facultative anaerobic Gram positive coccal bacterium. It is frequently found as a part of the normal skin flora and nose (nasal passages). It is estimated that 20% of the human population are long term carriers of *Staphylococcus aureus*. *Staphylococcus aureus* can be seen to b a successful pathogen because of the combination of bacteria immunoevasive strategies which includes the production of carotenoid pigment staphloxanthin responsible for the characteristic golden colour of *staphylococcus aureus* colonies. This pigment acts as a virulence factor by being a bacteria anti-oxidant which helps the bacteria evades the reaction oxygen specie which the host immune system uses to kill pathogen. *Staphylococcus aureus* was first identified in Abserdeen, Scotland in 1880 by the surgeon Sir Alexander Gorton in pus from surgical abscesses. (Kluytmens *et al.*, 1997).

Gerba *et al.* (2002) stated that *Staphylococcus aureus* can cause a range of illness most especially skin infection like boils, pimples, skin syndrome, abscesses cellulitis to chronic illness like pneumonia, meningitis, toxic shock syndrome, endocarditis, sepsis and bacteraemia. *Staphylococcus aureus* is also one the causes of nosocomial infections which cause post surgical wound infection. *Staphylococcus aureus* is a facultative anaerobic Gram positive coccal which

appears as a grape like clusters when viewed under the microscope and has a large round golden yellow colony often with haemolysis when grown on blood agar plate. *Staphylococcus aureus* is catalase positive which is able to convert hydrogen peroxide to water and oxygen which makes the catalase test an important test to distinguish *Staphylococcus aureus* from *Enterococci* and *Streptococci*. *Staphylococcus aureus* infection may spread through contact with an infected wound, skin to skin contact with an infected person by hyaluronic that destroys tissues and contact with objects such as towels, clothing used by an infected person.

#### 2.3.1.3. *Klebsiella* sp.

*Klebsiella* species is a non motile Gram negative rod shaped bacteria with a prominent polysaccharide based capsule (Hidron *et al.*, 2008). This organism was named after the German microbiologists Edwin Kleb (1834-1913*). Klebsiella* spp. can lead to a wide range of disease state notably pneumonia, urinary tract infection septicaemia and soft tissue infections (Pugh, 2006). *Klebsiella* species are ubiquitous in nature. *Klebsiella* spp. have been identified as important common pathogen for nosocomial pneumonia. They are important opportunistic pathogens particularly among immunocompromised people.

### 2.4. Public Health Implications Of Microbial Contamination Of Mobile Phones

Mobile phones have become ubiquitous, serving as essential tools for communication, business, and daily activities. However, their widespread use has also raised concerns about their role as potential vectors for microbial contamination, with significant public health implications. Mobile phones provide an ideal environment for microbial growth and transfer due to their frequent handling and warm surfaces. Studies have identified a wide range of microbial contaminants on mobile phones, including *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas* spp. some of which are pathogenic and antibiotic-resistant (Akinyemi *et al*., 2009; Tagoe *et al*., 2011). These contaminants can be transferred from the hands of users or

contaminated environments, posing risks for nosocomial infections in healthcare settings and community-acquired infections in public spaces.

In healthcare environments, contaminated mobile phones have been linked to the spread of multidrug-resistant bacteria, exacerbating the challenge of antimicrobial resistance (AMR) (Brady *et al*., 2009). The persistence of pathogenic microbes on mobile phone surfaces, coupled with infrequent cleaning, significantly increases the risk of cross-contamination and infection transmission. Vulnerable populations, such as market women, are at heightened risk due to frequent exposure to unhygienic conditions. Market environments, characterized by the handling of money, food, and contact with various surfaces, amplify the likelihood of microbial contamination on mobile phones. Market women often use mobile phones during food preparation or sales, inadvertently transferring microbes to food items, thereby contributing to foodborne illnesses (Eze *et al*., 2022).

The health burden on this demographic is exacerbated by limited access to healthcare, inadequate hygiene practices, and preexisting health vulnerabilities. Infections acquired through contaminated mobile phones may lead to lost productivity, increased healthcare costs, and in severe cases, mortality. In developing countries, where sanitation and hygiene infrastructure are often inadequate, the public health implications of microbial contamination of mobile phones are profound. Mobile phones serve as a reservoir for pathogenic microbes, facilitating their dissemination within communities and across borders (Ulger *et al*., 2009). This is particularly concerning in densely populated urban areas and informal settlements, where close contact and poor hygiene practices prevail. The spread of AMR through contaminated mobile phones further complicates public health efforts. Developing countries are disproportionately affected by AMR due to limited regulation of antibiotic use and insufficient healthcare resources (World Health Organization, 2018). The potential for mobile phones to act as vectors for AMR

underscores the need for public awareness campaigns, improved hygiene practices, and regular disinfection of mobile phones.

Furthermore, the implications extend to economic productivity and public health systems. Outbreaks of foodborne and other communicable diseases associated with microbial contamination can strain healthcare systems, reduce workforce productivity, and hinder socioeconomic development. Interventions targeting mobile phone hygiene, such as public education and policy measures, are critical components of broader public health strategies in these regions.

