ISOLATION AND IDENTIFICATION OF BACTERIA ISOLATE FROM STUDENT LECTURE TABLES, FACULTY OF LIFE SCIENCE, UNIVERSITY OF BENIN.

By

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LSC2003107

UNIVERSITY OF BENIN

BENIN CITY

FEBRUARY 2025.

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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 **EMMANUEL CHUKWUEMEKA OGADI** with matriculation number **LSC2003107,** 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)

APPROVAL

This project work was carried out by **EMMANUEL CHUKWUEMEKA OGADI** with matriculation number **LSC2003107,** in partial fulfillment of the award of a Bachelor of Science, B.Sc. (Hons) degree in the Department of Microbiology, University of Benin, Benin City.

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Prof. Mrs. F.I AKINNIBOSUN **Date**

(Head of Department)

DEDICATION

This report is primarily dedicated to the Divine Providence 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.

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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.

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

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ABSTRACT

Lecture theatre tables serve as potential reservoirs for bacterial contamination, posing a risk of microbial transmission among students and staff. This study aimed to isolate and identify bacterial species from tables in lecture theatres within the Faculty of Life Sciences, University of Benin. Total heterotrophic bacterial counts were determined over two weeks, with values ranging from $1.88 \pm 1.00 \times 10^4$ cfu/cm² to $3.80 \pm 0.53 \times 10^4$ cfu/cm². The highest bacterial load was recorded in the Microbiology Lecture Theatre ($3.80 \pm 0.53 \times 10^4$ cfu/cm² in Week 2), while the lowest was observed in the Optometry Lecture Theatre ($1.88 \pm 1.00 \times 10^4$ cfu/cm² in Week **1)**. Biochemical characterization and standard taxonomic references identified six bacterial genera: *Staphylococcus, Streptococcus, Pseudomonas, Enterobacter, Escherichia coli,* and *Bacillus***.** Among these, *Staphylococcus* spp. (31%) exhibited the highest occurrence, while *Pseudomonas* spp. (10%) had the lowest. Antibiotic susceptibility testing revealed varying resistance patterns, with Bacillus spp. being the most sensitive, whereas *Pseudomonas* spp. and *Escherichia coli* displayed resistance to multiple antibiotics. The multiple antibiotic resistance (MAR) index ranged from 0.2 to 0.4**,** with *Pseudomonas* spp**.** and *Escherichia coli* exhibiting the highest resistance. The findings underscore the need for regular sanitation of lecture theatre surfaces to mitigate the risk of bacterial transmission and potential health implications.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The rapid spread of infectious diseases, particularly in educational institutions, continues to be a significant public health challenge. Fomites non-living objects or surfaces capable of carrying pathogens are a critical vector in the transmission of these diseases (Nuttall, 2023), especially in high-traffic environments such as lecture halls. Lecture tables in academic settings are major reservoirs for bacterial pathogens due to their frequent contact by students, staff, and visitors. These surfaces, when not regularly cleaned and disinfected, serve as conduits for the spread of infectious microorganisms across the university environment.

Bacteria present on lecture tables can originate from several sources, including human skin, clothing, bags, food, and even the air. The act of students and faculty members touching these surfaces with contaminated hands, or depositing microorganisms via coughs, sneezes, or bodily fluids, increases the microbial load on the tables. Additionally, students may inadvertently transfer microbial agents onto these surfaces from shared materials such as books, stationery, or electronic devices. Since lecture tables are used frequently throughout the day, microbial contamination can accumulate over time, posing a serious risk for the spread of infectious diseases (Ababneh *et al*., 2022).

Studies have demonstrated that various types of pathogenic bacteria, including *Escherichia coli*, *Staphylococcus aureus*, *Salmonella spp.*, and *Enterococcus faecalis*, are commonly found on fomites in public spaces (Otter *et al*., 2016;Abiose, 2019). Contamination can occur via direct contact with human skin, saliva, or bodily fluids. Additionally, improper cleaning and disinfection of surfaces contribute to the persistence

of bacterial pathogens, which can remain viable for extended periods on inanimate surfaces (Kramer *et al*., 2006).

Lecture tables, being high-touch surfaces, are likely to harbor a range of bacterial isolates. Studies have shown that surfaces like desks, chairs, and computers in classrooms and lecture halls are regularly contaminated with microorganisms, especially in settings where frequent physical contact occurs. A study by Ababneh *et al*. (2022) found that high-touched surfaces surfaces in a university campus were reservoirs for a range of pathogens, including *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella* spp. These pathogens can survive on hard surfaces for varying lengths of time, depending on environmental factors such as temperature and humidity (Kramer *et al*., 2024).

The presence of pathogenic bacteria on lecture tables poses significant public health risks, as these bacteria can be easily transmitted from person to person, especially in crowded environments like universities. Contaminated surfaces are responsible for the transmission of gastrointestinal, respiratory, and skin infections among students and staff. Pathogens such as *Staphylococcus aureus* and *Escherichia coli* are known to cause skin infections and gastrointestinal distress, respectively, which are common complaints in densely populated environments. Furthermore, outbreaks of nosocomial infections, particularly in educational institutions where students often have close physical interactions, can increase the burden on healthcare facilities.

The public health implications are further exacerbated by the irregular cleaning practices and inadequate disinfection protocols in educational institutions. A study by Russell *et al*. (2018) reported that the frequency and efficacy of cleaning practices significantly affect the microbial load on high-contact surfaces. Institutions with poor cleaning practices see higher bacterial counts on surfaces like desks, chairs, and computer keyboards, increasing the likelihood of infection transmission. The spread of antibiotic-resistant

bacteria, such as multi-drug-resistant *Staphylococcus aureus* (MRSA), also heightens concerns about the effectiveness of current infection control measures.

Given the significant public health implications, effective control measures are crucial to reducing the risk of bacterial transmission in lecture halls. Regular and thorough cleaning of high-touch surfaces like lecture tables is essential to minimize microbial contamination. In addition to surface cleaning, the implementation of effective disinfection protocols using disinfectants that are effective against a wide range of pathogens can significantly reduce bacterial loads on fomites.

The use of alcohol-based hand sanitizers and promoting proper hand hygiene among students and staff can further decrease the transmission of pathogens via fomites. In some cases, antimicrobial coatings on surfaces or the use of UV-C light for disinfection has been shown to reduce microbial contamination on frequently touched surfaces (Albertini *et al*., 2023). Moreover, educational campaigns to raise awareness about the importance of personal hygiene and maintaining clean environments in academic institutions are essential in controlling the spread of infections.

The presence of bacterial pathogens on lecture tables poses a significant public health concern in educational institutions. The sources of contamination are varied, and bacterial isolates such as *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella spp.* have been identified as common pathogens found on lecture tables. The persistence of these microorganisms due to irregular cleaning practices and inadequate disinfection presents ongoing challenges for infection control. Therefore, regular cleaning, proper hand hygiene, and the use of effective disinfection methods are essential to reduce the risk of infection transmission in university environments.

