KWARA STATE UNIVERSITY, MALETE, NIGERIA

SCHOOL OF POSTGRADUATE STUDIES (SPGS)

DIVERSITY AND ANTIBIOTIC SUSCEPTIBILITY OF BACTERIA FROM URINE SAMPLES OF CATHETERIZED PATIENTS AT THE UNIVERSITY OF ILORIN TEACHING HOSPITAL

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BSc (AL-HIKMAH UNIVERSITY)

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M.Sc. THESIS SUBMITTED AND PRESENTED

BY

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DEPARTMENT OF MICROBIOLOGY,

FACULTY OF PURE AND APPLIED SCIENCES,

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DECLARATION PAGE

I hereby declare that this thesis entitled "Diversity and Antibiotic Susceptibility of Bacteria from Urine Samples of Catheterized Patients at the University of Ilorin Teaching Hospital" is a record of my research. It has neither been presented nor accepted in any previous application for higher degree.

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Student's Name **Signature** / Date

APPROVAL PAGE

This is to certify that this thesis by Habeeb Salman Isiaka has been read and approved as meeting the requirements of the Department of Microbiology for the award of the degree of Masters of Science (M.Sc.) in Microbiology.

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DEDICATION

This work is dedicated to my beloved parents, wife and children who encouraged and supported me all through to this level of education.

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ABSTRACT

Indwelling urinary catheter (IUC) is one of the significant risk factors for developing nosocomial urinary tract infections (UTIs). This study assessed the diversity and antibiotic susceptibility of bacteria from urine samples of catheterized patients at the University of Ilorin Teaching Hospital, Ilorin, Nigeria. A total of two hundred (200) urine samples were collected from male and female catheterized patients. The urine samples were collected aseptically using a sterile needle and syringe into a sterile universal container. The samples were analyzed by microscopy and cultured on Blood, MacConkey and CLED agar plates. The isolated bacteria were characterized and their antibiotic susceptibility profiles were determined. Out of the 200 urine samples examined, 77 (38.5%) yielded growth of bacteria while 123 (61.5%) were bacteriologically sterile. *Escherichia coli* was the most common pathogen isolated with 27 (35.1%), followed by *Klebsiella pneumoniae* 16 (20.8%), *Staphylococcus aureus* 11 (14.3%), *Pseudomonas aeruginosa* 8 (10.4%), *Proteus mirabilis* 6 (7.8%), *Streptococcus* 5 (6.5%) and *Enterococcus* 4 (5.2%). The antibiotic susceptibility testing revealed that most of the Gram-negative bacteria were sensitive to Ofloxacin (77.78%), followed ciprofloxacin (72.72%), gentamicin (43.75%) and augmentin (37.03%). Lower sensitivity was observed for ceftazidime (16.66%) and imipenem (12.50%). Highest degree of resistance was shown by all the Gram negative bacterial isolates to cotrimoxazole and imipenem. The Gram-positive bacteria were sensitive to nitrofuratoin (100%), followed by gentamicin (60%), Cotrimoxazole (60%) and Imipenem (50%), while sensitivity profile to augmentin, ofloxacin and ciprofloxacin were 20% each respectively. Bacteriuria observed was higher in female (68.8%) compare to male (31.2%). Essential hygiene practices and regular review of antibiotic used in the management of catheter-associated UTI is recommended to avoid multidrug resistance in catheterized patients.

CHAPTER ONE

1.0 INTRODUCTION

Urinary Tract Infection (UTI) is the invasion of urinary tract tissues which may involve the bladder, kidneys, and urethra by microorganisms such as bacteria or fungal, thereby inducing an inflammatory response, infection as well as signs and symptoms (Karkee *et al.,* 2017) and bacteriuria (presence of bacteria in the urine). Under normal circumstance, urine is sterile but as it passes along the urethra, it becomes contaminated by the microflora of the urethra's urogenital superficial membranes. In order to confirm infection, the species isolated or the number of organisms present in the urine must be shown to be significant. Significant bacteriuria is defined as a urine sample containing more than x10^5 colony forming units/ml of urine in pure culture using a standard calibrated bacteriological loop (Cheesebrough, 2006). UTIs are among the most common bacterial and fungal infections in humans. They are also one of the most prevalent nosocomial infections. They account for about 40% of all nosocomial infection of bacteria origin across the whole world (Dougnon *et al.,* 2016). UTI is said to be nosocomial when it is acquired in a healthcare institution or when it is related to the management of patient in hospital (Karkee *et al.,* 2017). Nosocomial Urinary Tract Infections (NUTI) still remains a significant contributor to the over-all incidence or prevalence of nosocomial infectious diseases (CDC, 2009; Karkee *et al.,* 2017). Amongst NUTIs, approximately 75% to 80% are attributed to the use of urinary catheter (CDC, 2009; Karkee *et al.,* 2017). Also, 15% and 25% of patients under admission may receive short-term indwelling urinary catheters (Jacobsen *et al.,* 2008; Karkee *et al.,* 2017).

Catheter is a hollow, partially flexible thin tube that can be inserted into a body cavity, vessel, or duct to allow drainage or injection of fluids (Olaniran *et al.,* 2016). Catheterization is the process of inserting a catheter to allow urine to drain from the bladder for collection or to inject liquids used for treatment or diagnosis of bladder conditions. A catheter that is left inside the body, either temporary or permanently is referred to as an indwelling catheter while a permanently placed catheter are referred to as permcath (Olaniran *et al.,* 2016).

Cathing involves the use of a plastic tube known as a urinary catheter that is gently slided into a patient's bladder via his or her urethra. The process of cathing allows the urine of patients to drain freely from the bladder for collection, or for diagnosis of bladder condition or inject liquid that is used for treatment (Olaniran *et al.,* 2016). The procedure is usually carried out or performed by a clinician or a certified nurse. When UTI results from the introduction of an indwelling catheter into the bladder for drainage of urine, the diagnosis is called Catheter-Associated Urinary Tract Infection (CAUTI) (CDC, 2015).