### 2.5 Preventive Measures And Recommendations

The increasing awareness of mobile phones as potential vectors for microbial contamination has spurred interest in preventive measures. Implementing effective hygiene practices, public awareness campaigns, and technological innovations can significantly reduce the associated risks.

Promoting personal and environmental hygiene is essential to mitigate microbial contamination of mobile phones. Regular handwashing with soap and water, particularly before and after handling mobile phones, is a simple yet effective strategy to minimize microbial transfer (Centers for Disease Control and Prevention, 2021). The use of alcohol-based sanitizers to clean both hands and mobile phone surfaces has been shown to reduce bacterial loads significantly (Karabay *et al*., 2007).

Disinfection protocols should include the use of 70% isopropyl alcohol wipes or ultraviolet (UV) sanitizers to clean mobile phone surfaces regularly. Studies have demonstrated that UV-C light is effective in deactivating a wide range of microorganisms, including bacteria, viruses, and fungi, without damaging phone components (Górny *et al*., 2024). Institutions, particularly

hospitals and schools, should establish guidelines for routine cleaning of shared electronic devices to reduce the risk of cross-contamination.

Educational initiatives aimed at raising awareness about the risks associated with contaminated mobile phones are critical. Public health campaigns should emphasize the importance of hygiene practices and the potential consequences of neglecting device sanitation. Strategies may include:

- Infographics and videos on social media platforms demonstrating proper mobile phone cleaning techniques.
- School and workplace training programs on the risks of microbial contamination and methods to mitigate them.
- Collaborative efforts with mobile phone manufacturers and retailers to include informational materials on hygiene practices with new devices.

Research highlights the efficacy of targeted education in changing behaviors. For instance, a study in healthcare settings showed a marked reduction in device contamination after implementing staff training on phone hygiene (Brady *et al*., 2011). Extending similar campaigns to community settings can amplify their impact.

Technological advancements offer promising solutions to reduce microbial contamination on mobile phones. The integration of antimicrobial coatings on mobile phone surfaces is a notable innovation. Materials such as silver nanoparticles, copper, and zinc oxide exhibit broad-spectrum antimicrobial activity and can be incorporated into device casings and screens (Jones and Hoek, 2010). Touchless technologies, such as voice-activated commands and gesture-based controls, can minimize direct contact with devices, reducing the likelihood of microbial transfer (Jarl and Olsby, 2024). Additionally, advancements in self-cleaning surfaces using

photocatalytic materials like titanium dioxide provide continuous antimicrobial action under light exposure (Foster *et al*., 2020). Mobile phone sterilization devices utilizing UV-C light have also gained popularity as an accessible and effective method to maintain device hygiene. Portable UV-C sanitizers designed specifically for mobile phones offer a convenient option for regular disinfection, especially in high-risk environments such as hospitals, markets, and schools.

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1 Study Area

This study was conducted in selected markets in Benin City, the capital of Edo State, Nigeria. Benin City is one of the largest urban centers in the southern region of Nigeria, with an estimated population of over 1.5 million people. The City's economic activities are primarily concentrated in its various bustling markets, where a wide range of goods, including food, clothing, and household items, are sold. These markets are typically characterized by high foot traffic and crowded conditions, making them conducive environments for the transmission of microorganisms.

## 3.2 Sample Collection

A total of 10 market women were randomly selected from various markets across Benin City for the study. The selection was based on the willingness of the vendors to participate and their active involvement in the daily operations of the markets. Prior to sample collection, written informed consent was obtained from each participant, ensuring that they understood the purpose of the study and agreed to provide samples from their mobile phones. The mobile phones were swabbed using sterile cotton swabs moistened with 0.85% saline solution to collect microbial samples. The swabbing was conducted in a sterile manner to avoid cross-contamination, with particular attention paid to the surfaces that are most frequently touched, such as the screens and buttons. Each swab was carefully rubbed across the surface of the mobile phone, ensuring that the entire screen and other areas of contact were adequately sampled.

After collection, each swab was placed into a sterile tube containing 10 mL of nutrient broth to maintain the viability of the microorganisms during transportation. The samples were

transported to the microbiology laboratory under aseptic conditions and processed within 24 hours of collection to prevent the potential loss of viable bacterial organisms. The nutrient broth served to support the growth of a wide range of bacterial species during subsequent microbiological analysis.

### 3.3.Sterilization of Materials

Materials such as Petri-dishes, pipette, glass containers (conical flask, round bottom flask) and bottles were washed, drained and dried. They were wrapped with aluminum foil and sterilized in a hot-air oven at 160$^{o}$C for an hour. They were allowed to cool after sterilization before usage. An aseptic working environment was achieved with the use of Bunsen burner flame and disinfection of work surfaces with alcohol.

### 3.3.1 Preparation and Sterilization of media

Materials used include; Glass wares such as test tubes, beakers, conical flasks, Petri-dishes, McCartney bottles, Sterile cotton swabs, Sterile gloves, Normal saline, Sterile sampling containers, stirring glass rod and measuring cylinder. Media and Biochemical test reagents and Gram's staining kit . All glassware which include MacCartney bottles, Petri dishes, test tubes,conical flasks, measuring cylinders and pipettes, were sterilized at 160 $^{o}$C for 1 hr in a hot-air-oven before use. The media used in this study were sterilized at 121 $^{o}$C for 15 min in an autoclave. Agar media, agar slant and biochemical reagents were prepared freshly and refrigerated at 3-4 $^{o}$C. Aseptic conditions were ensured during inoculation and subculturing.