1.2 Aim and Objectives

The aim of this study was to identify bacterial isolates present on lecture tables in the Faculty of Life Sciences University of Benin, Benin City.

The specific objectives of this study were to:

1. enumerate, isolate, and identify the bacterial isolates present on the surface of lecture tables at the Faculty of Life Sciences University of Benin, Benin City.

2. determine the frequency and distribution of the bacterial isolates on the lecture tables.

3. determine the antibiotic susceptibility of the bacterial isolates.

CHAPTER TWO

LITERATURE REVIEW

2.1. Lecture Tables as Fomites

Lecture tables, as commonly used surfaces in educational settings, represent significant fomites non-living objects or surfaces capable of harboring and transmitting pathogens. Fomites play a crucial role in the transmission of infectious diseases, particularly in environments like schools and universities, where large numbers of individuals regularly come into contact with shared surfaces (Otter *et al*., 2016). In lecture halls, where students and faculty members engage in prolonged periods of contact with tables, these surfaces become prime reservoirs for bacterial pathogens.

Lecture tables, being high-contact surfaces, can accumulate a variety of microorganisms, including bacteria, viruses, and fungi, transferred through human touch, food, and personal items (Russell *et al*., 2018). The microbial load on lecture tables can vary depending on factors such as cleaning frequency, the number of people using the surfaces, and environmental conditions. Since students often place bags, books, and sometimes food items on tables, the surfaces can easily become contaminated with bacteria from skin, clothing, or objects that come into contact with them. Additionally, students may inadvertently transfer pathogens from external environments, such as public transport, adding to the contamination risk (Bauer *et al*., 2018).

Studies have demonstrated that lecture tables in educational institutions can harbor a wide range of bacterial pathogens. Pathogens like *Escherichia coli*, *Staphylococcus aureus*, and *Salmonella spp.* have been commonly isolated from surfaces in classrooms, lecture halls, and other high-traffic areas (Yasin *et al*., 2017). These bacteria are often associated with gastrointestinal, skin, and respiratory infections, underscoring the public

health risk posed by microbial contamination in educational settings (Mansouri *et al*., 2018). Furthermore, studies have shown that surfaces that are not regularly cleaned or disinfected are more likely to harbor higher bacterial loads (Barker *et al*., 2001).

The level of bacterial contamination on lecture tables is influenced by various factors. High-frequency contact with the surface, especially during lectures and study periods, increases the likelihood of microbial transfer (Garrett *et al*., 2009). The types of activities taking place in lecture halls, such as eating, writing, or touching electronic devices, also contribute to the accumulation of microorganisms. Additionally, the presence of poor hygiene practices, such as inadequate hand washing and irregular cleaning of surfaces, can exacerbate the microbial burden (Reynolds *et al*., 2005). The layout and ventilation of the lecture halls can also play a role in the persistence of bacteria on surfaces, with poorly ventilated spaces potentially contributing to a higher microbial load due to lower air exchange rates

The presence of pathogenic bacteria on lecture tables poses significant public health risks, especially in environments like universities where students, faculty, and staff are in close proximity. The bacteria found on these surfaces can cause a range of infections, from mild skin infections to more severe gastrointestinal or respiratory diseases (Udijono *et al*., 2024). Given that students often touch their faces, eyes, and mouths after contact with contaminated surfaces, there is an increased risk of transmission, which can lead to outbreaks of infections in academic settings. The spread of pathogens through common surfaces like lecture tables highlights the importance of regular cleaning and disinfection to minimize the risk of disease transmission.

Lecture tables, as fomites in educational institutions, are significant reservoirs for bacterial pathogens. The microbial contamination of these surfaces is influenced by factors such as the frequency of contact, cleaning practices, and the behaviors of

individuals in the environment. Given the public health risks associated with bacterial contamination, it is essential to implement regular cleaning protocols and promote good hygiene practices to reduce the likelihood of infection outbreaks in academic settings. Future research should focus on further understanding the types of pathogens found on lecture tables and the effectiveness of various disinfection strategies to mitigate the spread of infectious diseases in educational institutions.

2.2. Bacterial Contamination of Lecture Tables

Lecture tables in educational institutions, such as universities, are high-contact surfaces frequently used by students and staff during academic activities. These surfaces can act as reservoirs for various microorganisms, including pathogenic bacteria, due to consistent human contact and inadequate cleaning protocols. The health implications are significant, as bacteria present on these surfaces may include both harmless environmental flora and pathogens capable of causing infections (Neely and Maley, 2000; Reynolds *et al*., 2005).

2.2.1. Sources of Bacterial Contamination

The primary source of bacterial contamination on lecture tables is human contact. Human hands harbor diverse microbial populations, including normal skin flora, respiratory pathogens, and bacteria from fecal matter. Inadequate hand hygiene practices, such as failure to wash hands after activities like eating, sneezing, or using the restroom, contribute substantially to the transfer of bacteria onto table surfaces (Scott and Bloomfield, 1990; Otter and French, 2011). A study assessing bacterial contamination of frequently touched objects in public and hospital environments revealed the prevalence of potential pathogens, highlighting the significance of hand hygiene (Bhatta *et al*., 2018).

In addition to direct human contact, contamination can also occur through airborne transmission. Particles from coughing, sneezing, or even dust laden with bacteria can

settle on lecture tables, particularly in poorly ventilated lecture halls (Boone and Gerba, 2007). Environmental factors such as moisture from spilled drinks or sweat can create conducive environments for bacterial proliferation. Moisture and inadequate cleaning further enhance microbial survival and transmission risks on these surfaces (Kramer *et al*., 2006; Gerhardts *et al*., 2012).

Educational institutions are high-traffic environments where students and staff frequently interact with shared surfaces. This repeated and unmonitored usage amplifies the risk of bacterial contamination, particularly when hygiene practices are suboptimal. Studies have demonstrated that surfaces in public spaces with high foot traffic, such as hospitals and schools, often harbor bacteria capable of causing healthcare-associated infections (Boyce, 2007; Weber and Rutala, 2013).

Proper cleaning protocols, regular disinfection, and education on hand hygiene practices are critical measures to minimize the risk of microbial transmission in such settings. For instance, rigorous cleaning practices and targeted interventions have been shown to significantly reduce contamination levels on frequently touched surfaces in public and healthcare settings (Lopez *et al*., 2013; Sattar and Maillard, 2013).

2.3 Bacterial Associated With Lecture Tables

Lecture tables in university environments, such as those in the University of Benin, Benin City, Nigeria, are frequently touched surfaces and can serve as reservoirs for various microorganisms. These surfaces are often contaminated with pathogenic and non-pathogenic microorganisms introduced through contact with hands, books, bags, and other materials. Pathogens are biological agents capable of causing damage to their hosts directly through infection or indirectly via immune responses (Casadeval and Pirofski, 1999). The capacity of these organisms to cause disease is referred to as pathogenicity,

which is influenced by their virulence—the relative ability to inflict damage on the host (Casadeval and Pirofski, 1999).