Catheter is predominantly used in urology and are of different sizes and shapes, and made of variety of materials. There are three main groups: urethral catheter, suprapubic catheter and urethra catheter. Urethral catheter is a drainage tube that is inserted into the bladder, which passes through the urethra. Suprapubic catheter is a urinary catheter that is inserted into the bladder through the abdominal wall. Suprapubic catheter is usually placed in an area above the level of the pubic hair or above the pubic or pelvic bone. Urethra catheter is a long highly small gauge catheter that is inserted directly into the urethra (CDC, 2002; Olaniran *et al.,* 2016). Catheter insertion may predispose a patient to urinary tract infection through unsanitary surgical procedure and when part of the catheter entering the bladder is contaminated. This occurs when the lubricant water applied to the tip of the catheter is contaminated prior to use. Also, the ineffective cleaning of the urinary meatus with disinfectant cause the introduction of organisms from the patient skin and lead to urinary tract infection in the patient (Olaniran *et al.,* 2016). A urinary catheter can be a temporary or long-term solution, as this depends on the assessment of the probable cause and outcome of a disease of the patient and patient's personal mobility. If the medical needs can be taken care of by the patient, temporary self-catheterization can be an option and it is easy to performed (Feneley *et al.,* 2015).

For patients who are not suitable or fit for self-catheterization, indwelling catheters become an option to maintain properly functioning urinary system. The most commonly used urinary catheter across the world is the foley catheter that was invented by an American urologist named Frederic Foley (Feneley *et al.,* 2015; Olaniran *et al.,* 2016). The foley catheter consists of a thin tube that controls two channels; the large channel which allows the urine to flow from the bladder, and the small channel that allows inflation of a balloon that is found below the tip of the catheter that, when inflated, it holds the catheter in position until it is removed. At optimal conditions, a urinary catheter can stay in position for up to approximately 12 weeks. However, this is often not the case as bacterial infection and encrustation can occlude or obstruct the catheter or lead to medical complication (Feneley *et al.,* 2015).

The ineffective cleaning of the urinary meatus can also cause introduction of organism from the patient skin due to failure in wiping the urinary meatus with disinfectant thereby resulting to urinary tract infection in the patient (Olaniran *et al.,* 2016). Causes of catheter associated infections include the presence of material or instrument within the urinary tract and left in place for a longer duration of time. An indwelling urinary catheter may facilitate urinary tract infection by promoting the entry of organisms into the bladder thereby inducing urethral inflammation. Microorganisms embedded around the catheter cause biofilm which are able to hinder the normal anti-bacterial function. During the process of inserting the catheter minor trauma may arise at mucosa membrane, urethral or bladder thereby enabling bacteria that occasionally pass through the urinary tracts without causing infection to settle in the inflamed mucosa to establish themselves to cause infection.

Several risk factors mediated the susceptibility of an individual to Catheter-Associated Urinary Tract Infection (CAUTI) and these factors include older age, female gender, diabetes, and impaired immunity. However, the most important risk factor is the use of an indwelling catheter and the duration of catheterization (Narayanan *et al.,* 2018). The CDC estimated that approximately 12% - 16% of hospitalized adult patients on admission will have an indwelling catheter at some point and that the risk for developing a CAUTI increases by 3% - 7% with each additional day of catheterization. The increase in susceptibility of the catheterized patients is mainly due to the chance of the catheter to pass through several host defenses resulting to entry of the bacteria into the urinary tract. In intubated patients, bacteria can rise upward from the urethral meatus into the bladder by moving between the mucosal and catheter surfaces. Moreover, the disruption in the tubing junction or contamination of the drainage bag may as well result in movement of bacteria via the drainage system. Additionally, the presence of an indwelling catheter favours the persistence of the causative agent in the urinary tract thereby promoting the risk for CAUTI (Narayanan *et al.,* 2018).

Urinary Tract Infections (UTIs) are caused by different microbial pathogens (Abejew *et al.,* 2014, Olaniran *et al.,* 2016). The most commonly reported bacteria associated with urinary tract infection (UTI) in patients with indwelling urinary catheter are *Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus mirabilis, Staphylococcus aureus, Enterococcus feacalis* (Khorvash *et al.,* 2009; Kolawole *et al.,* 2009; Olaniran *et al.,* 2016).

UTI is often treated by broad-spectrum antibiotics. The treatment is often not subject to thorough laboratory tests involving culture and sensitivity tests and may likely lead to the wrong use of antibiotic. This has invariably contributed to the development of worldwide antibiotic resistance in bacteria. This has led to the emergence of multiresistance strains of bacterial pathogens (Sayyed *et al.,* 2019). The survey conducted by the European survey of Antibiotic Consumption revealed that multidrug resistant (MDR) bacterial strains were found to be accountable for an increase in mortality rate in complications of UTIs (Sayyed *et al.,* 2019). Hence, it is needful to besiege non-judicious and inappropriate use of antibiotics that facilitate the emergence of antimicrobial resistance. Appropriate and judicious antibiotics for first-choice empiric treatment of UTIs should be opted for or considered (Goossens *et al.,* 2005; Sayyed *et al.,* 2019).

In some places where little or nothing has been done, under reporting may result in poor knowledge about the catheter-associated infection and treatment with indiscriminate and excessive use of broad spectrum and other stronger anti-microbial compounds. This may add to the issue of bacterial resistance in association with catheterization and pattern of susceptibility of catheterization related infectious bacteria to antimicrobial agents (Drekonya *et al.,* 2008; Esquevel *et al.,* 2009).

1.1 Statement of Problem

Urinary Tract Infections (UTIs) are attributed to the use of an indwelling catheter is one of the leading cause of infections acquired by patients in health-care settings. Almost 25% of patients on admission receive indwelling urinary catheter (CDC, 2013). About 75 % of UTIs occur in 15% - 25% of patients on admission in hospital who receive indwelling urinary catheters (CDC, 2013). This together with some existing underlying conditions undermines the patient's quality of life. It causes pain and burning sensation in the lower abdomen, burning sensation during urination, fever and also an increase in the frequency of urination (CDC, 2013). CAUTI also increase the duration of hospitalization, medication and also contribute to the financial burden of patients.