#### 3.3.1.1 Preparation of Nutrient agar

Twenty eight grams (28 g) of nutrient agar was dissolved in 1000 ml of distilled water in a conical flask corked with cotton wool and foil paper and allowed to dissolve in 1000 ml of distilled water in a conical flask. The medium will be the placed in an autoclave to sterilize it for 15 minutes at 121 °C. After sterilization, the flask will be allowed to cool.

#### 3.3.1.2 Preparation of Citrate agar

Twenty-four point twenty-eight (24.28)grams of agar was dissolved in 1000 ml distilled water and heated to boiling, to dissolve the medium completely. It was then mixed properly and distributed in conical flasks. The medium was sterilized by autoclaving at 15 lbs pressure (121 °C) for 15 mins and then left to cool before dispension on sterile petri dishes.

#### 3.3.1.3 Preparation of Triple Sugar Iron agar

A 64.6g of powder was dissolved in 1L of distilled water and then heated to properly dissolve the mixture. The mixture was autoclaved to sterilize the agar before it is dispensed into tubes and sterilized again at 121 °C for 15 mins. The agar was then left to solidify with short slant and good butts.

### 3.4. ENUMERATION AND ISOLATION OF BACTERIAL ISOLATES

Upon arriving at the laboratory, each swab sample was subjected to serial dilution followed by the pour plate method for isolating bacterial and fungal microorganisms. This method was employed to ensure accurate colony counts and to minimize overcrowding on the plates. The swab sample was transferred into a sterile test tube containing 9 ml of sterile normal saline. The mixture was vortexed to ensure proper homogenization. A series of tenfold dilutions were prepared by transferring 1 ml of the initial solution into a second test tube containing 9 ml of sterile saline, thereby producing a $10^{-1}$ dilution. This process was repeated to create further

dilutions ($10^2 10^3$, and $10^4$). The pour plate method was used to isolate microorganisms from the diluted samples.

For each dilution, the following steps were carried out: 1 ml of each dilution (from $10^{-1}$ to $10^{-4}$) was pipetted aseptically into sterile Petri dishes. Approximately 15-20 ml of molten agar (cooled to about 45°C) was poured into each Petri dish and gently swirled to ensure even distribution of the inoculum. Plates containing Nutrient Agar, were incubated at 37°C for 24-48 hours for the isolation of bacterial colonies.After the incubation period, distinct colonies were counted using a colony counter. The number of colony-forming units (CFUs) per milliliter was calculated based on the dilution factor.

$$\frac{cfu}{ml} = \frac{number\ of\ colonies\ x\ dilution\ fold/series}{volume\ of\ inoculum}$$

(Willey *et al.,* 2008).

### 3.4.1 Subculturing of Pure Isolates

After colony counting, well-isolated colonies with distinct morphologies were selected and subcultured onto fresh Nutrient Agar plates to obtain pure cultures. These pure cultures were then subjected to further identification tests, such as biochemical and morphological characterization.

## 3.5 BACTERIAL IDENTIFICATION

The bacterial isolates were characterized based on colonial morphological characteristics such as colony shape, size, elevation, optical activity, margination and pigmentation on nutrient agar and MacConkey agar. Biochemical tests were also carried out to further identify the bacterial isolates. The fungal isolates were identified using colonial morphological characteristics such as size, texture colour and reverse colour. These parameters were evaluated by physical

examination. Microscopy was also carried out using n-lactophenol cotton blue staining and a bright field microscope.

### 3.5.1 Gram staining

Smears of the bacterial isolates were prepared and heat fixed on clean grease free slides. The smears were stained for one minute with crystal violet. This was washed out with distilled water. The slides were flooded with dilute Grams' iodine solution for one minute. This was washed off with distilled water and the smears were decolorized with 95% alcohol for 30 seconds and rinsed off with distilled water. The smears were then counter stained with safranin solution for one minute. Finally, the slides were washed off with distilled water, air dried and observed under oil immersion objective.

### 3.5.2 Potassium Hydroxide (KOH) test

Two drops of 3% solution of KOH were applied on a clean glass slide and a loopful of pure bacterial growth was stirred in a circular motion in the slide. The loop was occasionally raised and observed for the presence of a string of the mixture. The solution was observed to be of a viscous and mucoid consistency indicating a Gram-negative bacterium. No reaction (absence of stringing) indicates a Gram-positive bacterium (Roberts and Sandle, 2008).

## 3.6. BIOCHEMICAL TEST

### 3.6.1 Catalase Test

This is a test to detect the presence or absence of catalase enzyme. The catalase enzyme catalyses the breakdown of hydrogen peroxide to release free oxygen gas and the formation of water. A few drops of freshly prepared 3% hydrogen peroxide were added onto the bacterial isolates smeared on a slide. The production of gas bubble indicated catalase enzyme positive.