Microorganisms associated with lecture tables include bacteria and fungi that are also commonly found on other high-touch surfaces such as toilet door handles. Examples include *Staphylococcus aureus*, *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Candida* spp., and *Klebsiella* spp. The presence of these pathogens underscores the importance of maintaining proper hygiene and sanitization practices in academic environments.

2.3.1. *Staphylococcus aureus*

Staphylococcus aureus is a Gram-positive bacterium frequently found on the skin and mucosal surfaces of humans. It can colonize inanimate objects, including lecture tables, where it can survive for extended periods. The presence of *S. aureus* on surfaces is often attributed to hand-to-surface transfer during table usage. Pathogenic strains of *S. aureus* are known to produce toxins and enzymes that enable them to evade immune responses and cause infections, ranging from mild skin conditions to life-threatening diseases such as pneumonia and sepsis (Ryan and Ray, 2004).

Recent studies have shown that *S. aureus* isolates from frequently touched surfaces exhibit high levels of antibiotic resistance, including methicillin-resistant *S. aureus* (MRSA), posing a significant public health challenge (Dancer, 2009).

2.3.2 *Escherichia coli*

Escherichia coli (commonly abbreviated as *E. coli*) is a Gram-negative, facultative anaerobic, rod-shaped bacterium found in the lower intestines of warm-blooded organisms (Singleton, 1999). While most *E. coli* strains are harmless and beneficial, pathogenic strains can cause serious illnesses such as food poisoning. The bacterium is

often used as an indicator of fecal contamination in environmental samples due to its ability to survive outside the body for limited periods (Corner *et al*., 2010).

Optimal growth occurs at 37°C, but some strains can tolerate temperatures as high as 49°C (Fotadar *et al*., 2005). Pathogenic strains of *E. coli* include Enterotoxigenic *E. coli* (ETEC) and Enterohemorrhagic *E. coli* (EHEC), which can cause severe diseases, particularly in vulnerable populations.

2.3.3 *Salmonella* spp.

Salmonella is a rod-shaped bacterium belonging to the Enterobacteriaceae family. It includes two species, *Salmonella enterica* and *Salmonella bongori*, both of which can cause illnesses such as typhoid fever and foodborne salmonellosis (Fabrega, 2013). These bacteria are facultative anaerobes that derive energy from organic compounds and are capable of surviving in various environments. Infections are typically transmitted through contaminated food or surfaces. *Salmonella* can be identified by its ability to produce hydrogen sulfide, which can be detected on selective media like triple sugar iron agar.

2.3.4 *Klebsiella* spp.

Klebsiella is a genus of non-motile, Gram-negative bacteria characterized by a prominent polysaccharide capsule that enhances its virulence (Ryan and Ray, 2004). These bacteria are ubiquitous and associated with a range of infections, including pneumonia, urinary tract infections, and septicemia (Podshin and Ullmann, 1998). *Klebsiella* species are commonly isolated from environmental samples, including lecture tables, due to their ability to survive in diverse conditions. Their presence highlights the need for regular cleaning and disinfection of high-touch surfaces in academic settings.

3.2.5. *Pseudomonas aeruginosa*

Pseudomonas aeruginosa is a Gram-negative, opportunistic pathogen known for its resistance to antibiotics and ability to form biofilms on surfaces. It is commonly found in soil, water, and on inanimate objects. This organism is a significant cause of hospital-acquired infections and can survive on surfaces such as lecture tables due to its environmental adaptability (Schroder *et al*., 2002). *P. aeruginosa* is capable of causing respiratory and urinary tract infections, particularly in immunocompromised individuals.

2.3.6. *Bacillus* spp.

Members of the genus *Bacillus* are Gram-positive, spore-forming bacteria widely distributed in the environment. They are frequently isolated from surfaces and are known for their resilience to adverse environmental conditions due to spore formation. *Bacillus subtilis* and *Bacillus cereus* are commonly associated with contaminated lecture tables. *B. cereus*, in particular, is a foodborne pathogen known to cause gastrointestinal illnesses (Granum and Lund, 1997).

2.3.7. *Micrococcus luteus*

Micrococcus luteus is a Gram-positive coccus that is part of the normal flora of the skin and mucosa. It is often introduced to lecture tables via hand contact. Although it is typically non-pathogenic, *M. luteus* can cause opportunistic infections in immunocompromised individuals. Its ability to form biofilms allows it to persist on surfaces for extended periods (Wieser *et al*., 2002).

2.4. Health Risks And Implications

The presence of pathogenic bacteria on lecture tables in the University of Benin poses significant health risks, particularly due to the high frequency of contact these surfaces experience. When individuals come into contact with contaminated lecture tables, they can easily transfer bacteria to other parts of their body, such as the mouth, eyes, or nose, or to open wounds. This process increases the likelihood of infections, ranging from minor skin conditions to severe systemic illnesses (French *et al*., 2004).

Bacteria on lecture tables are transmitted primarily through direct contact. Once transferred to the hands, these microorganisms can be spread to other surfaces or mucous membranes, facilitating the transmission of pathogens (Aiello and Larson, 2002). The risk is heightened in environments like lecture halls, where many individuals may not practice adequate hand hygiene, leading to increased potential for contamination. Universities and other educational settings experience high traffic, making it difficult to ensure consistent hygiene practices, which further exacerbates the risk of bacterial transmission.

Certain bacteria commonly found on communal surfaces, such as *Staphylococcus aureus* (including methicillin-resistant strains [MRSA]), *Escherichia coli* and *Klebsiella pneumoniae,* pose particular health threats in such environments. Vulnerable populations, such as individuals with compromised immune systems or underlying conditions, are at increased risk of infection. Infections caused by these pathogens can range from localized skin infections to more severe outcomes, including respiratory and gastrointestinal illnesses (Best *et al*., 2012).

Multidrug-resistant organisms such as MRSA and carbapenem-resistant *Klebsiella pneumoniae* present significant challenges in controlling infections in educational

institutions. These bacteria are resistant to many commonly used antibiotics, complicating treatment (Donskey, 2004). Lecture tables and other high-contact surfaces in such settings can act as fomites, serving as vehicles for the transmission of resistant bacteria. The global threat posed by antimicrobial resistance (AMR), as highlighted by the World Health Organization (WHO), emphasizes the critical need for robust infection prevention strategies in communal spaces (WHO, 2017).

In addition to health risks in educational settings, contamination of communal surfaces in public spaces such as schools, offices, and transportation hubs underscores the importance of proper hygiene practices. Studies have shown that bacterial contamination on frequently touched surfaces can lead to community-acquired infections. Organisms like *Escherichia coli, Pseudomonas aeruginosa,* and *Enterococcus faecalis* are commonly detected on public surfaces and have been implicated in gastrointestinal and respiratory infections (Gerhardts *et al*., 2012).