Among the ongoing concerns worldwide is the problem of emergence of antibiotic resistance against commonly prescribed antibiotics in the treatment of UTIs. The inappropriate use of antibiotics, availability of counterfeit drugs in the market, non-compliance to the ethic standard treatment guidelines by clinicians and non-availability of laboratory resources for culture and sensitivity evaluations are among the several factors attributed to the ongoing resistance to antibiotic.

Also, poor use and poor monitoring of antibiotic prescription in the treatment of catheter related UTI is a major contributor to antibiotic resistance. If attempt is not made to stop the progression of antibiotic resistance, there would be a higher risk of stimulating the emergence of UTI-related multidrug resistance (MDR) strains in catheterized patients. Moreover, Nigeria as a country would be faced with increased morbidity and mortality from CAUTI, as well as increase in the costs of treatment to the patients and healthcare system.

1.2 Justification of the Study

Urinary Tract Infections (UTIs) are among the bacterial infections that are commonly found in the hospital as well as long-term health care facilities. The indwelling urinary catheter (IUC) is a risk factor that is most significant for developing Catheter-Associated Urinary Tract Infections (CAUTIs). The risk of acquiring this infection depends on the method and duration of catheterization, the quality of healthcare and expertise of clinicians, and the susceptibility of the host among others. Since the use of urinary catheters are common in hospitals and health care facilities, the control of catheter-associated infections is gaining attention and becoming an essential area of study since large variety of microorganisms are involved.

Globally, surveillance of antibiotic on CAUTI is reported to be uncoordinated. A condition that has resulted in lack of proper or accurate data on antibiotic resistance (WHO, 2014). Also, the worldwide prevalence of multidrug resistance (MDR) bacteria could complicate the deliberate management of microbial pathogenic infections. Therefore, surveillance study is needed periodically at different levels to evaluate the efficacy of antibiotics being administered in the treatment of infections and also update the antibiogram data of the associated microorganisms arising from catheterization.

1.3 Aim of the Study

The aim of this study is to determine the diversity and antibiotics susceptibility of bacteria from urine samples of catheterized patients.

1.3 Objectives of the Study

The objectives of the study were to:

i. determine the incidence of bacteriuria associated with patients urinary catheter;

ii. characterize and identify the bacteria isolates from such urine samples and

iii. assess the susceptibility patterns of the isolated bacteria to different commercial brands of antibiotics.

CHAPTER TWO

2.0 LITERATURE REVIEW

The urinary system is one of the main route or passages through which liquid wastes are excreted from the human body. The urinary tract is composed of two sections: the upper urinary tract which consists of the kidneys and ureters, where liquid wastes from the body are converted into urine and other bye-products; and the lower urinary tract which consists of the bladder and urethra, where the liquid waste called urine is stored in the bladder before being released from the body through the urethra (Chapple, 2011; Yvonne *et al.,* 2018). The outermost section of the urethra and the surrounding tissue around the urethral opening are called the urethral meatus (Yvonne *et al.,* 2018).

When the urinary system is functioning normally, the lower part of the urinary tract flushes out the urethra as the bladder empties and this prevent bacteria movement up from the skin of the periurethral into the urethra and then into the bladder (Feneley *et al.,* 2015). If bacteria escape and enter the bladder of a healthy individual, they will be expelled during the process of micturition. However, if they remain, the internal surface of the bladder is resistant to attachment of bacteria because it is lined with urothelial cells that are protected in a glycosaminoglycan mucin that prevents the adherence of bacteria to the surface of the internal bladder (Feneley *et al.,* 2015). As long as the patient is healthy, the immune system should be able to eliminate the bacteria, if they bypass the first line of defences. However, failure of the immune system can result to Urinary Tract Infection (UTI) and can possibly lead to serious illness (Yvonne *et al.,* 2018). When there is a problem in the lower urinary tract such as stricture of the urethra, which results in urinary retention, muscle atrophy leading to incontinence, nerve damage or prostate enlargement, the use of a urinary catheter becomes a necessity (Chapple, 2011; Yvonne *et al.,* 2018).

2.1 Urinary Catheters

A urinary catheter is a hollow, partially flexible long tube constructed from different polymers made of latex rubber, plastic (PVC) or silicon when required, the urinary catheter is inserted into the urethra that collects urine from the bladder and leads to a drainage bag (Yvonne *et al.,* 2018). A urinary catheter can be a temporary or long-term solution and usually this depends on the personal mobility and prognosis of the patient involved (Yvonne *et al.,* 2018).

There are three main types of catheters: indwelling catheters, external catheters, and short-term catheters. An indwelling catheter resides in the bladder and it is also called Foley catheter, usually used for short and long periods of time. Catheter is the commonest used urinary catheter in the world and it was invented by an American urologist named Frederic Foley (Feneley *et al.,* 2015). Usually, an indwelling catheter is inserted into the bladder through the urethra by a nurse or a healthcare provider through a tiny hole in the abdomen. This type indwelling catheter is known as a suprapubic catheter. A balloon that is tiny is inflated with water at the end of the catheter to prevent the sliding of the tube out of the body. When the catheter needs to be removed, the balloon can then be deflated (Feneley *et al.,* 2015).

External catheters also known as condom catheters is a catheter placed outside the body. Typically, it is necessary for men who don't have urinary retention problems but have serious functional or mental disabilities, such as dementia. A device that looks like a condom covers the penis head and a tube leads from the condom device to a drainage bag. These catheters are generally more comfortable and minimal risk of infection than indwelling catheters. Usually, condom catheters usually need to be changed daily, but some brands are designed for longer use. These brands can cause minimal skin irritation than condom catheters that need to be removed daily and reapplied (Feneley *et al.,* 2015).