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

### 3.6.2 Oxidase Test

A piece of filter paper was wet with a few drops of the dilute (1%) solution of oxidase reagent (tetramethyl-pphenylenediamine-dihydrochloride) which was prepared by standard procedure. A bit of growth from the nutrient agar slant was obtained using sterilized platinum wire loop and smeared on the wet piece of paper. Development of an intense purple color by the cells within 30 seconds indicates a positive oxidase test.

$$NH_2CO.NH_2 + H_2O \rightarrow 2NH_3 + CO_2$$

### 3.6.3 Citrate Utilization Test

This test is based on the ability of some organisms to utilize citrate as a sole source of carbon. This was carried out by inoculating the test organism in test tube containing Simon's citrate medium and this was incubated at 37°C for 24 - 48 hr. The development of deep blue colour after incubation indicates a positive result.

### 3.6.4 Indole Test

Indole test is performed to determine the ability of the organism to split tryptophan molecule into indole. This test is performed to help differentiate species of the family enterobacteriaceae. Kovac's reagent which contains hydrochloric acid, dimethyl-aminobenzaldehyde and amyl alcohol is used. The broth was inoculated with the test organism and incubated for 18 hours at 37°C. 5ml of Kovac's reagent was then added down the inner wall of the tube. Development of bright red colour at the interface of the reagent and the broth within seconds after adding the reagent was indicative of the presence of indole and a positive result.

### 3.6.5. Triple sugar iron (TSI) agar test

The Triple Sugar Iron (TSI) test is an ability to test an organism's capability to ferment sugars and to produce hydrogen sulphide ($H_2S$) or gas ($O_2$), or both. The test was used primarily to differentiate members of the *Enterobacteriaceae* family based on their sugar fermentation patterns and from other Gram-negative rods. An agar slant prepared of a TSI agar was used in carrying out this test in a sterile test tube at a slanted angle. The slanted medium was inoculated with TSA pure culture using a straight inoculation needle by stabbing first through the center to the bottom of the tube and streaking the agar slant's surface. After inoculations, the test tubes were covered with foil paper and left at an ambient temperature of 36°C to incubate for 24 hours. Reactions on test tubes were examined, and sugar fermentations were indicated by the production of $H_2S$, gas and a change in colours from red (alkaline) to yellow (acid). When an alkaline/acid (red top/yellow bottom) slant reaction appeared, it only indicated dextrose (glucose) fermentation. When an acid/acid (yellow top/yellow bottom) slant reaction appeared, it showed the fermentation of dextrose, lactose and/or sucrose. The appearance of an alkaline/alkaline (red top/red bottom) slant reaction represented the absence of sugar fermentation. The blackening of the medium in the slant indicated $H_2S$ production. Bubbles, cracks, or bottom-raised space in the slanted agar indicated gas production (formation of $CO_2$ and $H_2$) (Fawole and Oso, 2007)..

### 3.7 Antibiotic susceptibility test

The identified colonies of bacteria were used to determine the susceptibility and resistance of bacterial isolates, which were subjected to standard antibacterial susceptibility testing (AST) to decipher their resistance or susceptibility to common antibiotics used for treatment within the locality. The standard discs were produced by Oxoid, UK, which was used to execute the disc diffusion method employed in this study. For this assay, a fully grown bacterial culture (from 18-24 hours) was cultured on MHA. The inoculum corresponding to 1.5 x $10^8$ cells/ml McFarland standard was streaked using a sterile loop onto the MHA plates before the

introduction of antibiotic discs and were added with extreme care to the plates with the aid of sterile forceps. The susceptibility results were recorded after incubation for 24 hours at 37 ºC. Following the standard or rules of AST established in 2017 by CLSI (Clinical Laboratory Standards Institute). The inhibition zone around each disc (measured using a meter rule in diameter) was assessed and interpreted based on the 2020 CLSI standard as Resistant (R), Intermediate resistant (I) and Sensitive (S). The antibiotic discs used in the study with their corresponding codes and concentrations include

### 3.8. Multiple Antibiotic Resistance (MAR) Index

This index is obviously a good tool which identifies the region where the isolates were obtained. Whether they are from places of high or low risks or from arears where antibiotics are abused. This tool becomes necessary for health risk assessment. According to Davis and Brown (2016), an index of ≥ 0.2 and above is indicative of a 'high-risk' contamination source. In this study the MAR index was determined by employing the methods delineated by Chitanand *et al.* (2010). The formula below was used to decipher MAR index of bacterial isolates.

$$MAR\ index = \frac{y}{nx}$$

$$where\ y = number\ of\ resistance\ scored,$$

$$n = number\ of\ isolates\ and$$

$$x = total\ number\ of\ antibioitics$$

MAR index greater than 0.2 is indicative of the fact that the bacterium originated from areas where antibiotics have been abused (or regularly used) or worse still from areas of high-risk source of contamination.

# CHAPTER FOUR

## RESULTS

Table 4.1 presents the total bacterial counts (TBC) recorded on mobile phones belonging to selected market women in Benin City, Edo State. The bacterial counts are expressed in colony-forming units per cubic meter (CFU/m³). the count ranged from $1.70 \pm 0.02 \times 10^4$ CFU/m³ to $3.80 \pm 0.53 \times 10^4$ CFU/m³ for sample I and E respectively.