Students in educational institutions such as schools and universities are particularly vulnerable to bacterial infections due to frequent contact with contaminated surfaces and the likelihood of poor hygiene practices. Outbreaks of illnesses caused by pathogens such as *E. coli* are common in settings where surface sanitation is inadequate (Aiello and Larson, 2002). Addressing these risks requires proactive measures, including regular cleaning, promotion of hand hygiene, and education on proper sanitation practices to mitigate the spread of harmful microorganisms.

2.5. Microbial Contamination of Fomite In Public Spaces

Microbial contamination in public spaces such as schools, hospitals, offices, and other communal environments is an ongoing concern, particularly with respect to the transmission of pathogenic microorganisms. Public spaces, being frequently accessed by

large numbers of individuals, often provide ideal conditions for the proliferation of microbes. The presence of bacteria, viruses, fungi, and other pathogens in these areas poses significant health risks, contributing to the spread of infectious diseases.

Microbial contamination is ubiquitous in public spaces, with high-touch surfaces such as tables, chairs, door handles, handrails, elevator buttons, and public transportation seats being primary sites for bacterial colonization. Research consistently shows that areas with frequent human interaction are more likely to harbor potentially harmful microorganisms (Burge *et al*., 2000). Schools, hospitals, and offices are particularly vulnerable, as they often have large numbers of people in close proximity to each other, leading to an increased likelihood of cross-contamination.

Hospitals and healthcare settings are especially prone to microbial contamination, with surfaces being contaminated by patient bodily fluids, medical instruments, and healthcare worker hands, potentially resulting in nosocomial infections. A study by (Dancer, 2007) highlighted the significant bacterial contamination in hospital environments, with high-touch surfaces like door handles, bedrails, and phones showing heavy microbial loads, including multidrug-resistant organisms.

Several factors contribute to the microbial presence in public spaces. Human activity plays a central role in the contamination of surfaces, as microorganisms are easily transferred from one person to another via touch, coughing, sneezing, or respiratory droplets. The skin, mucous membranes, and respiratory tracts of individuals are potential reservoirs for a wide range of bacteria, viruses, and fungi. As individuals move through public spaces, they may inadvertently introduce these pathogens to surfaces, where they can persist for varying lengths of time, depending on the microorganism and environmental conditions (Pillai *et al*., 2020).

Environmental conditions, such as temperature, humidity, and airflow, also influence microbial survival and proliferation. Bacteria such as *Escherichia coli* and *Staphylococcus aureus* thrive in warm and moist environments, often found in areas like bathrooms, kitchens, and cafeterias. Studies by Reichel *et al*. (2014) have shown that microorganisms can survive on surfaces for extended periods, particularly when the environment is conducive to their growth.

Additionally, the cleaning and disinfection habits of individuals and maintenance staff in public spaces play a crucial role in determining the microbial load. Inadequate cleaning practices, insufficient use of disinfectants, or irregular cleaning schedules can allow for the accumulation of pathogens on surfaces, which are then easily transferred to individuals. Research by Hall *et al*. (2017) demonstrated that despite routine cleaning in schools and offices, certain surfaces continued to exhibit high levels of microbial contamination, primarily due to inconsistent or inadequate cleaning techniques.

Numerous studies have assessed bacterial contamination on surfaces in public spaces, emphasizing the importance of high-touch surfaces as reservoirs for pathogens. A study by Morley *et al*. (2011) investigated bacterial contamination on office desks and computers, finding significant bacterial presence, particularly on keyboards and mouse devices, which are frequently touched by multiple people. Similarly, an investigation by Bhatta *et al*. (2011) in Nepal focused on the microbial contamination of door handles in public buildings, demonstrating that these surfaces were heavily contaminated with pathogens such as *Staphylococcus aureus*, *Enterococcus faecalis*, and *Pseudomonas aeruginosa*. The findings highlighted the role of door handles in the transmission of infectious agents in public spaces, particularly in hospital settings.

Some studies have reported that indoor formites such as desks, chairs, walls, and floors are the most common contaminated surfaces. Research in classrooms at the University of

Oregon identified several types of bacteria contaminants, including *Lactobacillus, Corynebacterium, and Staphylococcus on chairs; Streptococcus, Brevundimonas, and Candidatus phytoplasma on desks; Alicyclobacillus, Chroococcidiopsis, and Rhodopseudomonas* on walls; and *Roseomonas* and *Salmonella* on floors. These pathogenic bacteria causing mild to severe diseases include pneumonia, meningitis, and osteomyelitis (Stanley *et al*., 2020). A study by Udijono, *et al*. (2024) explored bacterial contamination in schools, focusing on commonly touched surfaces such as desks and chairs. The results indicated that although surfaces were frequently cleaned, bacteria such as *Streptococcus pneumoniae* and *Staphylococcus* species were still present, likely due to the high turnover of individuals and the limited effectiveness of cleaning measures. In contrast, a study conducted by Zhang *et al*. (2018) in a hospital setting revealed that surfaces like bed rails, call buttons, and light switches were contaminated with a range of pathogenic bacteria, including methicillin-resistant *Staphylococcus aureus* (MRSA) and *Clostridium difficile*. The research demonstrated the link between contaminated surfaces and the spread of hospital-acquired infections (HAIs), emphasizing the need for more stringent disinfection practices.

Another study held by Nworie *et al.* (2012) recognized that the increased incidence of outbreaks of certain diseases and its rate of spread from one community to the other had become a major health concern. The sample collected from the Door handles/knobs of public conveniences of selected public offices, motor parks, and markets in Abuja metropolis were investigated for bacterial contamination. Total of 180 swab samples cultured, 156 (86.7%) were positive. Most of the bacteria contaminants were coliforms. The isolated bacterial contaminants were *Staphylococcus aureus* (30.1%), *Klebsiella pneumoniae* (25.7%), *Escherichia coli (*1%), *Enterobacter* species (11.2%), *Citrobacter* species (7.1%), *Pseudomonas aeruginosa* (5.9%), and *Proteus* species (4.5%). This

shows that the city's convenient places harbours highly pathogenic bacteria which have the potentials of causing epidemics in the near future.

The prevalence of bacterial organisms on door handles in secondary schools in Bokkos Local Government; Jos Plateau State, Nigeria was evaluated by Maori *et al*. (2011). A total of 120 samples were collected and cultured, 40 from each of the schools (Government Secondary School Bokkos (G. S. S.B), All Nation Academy and Government secondary School Mushere). Out of the 120 samples that were collected 60(50%) yielded growth and 60 showed no growth at all. The following organisms were isolated *Staphylococcus* spp. (43.3%), *Candida* spp. (10%), *Escherichia coli* (16.7%), *Citrobacter* spp. (1.7%), *Klebsiella* spp. (20%), *Proteus* spp. (6.7%) and *Salmonella* spp. (1.7%). The result showed that G. S. S. B has the highest contamination (48.3%) followed by All Nations Academy (30%) and then G. S. S. M (21%).