Short-term catheters also known as intermitted catheters are used for a short period of time after surgery until the bladder empties. Intermitted catheters are usually removed after the bladder is emptied and they are usually referred to by healthcare practitioners as an in-and-out catheter (Feneley *et al.,* 2015).

2.2 Urinary Tract Infections

Urinary Tract Infection (UTI) is the invasion of tissues of the urinary tract which may involve the bladder, the kidneys and urethra by microorganisms such as bacteria or fungi that induce an inflammatory response as well as infection (Karkee *et al.,* 2017). Bacteriuria is the presence of bacteria in the urine. Urinary Tract Infection (UTI) is commonly caused by bacteria which include both Gram-positive and Gram-negative bacteria when the bacteria enter the urinary tract (Foxman, 2010). Before they cause any symptom, the host defence system removes the bacteria in most cases (Ana *et al.*, 2015). However, the body is not able to fight off the bacteria due to some underlying conditions and an infection occurs. When the urethra is inflamed a condition known as urethritis occur, inflammation of the bladder results to a condition called cystitis and pyelonephritis occurs if the kidney tissue is inflamed (Najar *et al.*, 2009).

One of the most commonly used devices in healthcare setting are catheters. However, these devices are notoriously predisposing patients to infection. With the use of catheter, whether long term or short term, infection is the largest concern. Among the most commonly faced hospital-acquired infections or nosocomial infections are catheter-associated urinary tract infections, abbreviated to CAUTIs (Jacobsen *et al.,* 2008; Jordan *et al.,* 2015).

A patient who had an indwelling urinary catheter in place at the time of or within 48 hours prior to the onset of urinary tract infection is said to be suffering from Catheter-Associated Urinary Tract Infection (CAUTI). Numerous medical complications can result from CAUTIs, and these include pyelonephritis, catheter encrustration, septicaemia, bladder stones, and endotoxic shock (Jordan *et al.,* 2015). Modification of the criteria of Costel and colleagues was used to define hospital acquired UTI as those patients with a positive urine culture (at least $x10^5$ colony forming units/ml (cfu/ml) of one or two organisms first identified on day 3 (49 hours) or later. Hospital-acquired UTIs were also considered to be developed by a patient with positive urine culture within 48 hours of collection.

A study by Chatterjee *et al*. (2014) sampled 150 catheters from patients with no history of UTIs and the results revealed that 130 of the catheter used had pathogens present both on the catheter and in accompanying urine samples. Chatterjee *et al*. (2014) in the study conducted found that the most common microorganisms are "*Pseudomonas aeruginosa, Staphylococcus aureus, Staphylococcus epidermidis, Klebsiella pneumoniae, Proteus mirabilis, Proteus vulgaris, Escherichia coli, Citrobacter freundii, Providentia rettgeri* and *Candida albicans*". All these bacteria can cause urinary tract infections (UTIs) or asymptomatic bacteriuria which can cause devastating effects on patients involved (Chatterjee *et al.,* 2014).

Asymptomatic bacteriuria is the isolation of a specified quantitative count of bacteria in urine sample obtained from an individual without signs and symptoms of UTI. Acute uncomplicated UTI is defined as a symptomatic infection of bladder which is characterized by urgency, frequency, dysuria, or suprapubic pain in a woman with normal genito-urinary tract and is associated with both behavioral and genetic determinants (Hooton *et al.,* 2009). Urinary infection in men is usually considered complicated because the uncomplicated urinary tract infections occur rarely in men (Hooton *et al.,* 2009).

Among the predisposing factors for UTI include instrumentation, impaired immunity, foreign bodies, functional abnormalities, metabolic abnormalities and urological surgery (Rane *et al.,* 2013). The use of an indwelling catheter is a known risk factor for UTI, and the most important single risk factor is the duration of catheterization (Rane *et al.,* 2013). Several different species of bacteria are involved, often multiresistant (Sandberg *et al.,* 2014). Approximately 30 - 40% of the health-asociated infections are related to catheter-associated UTI, and in a urological wards as many as 10% patient involved has complicated healthcare-associated infections (Rane *et al.,* 2013).

2.3 Burden of Illness

2.3.1 Asymptomatic Bacteriuria

The most important determinant of bacteriuria is the duration of catheterization (Hooton *et al.,* 2009; Nicolle, 2014). When an indwelling catheter is insitu, the daily risk of acquisition of bacteria is 3 – 7%. The acquisition rate is higher for women and older person (Hooton *et al.,* 2009; Nicolle, 2014). Once a catheter remains in place for several weeks, bacteriuria is universal. Continuous bacteriuric are assumed to be found in patient with chronic indwelling catheter. In hospitalized patients with an indwelling catheter, from 60 – 80% of them receive antimicrobial which is usually for indication other than urinary tract infection. The intense antimicrobial exposure denotes that antimicrobial resistant organisms are frequently isolated from the urine of individuals catheterized (Nicolle, 2014). In Michigan, statewide surveillance of Carbapenemase Resistant Enterobacteriacea (CRE) revealed 61% of isolates were from urine cultures, and a urinary catheter was present in 48% of these patients (Brennan *et al.,* 2014). The source for outbreaks of resistant organisms in acute care facilities have been reported to be as a result of bacteria colonizing the drainage bags of catheterized patients (Hooton *et al.,* 2009; Lo *et al.,* 2014). In the nursing home setting, the most common site of isolation of resistant gram negative organisms was found to be in the urine of residents with chronic indwelling catheters (Arnoldo *et al.,* 2013; Nicolle, 2014).

2.3.2 Symptomatic Urinary Tract Infection

The most common adverse effect associated with indwelling urinary catheter is Catheter-Associated Urinary Tract Infection (CAUTI). The development of symptomatic infection is found in only a small proportion of residents of acute care facility with Catheter-Associated Asymptomatic Bacteriuria (CA-ASB) (Nicolle, 2014). The prevalence survey by the European showed that 1.3% of patients had urinary tract infection and of all health care acquired infections, it represents 17.2%, the third most frequent infection (Zarb *et al.,* 2012). The presence of any health care acquired infection was found to be independently associated with the number of devices that are invasive, and these include indwelling urinary catheters, but the proportion with urinary infections and a catheter in patient was not reported (Nicolle, 2014).