Table 4.2. Shows the result of the cultural, morphological and biochemical identification of the bacterial isolates. The characteristics were used for morphological identification of the isolates and these includes; shape, size, arrangement, cell type, colour and surface appearance of each isolates. The biochemical test conducted were Gram stain, Urease test, Citrate test, Indole test, Catalase, Lactose and gas formation test etc. Possible organism identified include , Samonella sp. *Escherichia coli,* *Bacillus* sp.*,* *Klebsiella* sp.*,* *Streptococcus* sp., *Staphylococus* sp. and *Enterococcus* sp.

Figure 4.1. present the percentage occurrence of bacterial species isolated from mobile phones of selected market women in Benin City, Edo State. *Staphylococcus* sp. exhibited the highest occurrence at 20%, *Streptococcus* sp. occurred at 16%, followed by *Escherichia coli* with 13%, *Salmonella* sp. accounted for 10%, *Enterococcus* sp. and *Bacillus* sp. were both moderately present, at 8% each, *Klebsiella* sp. showed the lowest percentage of occurrence at 5%.

Table 4.3 presents the results of the antibiotic sensitivity test performed on bacterial isolates obtained from mobile phones of market women. The results are represented as zones of inhibition (in millimeters) for each bacterial isolate against various antibiotics, classified into Resistant (R)**,** Intermediate (I)**,** and Sensitive (S**)** based on the zone size. *Echerichia coli,* Showed sensitivity to gentamicin and ofloxacin , demonstrated resistance to most antibiotics,

including cefotaxime and nitrofurantoin . *Staphylococcus* sp., exhibited sensitivity to ampicillin, levofloxacin and imipenem and was resistant to cefotaxime and nitrofurantoin. The antibiotic sensitivity patterns suggest that levofloxacin**,** gentamicin and imipenem are among the most effective antibiotics against the tested bacterial isolates, with notable resistance observed for cefotaxime and nitrofurantoin**.**

Figure 4.2: Shows the multiple antibiotic resistant (MAR) index of the bacterial isolates indicating the isolates with potential health implication. The MAR index ranged ranged from 0.3 to 0.5.

**Table 4.1.Total bacterial counts (CFU/$m^3$) on mobile phones of selected market women**

| SAMPLE | TOTAL BACTERIAL COUNT ($x10^4$ cfu/$m^3$) |
|---|---|
| Sample A | 1.90 ± 0.10 |
| Sample B | 3.23 ± 0.25 |
| Sample C | 2.70 ± 0.30 |
| Sample D | 3.30 ± 0.02 |
| Sample E | 3.80 ± 0.53 |
| Sample F | 3.67 ± 1.50 |
| Sample G | 2.4 ± 0.20 |
| Sample H | 3.37 ± 1.50 |
| Sample I | 1.70 ± 0.02 |
| Sample J | 3.30 ± 0.50 |

*Values are represented as mean ± standard deviation*

**Table 4.2. Cultural, morphological and biochemical tests of the bacterial isolates on mobile phones**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Shape | Irregular | Circular | Irregular | Irregular | Circular | Irregular | Circular |
| Size | Medium | Small | Medium | Medium | Medium | Medium | Medium |
| Colour | Cream | Cream | Cream | Golden yellow | Cream | Milky | Cream |
| Cell type | Rod | Rod | Rod | Rod | Cocci | Rod | Cocci |
| Cell arrangement | Disperse | Clusters | Disperse | Disperse | Disperse | Disperse | Disperse |
| Gram | - | + | - | - | + | - | + |
| KOH | + | - | + | + | - | + | - |
| Gas formation | + | - | + | + | - | - | - |
| Indole | - | - | - | + | - | - | - |
| Citrate | + | + | - | - | - | - | + |
| Oxidase | - | - | - | - | - | - | + |
| Catalase | + | + | + | + | + | + | - |
| $H_2S$ formation | + | + | - | - | - | - | - |
| Sucrose | + | + | + | + | + | + | + |
| Glucose | + | + | + | + | + | + | + |
| Lactose | + | - | - | + | + | + | + |
| TSI reaction (slant/butt) | A/A | (K/A) | K/A | A/A | A/A | A/A | A/A |
| Identity | *Salmonella* sp. | *Bacillus cereus* | *Klebsiella a* sp | *Escherichia coli* | *Staphylococcus* sp. | *Enterococcus* sp. | *Streptococcus* spp. |

KEY: +: Positive to test, -: Negative to test. A)acid; (K) alkaline; (G) gas production (bubble); ($H_2S$) hydrog