The microbial contamination of public spaces is a pressing issue, with surfaces such as tables, chairs, and door handles serving as common vectors for pathogen transmission. Human activity, environmental factors, and cleaning practices all play vital roles in the presence and persistence of microbes in these spaces. Previous studies have consistently shown that despite cleaning efforts, high-touch surfaces remain a significant source of bacterial contamination. To reduce the risk of infection, it is crucial for public spaces, particularly hospitals and schools, to implement regular and effective cleaning protocols, combined with proper hygiene practices and public education on preventing the spread of infectious diseases.

2.6. Preventive Measures of Bacterial Contamination On Lecture Tables

Bacterial contamination on lecture tables is a significant concern in educational environments, as these surfaces come into contact with numerous students, potentially

facilitating the spread of harmful bacteria. Given the high frequency of contact with hands, bags, and books, lecture tables are a primary source of microbial transmission within classrooms. Effective preventive measures are necessary to minimize the risk of bacterial contamination and protect public health. Below are some key strategies for preventing bacterial contamination on lecture tables:

2.6.1. Regular Cleaning and Disinfection

One of the most effective measures to prevent bacterial contamination is frequent cleaning and disinfection of lecture tables. Surfaces should be wiped down with antibacterial or disinfectant wipes at regular intervals, particularly after each class. This reduces the microbial load and eliminates potential pathogens that may be transferred from one individual to another. According to Kramer and Assadian, (2014), frequent disinfection of surfaces can significantly lower the presence of harmful bacteria like *Escherichia coli* and *Staphylococcus aureus* on high-touch areas, including lecture tables.

2.6.2. Use of Antimicrobial Coatings

Another preventive measure is the application of antimicrobial coatings to lecture tables. These coatings are designed to kill or inhibit the growth of bacteria on the surfaces. Studies such as those by Schmidt, (2020) have demonstrated that antimicrobial surface coatings can reduce bacterial survival on surfaces for extended periods, decreasing the likelihood of cross-contamination. Materials such as silver-infused coatings or copper surfaces have been shown to possess antibacterial properties, offering a proactive solution to contamination.

2.6.3. Hand Hygiene Promotion

Ensuring proper hand hygiene among students and staff is another crucial preventive measure. As bacteria are often transmitted through hands, promoting regular handwashing or the use of alcohol-based hand sanitizers can significantly reduce the spread of harmful microorganisms. Educational institutions can make hand sanitizers available in classrooms and other high-contact areas, as recommended by WHO (2020). The implementation of hand hygiene policies in schools, including reminders to wash hands after touching communal surfaces, is an essential step in reducing the risk of bacterial contamination.

2.6.4. Minimizing Direct Contact with Surfaces

Encouraging students to avoid direct contact with lecture tables whenever possible can further reduce bacterial contamination. This can be achieved by using personal items such as books, notebooks, or trays to shield direct contact with the surface. For instance, placing a personal item between the table and the hands can prevent the transfer of bacteria from the skin to the surface. DeFlorio *et al.* (2021) found that reducing physical contact with contaminated surfaces through protective barriers can reduce the risk of bacterial transmission.

2.6.5. Environmental Controls

Proper ventilation and air quality control in classrooms play a vital role in minimizing the airborne transmission of bacteria. Ventilated spaces help disperse the accumulation of airborne pathogens that might settle on surfaces, including lecture tables. According to *Dancer (2014)*, maintaining an optimal level of air circulation through open windows or HVAC systems reduces microbial load. This reduces the potential for bacteria to settle on lecture tables and other furniture, further decreasing contamination risks.

2.6.6. Awareness and Education

Raising awareness among students and staff about the importance of preventing bacterial contamination on lecture tables is key. Educational campaigns that highlight the role of cleanliness, personal hygiene, and proper disinfecting protocols can create a more conscientious approach to maintaining a cleaner classroom environment. Regular seminars, posters, and class discussions on proper hygiene practices can increase the likelihood of adherence to preventative measures.

2.6.7. Monitoring and Surveillance

Ongoing monitoring of bacterial contamination levels on lecture tables is crucial for evaluating the effectiveness of preventive measures. Regular microbiological testing of lecture tables can help identify high-risk areas and determine whether current cleaning and disinfecting protocols are sufficient. Institutions can implement routine swabbing and bacterial culture methods, as suggested by Reddy *et al*. (2019), to track the effectiveness of cleaning efforts and adjust strategies as needed.

Bacterial contamination on lecture tables poses a significant public health risk in educational environments. By implementing comprehensive preventive measures, including regular cleaning, antimicrobial coatings, hand hygiene, environmental controls, and awareness campaigns, institutions can effectively minimize the spread of harmful bacteria. Continued vigilance through monitoring and education is essential for maintaining a safe and hygienic environment for students and staff alike.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The study was conducted in various lecture halls within the Faculty of Life Sciences at the University of Benin, Benin City, Edo State, Nigeria. The selected lecture halls were chosen based on high student activity and frequent usage of the lecture tables by both students and staff. These high-traffic areas were expected to exhibit microbial contamination due to the regular contact with surfaces by individuals throughout the academic day.

3.2 Sample Collection

Samples were collected from lecture tables in five lecture halls within the Faculty of Life Sciences at the University of Benin. Sterile cotton swabs moistened with normal saline were used to swab high-contact areas of the tables, such as the writing surface and edges. Sampling occurred once a week for two consecutive weeks, during peak hours (8:00 AM to 12:00 PM) when lecture activity was highest. Each sample was placed in a sterile container, labeled with relevant details (lecture hall, date, and time), and transported to the microbiology laboratory within one hour for 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

Sixty-four point six (64.6) g 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. Biochemical tests were also carried out to further identify the bacterial isolates.

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.

3.5.3 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.

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

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

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

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

It is a general established rule that MAR index greater than 0.2 is indicative of the fact that the bacterium originates 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 heterotrophic bacterial count ($\times 10^4$ cfu/cm^2) for tables in lecture theatres in the Faculty of Life Sciences, University of Benin, over two weeks. A range of bacterial counts of $1.88 \pm 1.00 – 3.37 \pm 0.55 \times 10^4$ cfu/cm^2 and $2.17 \pm 0.12 – 3.80 \pm 0.53 \times 10^4$ cfu/cm^2 was recorded in Week 1 and Week 2, respectively. The Microbiology Lecture Theatre (MLT) recorded the highest bacterial count in Week 2 ($3.80 \pm 0.53 \times 10^4$ cfu/cm^2), while the Biochemistry Lecture Theatre (BLT) had the highest count in Week 1 ($3.37 \pm 0.55 \times 10^4$ cfu/cm^2). The Optometry Lecture Theatre (OLT) consistently recorded the lowest bacterial counts across both weeks, ranging from $1.88 \pm 1.00 \times 10^4$ cfu/cm^2 in Week 1 to $2.17 \pm 0.12 \times 10^4$ cfu/cm^2 in Week 2.