Urinary Tract Infection was the fourth most common infection reported by the recent US point survey, this accounts for 12.9% of health care infections, and of these patients, 67.7% had a urinary catheter (Magill *et al.,* 2014). At one Veteran's Affairs (VA) hospital, 0.3% of all urinary catheter days involved symptomatic UTI (Leuck *et al.,* 2012). Rates of CAUTI of 10.6% - 12.6% of catheterized patients was reported by a comparative British trial evaluating different types of catheters, although only 3.2% - 5.0% of infections were confirmed microbiologically (Pikard *et al.,* 2012).

2.4 Classification of UTI

2.4.1 Uncomplicated UTI (Cystitis)

Uncomplicated UTI occurs when a non-resident infectious organism invades the urinary tract both structurally and functionally (Mc Lellan and Hunstad, 2016). Most male UTI's are considered to be complicated due to urological abnormalities that are associated with male infections which mostly occur in infants and the elderly (Grabe *et al*., 2013).

2.4.2 Uncomplicated Pyelonephritis

Simplified clinical and laboratory procedures can be used to diagnose uncomplicated pyelonephritis which can be a simple urinary tract infection. Uncomplicated pyelonephritis can also be a severe infection where the kidney parenchyma is involved and for proper diagnosis, specific imaging materials are required (Najar, 2009). Nausea, vomiting, flank pain, fever

(>38^{O}C) complains are presented by most men and this can occur without symptoms of cystitis (Nieuwkoop *et al*., 2017).

2.4.3 Complicated UTI

Structural, metabolic or functional abnormality in the urinary tract exist in complicated UTI (Brusch, 2017). When there is presence of bladder abscess, spinal cord injury and catheters, structural abnormality is said to occur. Hormonal abnormalities which include uncontrolled diabetes is one of metabolic abnormalities. Impaired host responses such as in AIDS patients and renal transplant patients is an example of functional abnormalities (Nieuwkoop *et al*., 2017). Majority of UTIs in men occur in infants or the elderly who have urologic abnormalities, that include, bladder outlet obstruction like in catheterization or prostatic hyperplasia and they should be considered complicated (Bergamin and Kiosoglous, 2017).

2.4 Frequently Isolated Causative Organisms

In Abeokuta, western Nigeria, Abaeze and Abasiama (2011) and Indranil *et al.* (2012) in India, isolated *E. coli* as the most common organism causing CAUTI in ICU settings. Also, Taiwo and Aderuomu (2006) in Osogbo, western Nigeria and Mahshid and Ali (2009) in Iran discovered *Klebsiella* species as the commonest organisms causing CAUTI. Duoshuang in Singapore isolated *Candida* species as the lead organisms in their independent studies. In the studies of Abaeze and Abasiama (2011), out of the 200 patient samples, 82(41 %) yielded bacteria growth while 118(59%) showed no significant growth. From the bacterial isolates, 29(37.3%) of the isolates were *E. coli,* 17(20.73%) were *Klebsiella pneumonia,* 13(15.85%) were *Staphylococcus aureus,* 10(12.2 %) were *Pseudomonas aeruginosa,* 8(9.75%) were *Proteus mirabilis* while 5(6.1%) were enterobacteriacaea group (*Escherichia coli* and *Klebsiella pneumoniae*). These organisms are found in the bowel and as a result of contamination, they may have ascended into the urinary tract (Abaeze and Abasiama, 2011).

The most sensitive drug was Ofloxacin with 52.9% sensitivity for *Klebsiella pneumoniae* and for *Escherichia coli*, the sensitivity was 13.8%. The next sensitive drug was Gentamycin with sensitivity of 41.17% for *Klebsiella* and for *Escherichia coli* 13.79%. Augmentin had the highest sensitivity of 41.17% for *Escherichia coli,* the commonest organism and *Proteus mirabilis* has 12.5%. The reason may likely because the drugs are not easily abused. Cotrimoxazole and Amoxycillin that are commonly used antibiotics had 100% resistance probably because of the abuse or inappropriate uses (Abaeze and Abasiama, 2011).

Among the family of bacteria that cause UTI is Enterobacteriacea with *Escherichia coli* reported as the dominant species. Non-fermenters like *P. aeruginosa, Acinetobacter* and gram-positive cocci like *S. saprophyticus, E. faecalis* and *S. aureus* also causes urinary tract infection (Van Aarle *et al*., 2013).

2.5.1 *Escherichia coli*

The best known pathogens that affect human health is *E. coli* which is a member of the *Enterobacteriaceae* family. The most well-documented and studied bacterial species in the world is *E. coli*, yet consistent threat is still posed by these organisms to human health, particularly in a medical setting (Yvonne *et al.,* 2018). *E. coli* is primarily found in the Gastro Intestinal Tract (GIT) within human anatomy. In female patients, especially, as a result of the proximity of the urethra to the anus, *E. coli* is a large initiator or contributor in the majority of CAUTIs for intermittent catheter users (Yvonne *et al.,* 2018).

Uropathogenic *E. coli* (UPEC) that are associated with UTIs are part of a subset of strains referred to as extraintestinal pathogenic *E. coli* strains, and in addition to UTIs, they can as well cause sepsis and meningtis (Yvonne *et al.,* 2018). Amongst the most common isolates of nosocomial UTIs are strains of uropathogenic *E.coli* (UPEC) and they are said to be the most common cause of UTIs in general public. In the general public, *E. coli* accounts for 70 – 90% of UTIs and of all nosocomial UTIs, it accounts for 50% (Yvonne *et al.,* 2018).

E. coli is a motile species of bacteria that utilizes flagellum-mediated motility to cause invasion of the urinary tract. The introduction of *E. coli* into the urinary tract on the surface of a catheter gives them access into the bladder and eventually, they can move into the upper urinary tract, potentially resulting to kidney infection (Yvonne *et al.,* 2018).