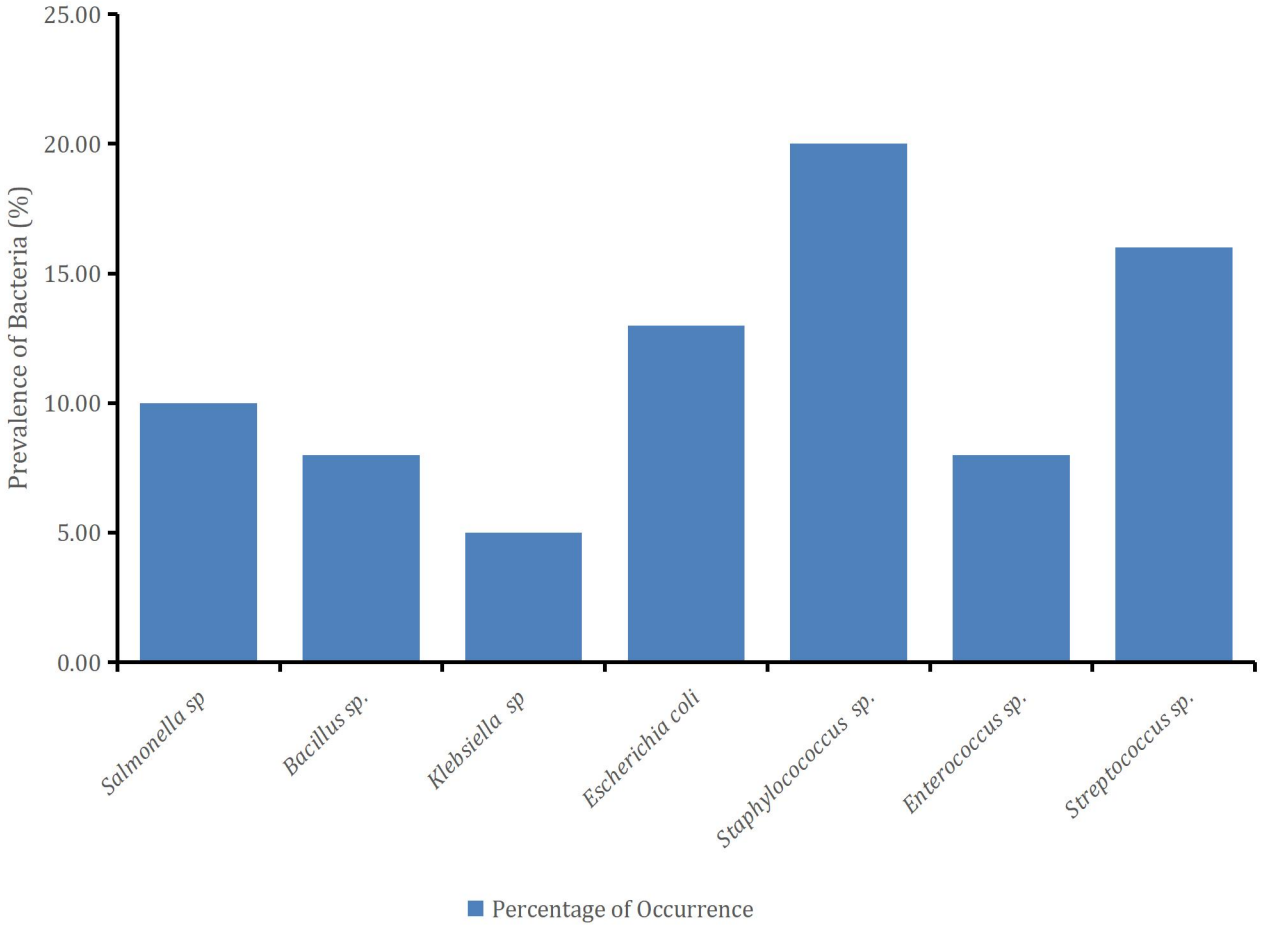


**Figure 4.1. Percentage frequency of occurrence of bacterial isolates on mobile phones of market women.**

**Table 4.3. Antibiotic sensitivity test on the bacterial isolates on mobile phones of market women represented as zones of inhibition measured in millimeters**

| ISOLATES | CTX | OFX | GEN | CFX | AMP | NIT | CFM | LEV | IPM | NAI |
|---|---|---|---|---|---|---|---|---|---|---|
| *Escherichia coli* | 3(R) | 18(S) | 22(S) | 10(R) | 16(I) | 0(R) | 9(R) | 16(I) | 10(R) | 16(I) |
| *Staphylococcus* sp. | 0(R) | 16(I) | 12(I) | 8(R) | 20(S) | 7(R) | 6(I) | 20(I) | 20(S) | 18(S) |
| *Klebsiella* sp. | 10(R) | 20(S) | 14(I) | 3(R) | 24(I) | 10(R) | 0(R) | 24(S) | 16(I) | 10(R) |
| *Samonella* sp. | 3(R) | 18(S) | 14(I) | 10(R) | 12(I) | 8(R) | 10(R) | 18(S) | 24(S) | 10(R) |
| *Streptococcus* sp. | 0(R) | 12(I) | 18(S) | 10(I) | 18(S) | 0(R) | 3(R) | 15(I) | 0(R) | 12(I) |
| *Bacillus cereus* | 9(R) | 16(I) | 14(I) | 6(R) | 12(I) | 7(R) | 10(R) | 9(R) | 14(I) | 17(S) |
| *Enterococcus* sp. | 3(R) | 14(I) | 20(S) | 10(R) | 24(I) | 12(I) | 10(R) | 18(S) | 16(I) | 10(R) |