Table 4.2. shows the biochemical test for identification of microorganisms isolated from lecture table in the Faculty of Life sciences, University of Benin, Benin City. from the results, it was shown that three Gram positive bacteria and three Gram-negative bacteria were isolated from the tables in the lecture theatre. Detailed tests and observations including their growth features, biochemical reactions and sugar utilization as well as a crosscheck with existing Taxa in standard manuals Bergey's manual of determinative bacteriology and manual for identification of medical bacteria led to their identification as species of *Staphylococcus*, *Streptococcus*, *Pseudomonas*, *Enterobacter*, *Escherichia* coli, and *Bacillus*.

Table 4.4. shows the occurrence of bacteria isolates in lecture table in the Faculty of Life sciences, University of Benin, Benin City. Several species of bacteria were isolated from the different machines. The isolates were found to have varying percentages of occurrence including *Staphylococcus* sp with an occurrence of 31%, *E.coli* 12%,

Enterobacter spp. 20%, *Streptococcus* sp. 18% and *Bacillus* spp. 14%, while *Pseudomonas* sp. recorded 10% occurrence.

Table 4.5 shows the susceptibility pattern of bacterial isolates. The isolates displayed varying degrees of sensitivity and resistance to the tested antibiotics. *Bacillus* sp. was the most sensitive isolates. *Pseudomans* sp. and ***Escherichia coli*** exhibited resistance to some of the test antibiotics

Figure 4.2. shows the multiple antibiotics resistance index of the bacterial isolates. The resistance index ranged from 0.2 to 0.4 The highest resistance index was recorded for *Pseudomans* sp. and *Escherichia coli.*

Table 4.1: Total Heterotrophic Bacterial Count X 10^4 (cfu/ml) from Lecture Tables.

Bank	Week 1	Week 2
ALT	2.63 ± 0.29	3.26 ± 0.22
MLT	3.30 ± 0.17	3.80 ± 0.53
BLT	3.37 ± 0.55	3.10 ± 0.43
OLT	1.88 ±1.00	2.17 ± 0.12
PLT	2.03± 0.03	3.13 ± 0.07

KEY

ALT: Animal and Environmental Biology Lecture theatre

MLT: Microbiology Lecture theatre

BLT: Biochemistry Lecture theatre

OLT: Optometry Lecture theatre

PLT: Plant Biology and Biotechnology Lecture theatre

Table 4.2: Cultural, Morphological, and Biochemical Charateristic of the Bacterial Isolate

Elevation	Raised	Flat	Flat	Raised	Flat	Flat
Margin	Entire	Undulate	Entire	Undulate	Entire	Undulate
Color	Cream	Cream	Yellow	Green	White	Cream
Shape	Circular	Irregular	Circular	Irregular	Circular	Irregular
Size	Medium	Large	Medium	Medium	Small	Large
Gram Stain	+	-	-	-	+	+
Cell Type	Cocci	Rod	Rod	Rod	Cocci	Rod
Arrangement	Clusters	Disperse	Disperse	Disperse	Chains	Disperse
Color (Gram Reaction)	Purple	Pink	Pink	Pink	Purple	Purple
KOH String Test	-	+	+	-	-	-
Catalase	+	+	+	+	-	+
Indole	-	+	-	-	-	-
Citrate	-	-	+	+	-	+
Oxidase	-	-	-	+	-	-
Glucose	+	+	+	+	+	+
Sucrose	+	-	+	-	+	+
Lactose	+	+	+	-	+	+
Gas Formation	-	+	+	-	-	-
H_2S Formation	-	-	-	-	-	-
TSI (Slant/Butt) Reaction	K/A	A/AG	A/A	K/AG	A/A	A/A
Identity	*Staphylococcus* sp.	*E. coli*	*Enterobacter* sp.	*Pseudomonas* sp.	*Streptococcus* sp.	*Bacillus* sp.

Key: (-) negative test; (+) positive test; (A) Acid; (K) Alkaline; (G) Gas production (bubbles); (H_2S) Hydrogen sulphide (black precipitate); (KOH) Potassium hydroxide test; (TSI) Triple sugar iron test