A number of virulence factors is exhibited by UPEC strains once inside the body, and this contributes to the formation and recurrence of UTIs and CAUTIs (Yvonne *et al.,* 2018). Expression of type 1 fimbriae is one of such virulence factors and is found in 80 – 100% of UPEC strains (Yvonne *et al.,* 2018). This adhesion allows strains of UPEC and some other uropathogens adhesion to uroepithelial cells that lined the urinary tract as well as the catheter surface (Ulett *et al.,* 2013). The adherence ability of the UPEC to the catheter supports the establishment of a UPEC infection, thereby allowing complex biofilm formation for UPEC and other stains (Yvonne *et al.,* 2018). Attachment to the cells of the uroepithelia can result to invasion and deterioration of the layers of uroepithelia and perpetuation of CAUTIs after removal of the catheter (Ulett *et al.,* 2013). UPEC stains also have the capability to avoid the host immune system production of capsule and liposaccharide (LPS). The production of capsule by UPEC play an important role in UTIs and CAUTIs because the capsule aid in immune avoidance of host, provide resistance to phagocytosis by immune cells and masking the bacterial cells with surface structural similarities to human cells (Yvonne *et al.,* 2018). The LPS expression by UPEC stain and the capsules have been shown to also aid in their endogenous antimicrobial peptides and resistance to complement-mediated lysis (Yvonne *et al.,* 2018).

More than 80% of all acute UTIs are caused by *E. coli* infection (Najar, 2009). In all UTI infections, the *E. coli* recurrence rate is cited to be 44% (Totsika, 2012). Among the infections caused by this bacteria are: uncomplicated urethritis, cystitis, symptomatic cystitis, urosepsis, prostatic abscess and pyelonephritis (Grabe *et al*., 2013).

2.5.2 *Klebsiella pneumoniae*

After *E. coli*, *Klebsiella pneumoniae* is the second pathogen to cause urinary tract infection affecting persons with low immunity (Behzadi *et al*., 2010). Due to its production of carbapenemese, it has challenged antibiotic therapy as a results of its high resistance level to all beta lactams antibiotics (Totsika, 2012). *Klebsiella pneumoniae* uses biofilm formation and bladder colonization to cause UTI in a similar way to UPEC (Rosen, 2008). An adhesin similar to the one used by UPEC called TYPE 1 fimbrial adhesin is also been used by this bacterium but of different binding specificities (Flores-Mireless *et al*., 2014).

2.5.3 *Proteus mirabilis*

Proteus mirabilis is a member of the family *Enterobacteriaceae* (Jacobsen *et al.,* 2008). Species belonging to proteus genus are distributed widely in the environment and are also opportunistic due to been linked to numerous hospital-acquired infections throughout the body (Jacobsen *et al.,* 2008). In healthy persons with unobstructed urinary tracts, *P. mirabilis* is normally not associated with UTIs (Norsworthy and Pearson, 2017). The urinary tract of individuals who have functional or structural abnormalities can, however be colonized by *P. mirabilis*. Due to their existing colonization of gastrointestinal tract, *P. mirabilis* can move along catheter surfaces from the outside and thus predisposing catheterized patients to risk (Jacobsen *et al.,* 2008).

The second most common bacterial strain isolated from CAUTIs in patients with long-term indwelling catheters is *P. mirabilis*. This Gram-negative bacteria tends to display the greatest propensity to bind the catheter surface and other urological devices in general (Jacobsen *et al.,* 2008). *Proteus mirabilis* displayed greater adherence abilities by producing multiple adherence factors such as fimbriae and hemaglutinins and these allow their attachment to devices with or without the presence of a conditioning film (Stickler, 2012). *Proteus mirablis* adherence ability plays enormous role in CAUTIs and particularly in catheter encrustation/crystalline biofilm formation (Jacobsen *et al.,* 2008). High motility and flagella-mediated swarming is a distinguished feature of *P. mirabilis* as compared to other uropathogens (Yvonne *et al.,* 2018).

The recurrent CAUTIs, particularly recurrent catheter encrustation and blockage have been found to be carriers of *P. mirabilis* and this is experienced in many patients (Yvonne *et al.,* 2018).

2.6 Hospital Resident Organisms

A study by sehulster *et al*. (2003) has shown that surfaces in the hospital and medical equipment that are frequently used become contaminated by a different group of pathogenic and non-pathogenic microorganisms. In a study by Kramer, they found that most gram positive bacteria such as *Staphylococcus aureus* including Methicillin Resistant *Staphylococcus aureus* (MRSA), *Enterococcus* species including Vancomycin Resistant Enterococcus (VRE), and *Streptococcus pyogenes* survive on dry surfaces for months. Many gram negative organisms such as *Escherichia coli, Pseudomonas aeruginosa, Klebsiella, Shigella,* and *Actinobacter* species can survive also on dry surface for months. The most important nosocomial fungal pathogen which is *Candida albicans* can survive on surfaces for four months. These imply that the most common nosocomial pathogens can persist or survive for longer periods in formites and surfaces in the hospital (Kramer *et al.,* 2006), if no regular preventive measure is applied, thereby becoming continous sources of infection transmission (Kramer *et al.,* 2006). Through the hand of the healthcare worker, the mode of transmission can be direct or indirect from inanimate surfaces to susceptible patients but this can be reduced through compliance with hand hygiene to 50% (Kramer *et al.,* 2006). Health workers compliance with hand hygiene is critical to reducing this. In the ICU, hand washing remains the cornerstone of infection control

(Tambekar and Shirsat, 2009). In a study conducted in Amravati India by Tambekar to see the effect of hand washing on microbial flora of the hand, 400 swab samples were collected from the hands of 100 students before and after hand washing and were analyzed. The hands of all the students were found to harbor pathogens prior to their hand washing and these pathogens were: *Salmonella* species 2%, *Pseudomonas* 3%, *Enterococcus* 4%, *Enterobacter* 6%, *Citrobacter*, *Streptococcus* and *Proteus* species 7% each, *Micrococcus* species 9%, *Klebsiella* 10%, *Escherichia coli* 20% and *Staphylococcus* species 23%. There was 54% reduction in microbial flora after the hand washing. *Klebsiella* had 39% reduction, *Citrobacter* 45%, *Streptococcus* 54%, *Proteus* 55%, *Enterococcus* 59%, *Escherichia coli* 59%, *Staphylococcus* 88%, and *Salmonella* had 100% reduction. This indeed showed that health care personnel compliance to hand washing reduces transmission of nosocomial infections (Tambekar and Shirsat, 2009).