KEY:

Resistance (R) = 0-10mm

Intermediate (I) = 11-16mm

Sensitive (S) = 17mm and above

CTX=cefotaxime, OFX=ofloxacin, GEN=gentamicin, CFM=cefixime, LEV=levofloxacin, IPM=imipenem, NAL=nalidixicacid, CFX=cefuroxime, AMP=ampicillin, NIT=nitrofurantoin

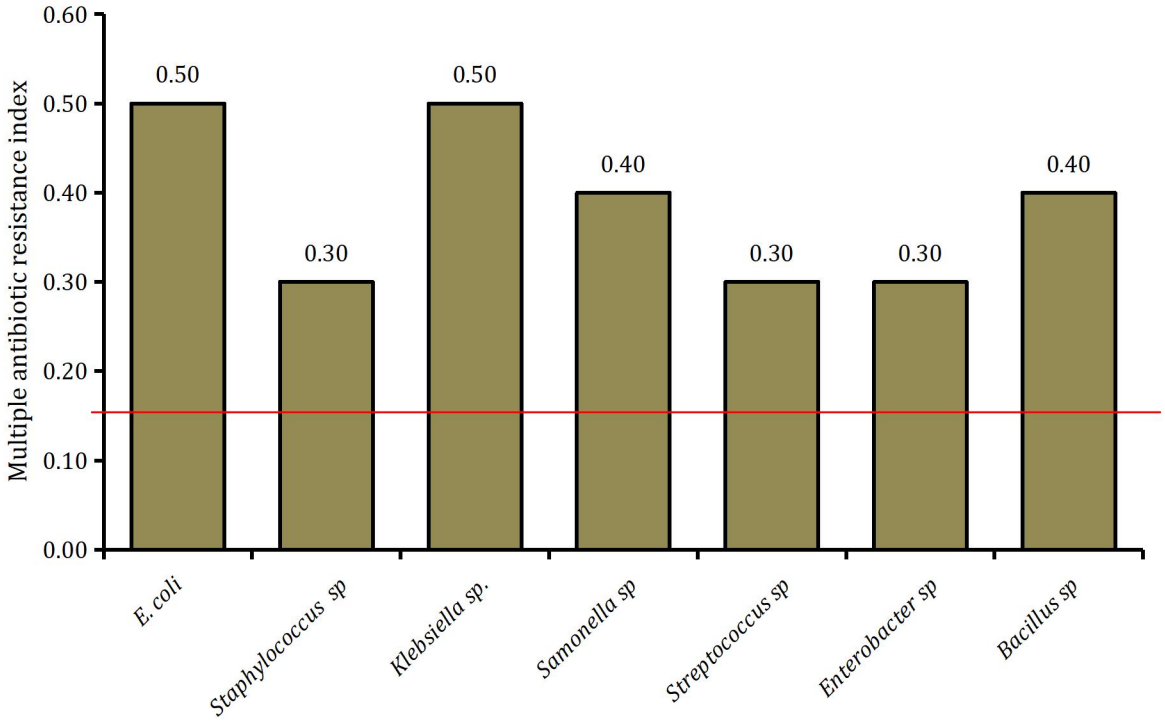


**Figure 4.2 Multiple antibiotics resistance index (MARI) of the isolates**

# CHAPTER FIVE

## 5.0. DISCUSSION

The total bacterial count (TBC) observed in this study reflects significant microbial contamination, with values ranging from $1.70\pm0.02\times10^4$ cfu/m³ to $3.80\pm0.53\times10^4$ cfu/m³. This variation underscores the differences in hygiene practices, environmental exposure, and frequency of mobile phone usage among market women. Market environments are typically characterized by poor sanitation, exposure to dust, food residues, and direct contact with money, which are all potential sources of microbial contamination.

Comparatively, previous studies have reported TBC values on mobile phones used by health workers, students, and food handlers, with similar ranges of contamination. For instance, Akinyemi *et al.* (2019) noted TBC values between $2.0\times10^4$ and $5.6\times10^4$ cfu/m³ on mobile phones used by food handlers in Lagos, Nigeria. These findings suggest that the level of bacterial contamination on mobile phones is influenced not only by the environment but also by the nature of activities conducted by the users. The elevated microbial load poses significant public health risks, particularly in markets where mobile phones are often used during food handling and sales, facilitating the transmission of pathogens. The results obtained in this study are however, contrary to the findings of Yusha`u *et a*l. (2010) who reported a gross contamination rate of both commercial and personal cell phones.

The bacterial isolates identified in this study include *Escherichia coli*, *Staphylococcus* sp., *Salmonella* sp., *Bacillus cereus*, *Klebsiella* sp., *Enterococcus* sp. and *Streptococcus* sp.. Each of these organisms carries significant health implications, particularly in environments with poor hygiene. The presence of *E. coli* on mobile phones is indicative of fecal contamination. *E. coli* is commonly associated with gastrointestinal infections, and its presence highlights the

likelihood of inadequate hand hygiene after using the toilet or handling contaminated materials. Similar findings have been reported in studies by Nworie *et al.* (2020), where *E. coli* was identified on mobile phones used in hospital and food service environments.