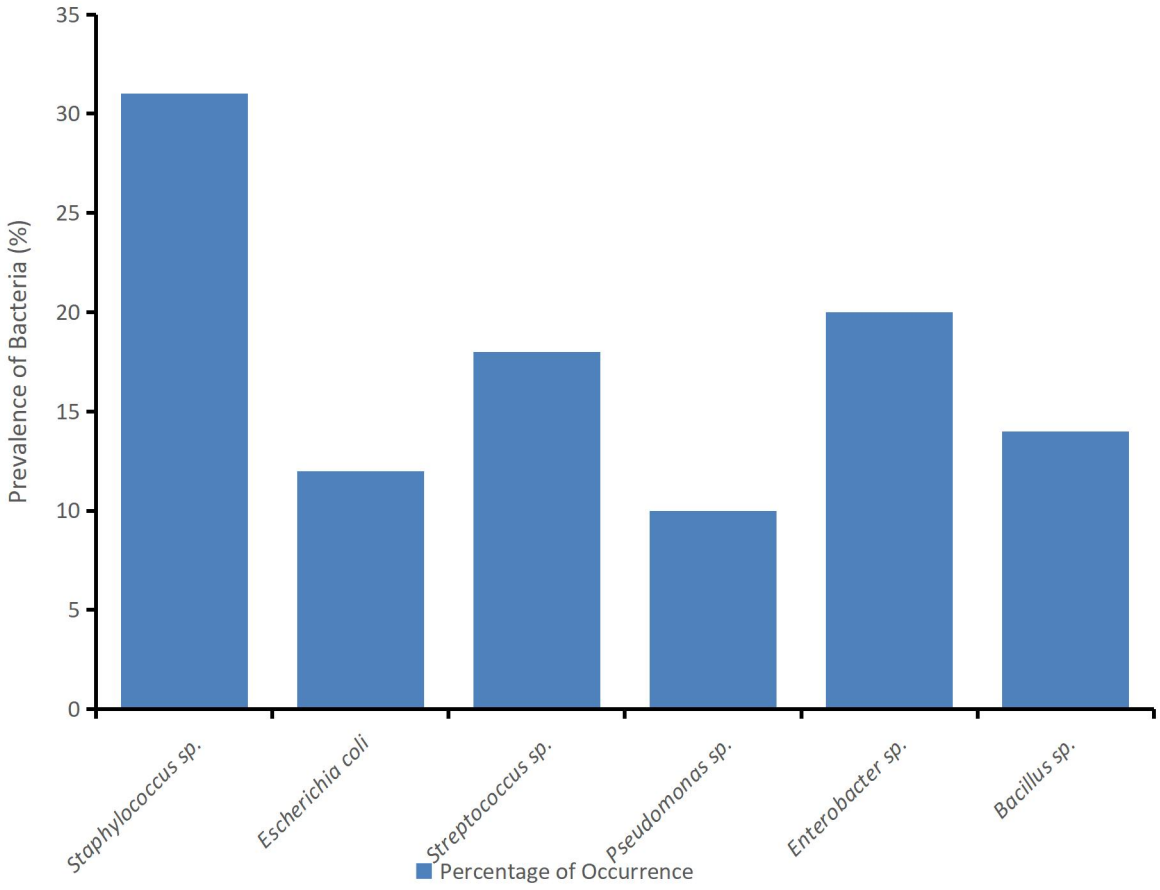

Figure 4.1: Percentage frequency of occurrence of bacteria isolates in Lecture Tables In The Faculty of Life Sciences, University Of Benin, Benin City

Table 4.3. Antibiotics Susceptibility of bacteria Isolates from Lecture Tables.

Bacteria isolates	**Antibiotics (Zone of Inhibition [mm])**									
	PEF	**CN**	**APX**	**Z**	**AM**	**R**	**CPX**	**AZ**	**LEV**	**E**
Gram positive										
***Streptococcus* sp.**	18(S)	16(S)	10(R)	14(I)	10(R)	10(R)	16(S)	18(S)	22(S)	18(S)
Bacillus cereus	22(S)	22(S)	12(I)	10(R)	10(R)	20(S)	22(S)	14(I)	18(S)	16(S)
***Staphylococcus* sp**	16(S)	10(R)	12(S)	9(R)	6(R)	16(S)	16(S)	12(I)	18(S)	20(S)
Gram negative	**LEV**	**CF**	**SP**	**CPX**	**AM**	**AU**	**CN**	**PEF**	**OFX**	**AZ**
Escherichia coli	18(S)	9(R)	8(R)	18(S)	9(R)	10(R)	16(S)	16(I)	18(S)	18(S)
***Pseudomonas* sp.**	24(S)	6(R)	10(R)	14(I)	6(R)	10(R)	12(I)	16(I)	18(S)	20(S)
***Enterobacter* sp.**	18(S)	16(S)	0(R)	10(R)	10(R)	16(S)	18(S)	18(S)	16(I)	16(I)

Resistant (R)= 0-10mm

Intermediate (I) = 11-16mm

Sensitive (S) =17mm and above

KEY: Resistance (R) = 0-10mm, Intermediate (I) = 11-16mm, Sensitive (S) = 17mm and above, PEF: Pefloxacin, CN: Gentamycin, APX: Ampiclox, Z: Zinnacef, AM: Amoxacillin, R: Rocephin, CPX: Ciprofloxacin, E: Erythromycin, LEV: Levofloxacin, AZ: Azithromycin, CF: Cefotaxim, SP: Saprifloxacin, OFX: Ofloxacin

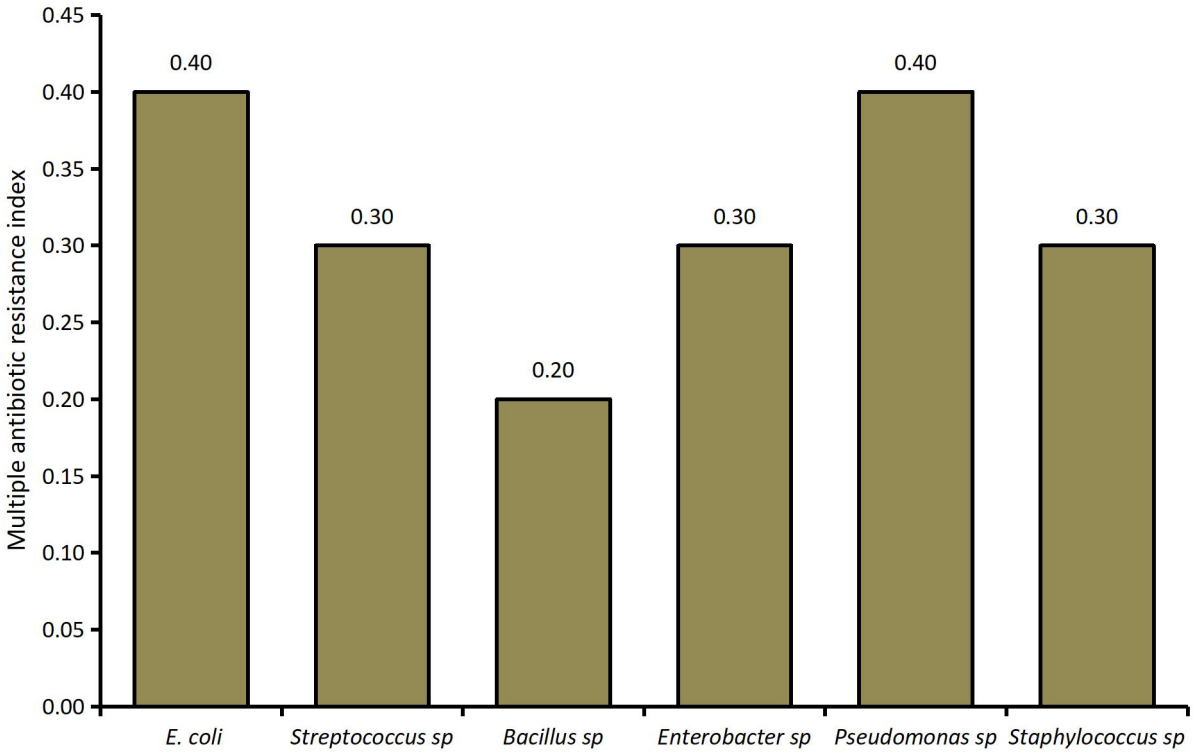

Figure 4.2: Multi-antibiotic Resistance Index of Isolated Bacteria.

CHAPTER FIVE

DISCUSSION

The lecture tables in the Faculty of Life Sciences at the University of Benin serve as common surfaces in classrooms where students interact with various materials during lectures. These tables are subject to frequent contact with students' hands, books, writing instruments, and personal items, making them potential sites for microbial contamination. They are located in different lecture theatres, each designated for specific academic disciplines, such as Animal and Environmental Biology Lecture Theatre, Microbiology Lecture Theatre, Biochemistry Lecture Theatre, Optometry Lecture Theatre and Plant Biology and Biotechnology Lecture Theatre . Given their constant use by a large number of students and staff, lecture tables become hotspots for bacterial accumulation, which may pose health risks if not properly maintained. The surfaces of these tables provide an ideal environment for the growth of various microorganisms, including both pathogenic and non-pathogenic bacteria, which can transfer through direct or indirect contact (El-Kased and Gamaleldin, 2020). This study aimed to isolate, identify, and assess the microbial load and antibiotic resistance of bacteria found on these lecture tables over a two-week period.