2.7 Epidemiology of Catheter-Associated Urinary Tract Infection

Among bacterial infections managed in healthcare setting, infections occurring in the urinary tract are ranked highest (WHO, 2018). Clinicians prescribe antibiotics empirically when patients are presented with these infections (Lee *et al*., 2015). These infections have caused a tremendous public health concern globally due to rising of healthcare cost burden resulting from the antibiotic management. About 150million people are reported to have been affected worldwide each year by urinary tract infections (Flores-Mireles, 2014).

2.7.1 Incidence and Prevalence

As reported from hospitals by International Nosocomial Infections Control Consortium (INICC), rates in the ICU of countries with limited resources are 3 – 5 times higher than rates in the high-income countries for Devices-Associated Hospital Acquired Infection (DA–HAI) (Rose-enthal *et al.,* 2009).

In a prospective study conducted in a tertiary University Hospital in Lebanon, incidence of CAUTI in an adult surgical ICU was 13.07 per 1000 urinary catheter days which was about tenfold greater than the US rate of 1.5 CAUTI rate per 1000 urinary catheter days determined by the CDC/NHSN (Dudeck *et al.,* 2011) and this was determined by KISS to be 2.5 CAUTI rate (Geffers and Gastmeier, 2011). Asymptomatic bacteriuria in patients with short – term urethral catheterization had a prevalence of 9 – 23 % while for long-term catheterization, the prevalence was 100% (Colga *et al.,* 2006).

In healthcare settings, urinary catheter placement is a medical procedure that is commonly used in the treatment of 60% of critically ill patients, 5 – 22% of patients in long – term care facilities, and 20% of patients in medical and surgical intensive care units (Dudeck *et al.,* 2013). This is true particularly in nursing homes, where 12 – 15% of individuals newly admitted have an indwelling urinary catheter and individuals with chronic urinary catheter make up 5 – 10%. The later are patients with indications such as traumatic pelvic injury, neurogenic bladder, and chronic pressure ulcers or wounds (Rogers *et al.,* 2008). Urinary catheters in place for prolonged periods of time are also observed in these individuals and this doubles the risk of developing symptomatic Catheter-Associated Urinary Tract Infection (CAUTI), thus providing a means for antimicrobial resistant bacteria (Nicolle, 2014).

The presence of bacteria in urine (bacteriuria) is facilitated by indwelling urinary catheters within 5 – 7 days after insertion (Averch *et al.,* 2015). Bacteria that are found around the periurethral area are excluded typically from the urinary tract by a combination of the regular passing of urine (micturition), the innate immune defenses, and by the physical barrier provided by intact urothelial cells along with the mucin they produce.

The placement of a catheter however, damages the urothelial barrier, disrupts regular passing of urine (micturition), and results in low volume of urine retention within the bladder, all of which encourage bacterial growth (Garcia *et al.,* 2007). The accumulation of host proteins such as fibrinogen is as a result of the immune response elicited by the catheter and this prime the catheter surface and facilitates bacterial attachment (Armbuster *et al.,* 2018). All these factors combined and create a permissive environment that is unique for numerous bacterial species to potentially colonize and establish infection. There is a 3 - 8% incidence of bacteriuria for each day that a urinary catheter is in place, and continuous bacteriuria and symptomatic CAUTI result from long-term catheterization greater than 28 days (Nicolle, 2014).

Numerous adverse outcomes, such as increased hospital stays, functional decline, inadequate or inappropriate antimicrobial treatment are associated with catheterization and resulting bacteriuria. This nearly doubles the mortality rate compared to non-catheterized individuals (Bootsma *et al.,* 2013). Catheter-Associated bacteriuria can be challenging to distinguish from CAUTI especially in long-term care settings, however catheter-associated bacteriuria is frequently asymptomatic. The presence of clinical signs and symptoms in addition to a positive urine culture are among the guidelines for diagnosis of CAUTI (Fekete, 2020). For instance, CAUTI is defined by the 2010 clinical care guidelines of the Infections Diseases Society of America (IDSA) as a positive urine culture ($\geq 10^3$CFU/ml of ≥ 1 bacterial species) combined with signs or symptoms compatible with UTI (fever, flank pain, rigors, malaise or lethargy with no other identified cause, altered mental status, acute hematuria, pelvic discomfort, or costovertebral tenderness) in the absence of an alternate source of infection (Nicolle *et al.,* 2019). However, a culture with $\geq 10^3$CFU/ml of ≥ 1 bacterial species is considered asymptomatic catheter-associated bacteriuria if there is absence of aforementioned symptoms (Hootom *et al.,* 2010). In contrast, the criteria for long-term care facilities of the National Health Safety Network (NHSN) surveillance define symptomatic CAUTI as having a positive urine culture (no more than 2 species, of which at least one must be a bacteriurium at ≥10CFU/ml of urine) combined with at least one of the following : (a) fever (single temperature >100^{O}F, repeated temperatures >99^{O}F, or an increase of >2^{O}F of baseline), (b) rigors, (c) new onset hypotension (<90 systolic or <60 diastolic blood pressure) without an alternate non-infectious cause, (d) new onset decline in mental or functional status combined with leukocytosis (>14,000 leukocytes/mm) and without an alternate diagnosis, (e) new or increased suprapubic tenderness, (f) new or increased costovertebral pain, swelling, or tenderness of the testes, epididymis, or prostate, or purulent discharge from the catheter insertion site (Stone *et al.,* 2012). In older adults, especially those with cognitive impairments, neurogenic bladder, or a high degree of functional dependence, the diagnosis of CAUTI is particularly the challenging type. CAUTI is often a diagnosis of exclusion in this population, as many signs and symptoms of infection (such as fever and leukocytosis) are absent while other signs of infection may be non-specific (Armbruster *et al.,* 2017).