This genus, particularly *Staphylococcus aureus*, was the most frequently isolated bacterium in this study, accounting for 20% of the isolates. This corresponds with the findings of Famurewa and David, (2009) in which *Staphylococcus* was the most frequently encountered bacterial agent isolated. This may be because this type of bacterium increases in optimum temperature as phones are kept warm in pockets, handbags etc. the high occurrence of *Staphylococcus aureus* could be the fact that it is abundant in human body especially as a normal flora of the skin. It also contributes 50% nasal carriers in humans (Uabol-Egbenni, 2003). *Bacillus* sp. Known for its role in foodborne illnesses *Bacillus* sp. contamination points to environmental exposure, particularly in markets where food residues and dust are prevalent. *Salmonella* sp. and *Klebsiella* sp. are significant in both public health and clinical microbiology due to their association with foodborne outbreaks and opportunistic infections, respectively. The presence of *Salmonella sp.* is particularly concerning, as it is a leading cause of diarrheal diseases worldwide (Anyanwu *et al*., 2022). *Klebsiella* spp. could be the fact that it is present in the respiratory tract and faeces of about 5% normal individuals (Chesebrough, 2000). The occurrence of *Salmonella* species, in market women and being potential pathogens, could have been as a result of community acquired infections (Togoe *et al.,* 2011). Thus, these organisms could have come in contact with the cell phones through soil, clothing, food and hands of the users (Uabol-Egbenni, 2003). *Enterococcus* sp. and *Streptococcus* sp, though part of the normal microbiota, can cause severe infections, including urinary tract infections and respiratory illnesses, under certain conditions.

*Salmonella and Klebsiella* species are responsible for intestinal and respiratory infection, enteritis and stomach disorders (Garba, 2002). The role of these organisms in both nosocomial and community acquired infections have been well documented (Ekrakene and Igeleke 2007, Glodblatt et al., 2007, Akinyemi et al., 2007; 2009, Hota, 2004, Borer *et al.,* 2005, Brady *et al.*, 2006). The frequent handling of both the cell phones and money could also make it easy for cross contamination (Kawo *et al.,* 2008, Yusha`u *et al.,* 2010).

The antibiotic resistance patterns observed in this study further emphasize the public health challenges posed by microbial contamination on mobile phones. Resistance to commonly used antibiotics such as cefotaxime, nitrofurantoin, and ampicillin was evident, particularly among isolates of *Escherichia coli* and *Staphylococcus* sp.. Conversely, sensitivity to gentamicin and ofloxacin indicates that these antibiotics remain effective against some bacterial strains.

The multiple antibiotic resistance index (MARI) of 0.3 to 0.5 in the isolates signals significant prior exposure of these bacteria to antibiotics, likely due to misuse or overuse in human and veterinary medicine. High MARI values have been consistently linked to environments with heavy antibiotic use, such as hospitals and agricultural settings (Okeke *et al.,* 2020). The identification of multidrug-resistant strains highlights the potential for these bacteria to serve as reservoirs of resistance genes, which can be transferred to other bacterial populations through horizontal gene transfer mechanisms.

The contamination of mobile phones by pathogenic and antibiotic-resistant bacteria has far-reaching implications. These devices act as fomites, facilitating the transmission of pathogens within the community. Market women frequently handle food items such as vegetables, fruits, and grains, increasing the likelihood of transferring these bacteria to food products, ultimately exposing consumers to foodborne illnesses. Moreover, the emergence of antibiotic-resistant

bacteria on these devices exacerbates the challenge of treating infections. In a setting like Benin City, where healthcare access and sanitation infrastructure may be limited, the spread of resistant pathogens could lead to severe public health outcomes (Ogbonna *et al*., 2023).

The findings align with global and local studies on mobile phone contamination. A study by Tunc and Olgun, (2006), Okpalla *et al*. (2011), Shahaby *et al*. (2012), David *et al*. (2016) reported similar bacterial diversity on mobile phones used in public transport systems, emphasizing the ubiquity of this issue across different environments. Additionally, studies from India and Pakistan have highlighted the role of mobile phones in the dissemination of multidrug-resistant *Salmonella sp.* and *Klebsiella sp.*, corroborating the observations in this study (Kumar *et al.,* 2021; Ahmed *et al.,* 2020).

**Recommendations**

To mitigate the risks associated with microbial contamination on mobile phones, the following measures are recommended:

1. **Hygiene Education**: Market women should be educated on the importance of regular handwashing and cleaning of mobile phones using alcohol-based disinfectants.
2. **Policy Interventions**: Authorities should enforce stricter regulations on antibiotic use to curb the emergence of resistance.
3. **Routine Monitoring**: Periodic microbial assessments of mobile phones in high-risk environments can help identify and address contamination hotspots.

**Conclusion**

This study underscores the critical role of mobile phones as reservoirs for pathogenic and antibiotic-resistant bacteria. The high bacterial load and diversity observed call for urgent

public health interventions to mitigate the risks associated with microbial contamination. Improved hygiene practices, coupled with prudent antibiotic use, can significantly reduce the transmission of pathogens and enhance community health.

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