The results from (Table 4.1) indicated varying levels of bacterial contamination across different lecture tables within the Faculty of Life Sciences, University of Benin, during Weeks 1 and 2. The Microbiology Lecture Theatre (MLT) recorded the highest bacterial count during Week 2, with $3.80 \pm 0.53 \times 10^4$ cfu/cm², followed closely by the Biochemistry Lecture Theatre (BLT) in Week 1 with $3.37 \pm 0.55 \times 10^4$ cfu/cm². On the other hand, the Optometry Lecture Theatre (OLT) consistently showed the lowest bacterial counts over the two-week period, with $1.88 \pm 1.00 \times 10^4$ cfu/cm² in Week 1 and $2.17 \pm 0.12 \times 10^4$ cfu/cm² in Week 2.

These findings suggest that certain areas within the Faculty of Life Sciences have higher bacterial contamination than others, possibly due to varying levels of cleanliness, frequency of use, or environmental conditions. The Microbiology Lecture Theatre, in particular, might have higher contamination due to the nature of its use, with students potentially engaging in activities that involve direct contact with laboratory equipment or materials, which may harbor higher concentrations of bacteria. The consistent presence of relatively low contamination in the Optometry Lecture Theatre suggests better hygiene practices or less frequent use, which may result in reduced bacterial accumulation on surfaces.

It is worth noting that the overall increase in bacterial counts from Week 1 to Week 2 across most lecture theatres could be attributed to factors such as increased human traffic, accumulation of dust, or reduced cleaning efforts during the second week of the study. Similar studies on bacterial contamination in lecture theatres and public spaces have reported similar fluctuations in microbial load based on usage and cleaning practices (Kadambini *et al*., 2022).

The isolation and identification of bacteria from the lecture tables revealed a diverse microbial community, with both Gram-positive and Gram-negative bacteria present. The biochemical tests conducted (Table 4.2) identified species from various genera, including *Staphylococcus, Streptococcus, Pseudomonas, Enterobacter, Escherichia coli,* and *Bacillus*. Staphylococcus species were frequently isolated, exhibiting characteristics such as cluster arrangements and positive catalase reactions. *Staphylococcus aureus*, a common isolate in similar studies of environmental surfaces (El-Kased and Gamaleldin, 2020), is known for its persistence in hospital and public environments due to its ability to survive on dry surfaces and in the presence of various environmental stressors (Kramer and Assadian, 2014).

Streptococcus species, identified as chain-forming cocci, were another significant isolate, with the potential to cause infections such as pharyngitis and pneumonia (Musher, 2000; Karlowsky *et al*., 2003;Tagg *et al*., 2019). *Streptococcus pyogenes* has been documented to thrive in public spaces, where human interaction is frequent. *Pseudomona* sp and *Escherichia coli* are notable Gram-negative bacteria, both of which are opportunistic pathogens capable of causing infections, particularly in immunocompromised individuals (Zaborina *et al*., 2006; Dropulic and Lederman, 2016). *Pseudomonas* species are known for their environmental persistence and resistance to many antibiotics (Laborda *et al*., 2022). *Enterobacter* and *Bacillus* species were also identified, with *Enterobacter* often found in human-associated environments and *Bacillus* species well-known for their spore-forming ability, contributing to their resilience in harsh conditions (Mohammed *et al*., 2022). The identification of these bacterial species highlights the risk of cross-contamination in lecture theatres, where frequent human contact with surfaces may contribute to the spread of infectious agents. Studies by Nnamdi *et al*. (2020) and Latorre *et al*. (2021) also support the notion that high-touch surfaces in public spaces harbor a diverse array of pathogenic microorganisms (Ababneh *et al*., 2022).

The antibiotics susceptibility pattern (Table 4.3) revealed that the bacterial isolates displayed varying degrees of sensitivity and resistance to commonly used antibiotics. *Bacillus* species exhibited high sensitivity to most antibiotics tested, including Pefloxacin, Gentamycin, and Ciprofloxacin. However, certain isolates, particularly *Pseudomonas* and *Escherichia coli,* demonstrated notable resistance to some antibiotics. *Pseudomonas* species were resistant to antibiotics such as Ampiclox and Gentamycin, while Escherichia coli showed resistance to several antibiotics, including Ampiclox and Rocephin. This is concerning, as both *Pseudomonas* and *E. coli* are known to harbor multi-drug resistance mechanisms, making

them difficult to treat, particularly in hospital or community-acquired infections (Kunz Coyne *et al*., 2022).

The Multi-Antibiotic Resistance (MAR) index (Figure 4.2) ranged from 0.2 to 0.4, with Pseudomonas and Escherichia coli recording the highest MAR values. A MAR index greater than 0.2 is typically considered indicative of high resistance to antibiotics and suggests the potential for the development of more severe, difficult-to-treat infections in individuals exposed to such bacteria. This finding is consistent with other studies on environmental surfaces, where antibiotic-resistant bacteria have been isolated, posing a significant public health risk (Nwankwo *et al*., 2022).

The presence of antibiotic-resistant bacteria on lecture tables raises significant public health concerns, particularly for students and staff who frequently come into direct contact with these surfaces. Such bacteria may act as reservoirs for infection, potentially leading to the transmission of resistant pathogens in the community. The identification of *Escherichia coli* and *Pseudomonas* species, both known for causing gastrointestinal and respiratory infections, underscores the need for effective cleaning and disinfection practices to minimize microbial contamination (Cobrado *et al*., 2017).

Moreover, the high occurrence of *Staphylococcus* species on these surfaces suggests that proper hand hygiene and infection control measures are essential to preventing the spread of such bacteria in shared spaces like lecture halls (Ababneh*et al*., 2022). Previous studies by Bright *et al*. (2010) highlight the importance of regular cleaning and disinfection in reducing the bacterial load on public surfaces, especially in educational settings.

5.1. CONCLUSSION

The isolation and identification of bacteria from lecture tables in the Faculty of Life Sciences, University of Benin, reveal a diverse range of Gram-positive and Gram-negative bacterial species, some of which are resistant to common antibiotics. The antibiotic resistance profiles of Pseudomonas sp and Escherichia coli raise concerns about the potential for bacterial transmission and resistance development in public spaces. These findings emphasize the importance of proper hygiene practices and surface disinfection to prevent the spread of microbial contamination and the risk of infections, particularly in environments with high human traffic, such as lecture halls. Future studies could explore the implementation of antimicrobial surface coatings or the development of more effective cleaning protocols to mitigate the risk of bacterial spread and improve public health safety in academic settings. Furthermore, efforts to raise awareness among students and staff about the importance of hand hygiene and infection control measures could help reduce the transmission of harmful bacteria in shared environments.

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