The high prevalence of acute mental status change and confusion in this population are the further confounding issue (Kizilbash *et al.,* 2013), and this is coupled with issues regarding non-specific symptoms and reliable assessment of mental status (Juthani-Mehta *et al.,* 2008). To limit inappropriate antimicrobial treatment risk of *clostridioides difficile* infection and development of antimicrobial resistance, the 2019 IDSA guidelines strongly recommend against screening for or treating asymptomatic bacteriuria in older, functional or cognitive impaired adults, especially those residing in long-term care facilities, as well as individuals with indwelling urinary catheters (Nicolle *et al.,* 2019)

The epidemiology of bacteriuria in catheterized individuals have been reported in several studies (Fourcade *et al.,* 2015), but few have conducted a longitudinal assessment of colonization dynamics or included assessment of signs and symptoms of infection to differentiate clearly between asymptomatic colonization and CAUTI.

2.8 Pathogenesis

Urinary Tract Infection (UTI) is the invasion of tissue of urinary tract by microorganisms such as bacteria or fungal pathogen, thereby inducing an inflammatory response as well as signs and symptoms (Karkee *et al.,* 2017). Most of the bacteria causing CAUTI gain access to the urinary tract either intraluminally or extraluminally (Newman and Wein, 2009). Extraluminal contamination may occur when there is contamination of the catheter from any source during the insertion of the catheter. Also, it is said to occur when there is an ascend of microorganisms from the perineum along the surface of the catheter. Due to shorter length of the urethra and its proximity to the anus, it is more common in women (Shuman and Chenoweth, 2010). Intraluminal contamination occurs when bacteria ascend from contaminated catheter drainage tube or urine drainage bag (Pratt *et al.,* 2007). These are three main catheter-associated entry points for bacteria. (1) the urethral meatus, with the introduction of bacteria during catheter insertion, (2) the junction (connection) of the catheter with the drainage bag especially when there is breakage in the close catheter system and (3) the drainage part of the collection. In the pathogenesis of colonization and injection of the urinary tract, all the afore mentioned mechanisms are involved and thus make CAUTI very difficult to prevent in patients with indwelling catheter in place for more than two weeks. Catheter-associated bacteriuria may be symptomatic or asymptomatic and 20 – 30 % of patients with bacteriuria will present with symptoms of CAUTI (Pratt *et al.,* 2007; Mabbette *et al.,* 2009).

Most CAUTI are associated with multiple resistant bacteria and other organisms from catheter-associated biofilms, and include *Escherichia coli* and other enterobacteriaciae (e.g *Klebsiella, Proteus, Citrobacter* and *Enterobacter)*, *Staphylococci*, *Pseudomonas aeruginosa, Enterococci* and *Candida* (Shuman and Chenoweth, 2010).

The infecting organism depends on the hospital unit (Shuman and Chenoweth, 2010). In ICU unit, the predominant organisms causing CAUTI are the enteric Gram-negative Bacilli, Enterococci, *Candida* species and *Pseudomonas aeruginosa* (Shuman and Chenoweth, 2010). Candiduria is common especially in individuals broad spectrum antibiotic therapy (Shuman and Chenoweth, 2010). Resistant microorganisms especially *Pseudomonas aeruginosa* and *Candida albicans* are frequently involved in device-associated nosocomial infections because of increased use of antibiotics (Shuman and Chenoweth, 2010).

The likely contributor to colonization by *Candida* species is the use of broad spectrum antibiotics. This is usually by suppressing endogenous bacterial flora, primarily in the gut and lower genital tract and possibly in the superficial area adjacent to the urethral meatus. Phagocytic function and antibody formation may interfere with subsequent impaired host defense mechanism against Candida infections (Guler *et al.,* 2006). An important subgroup of nosocomial UTI is candiduria which is beaming increasing (10 – 15%) and almost all are caused by *Candida albicans* (Guler *et al.,* 2006). In the hospital settings, the prevalence varies and among patients in the intensive care units, more especially surgical ICU, leukaemia and bone marrow transplant units, it is the most prevalent (Pappas *et al.,* 2004; Kauffman, 2005). Among the common risk factors showed by the previous studies were urinary tract instrumentation, prolonged hospital stay, previous surgical procedures, immune suppressive therapy, recent use of antibiotics, diabetes mellitus, advanced age and female sex (Kobayashi *et al.,* 2004). The risk factor to develop candiduria was shown in a recent case controlled study to increase by 12-fold after urinary catheterization, 4-fold following abdominal surgeries, 6-fold each after use of broad spectrum antibiotics and presence of urinary tract abnormalities, 1-fold with the use of corticosteroids and 2-fold in the presence of diabetes mellitus (Guler *et al.,* 2006). No significant difference between the groups compared in terms of age and female sex was found in the study (Guler *et al.,* 2006).

2.9 Catheter-Associated Bio-films

The cellular structure of the bladder and emptying of its contents regularly prevent bacteria growth or their multiplication to dangerous levels and their adherence to the surrounding mucosa. Bacterial contamination may occur when a foreign object like a catheter is inserted or introduced (Feneley *et al.,* 2015). A good medium for bacterial growth is catheter because once bacteria gain access to the urinary tract, they produce different adhesions which include hair-like fimbrae that allow them to attach firmly to the wall of the catheter (Talsma, 2007).

Normally, microorganisms are present in a planktonic state in the bladder and are freely suspended in the urine. They are unlikely to cause a UTI in this state, unless they are present in large amounts that may overcome the innate defenses of the bladder (Yvonne *et al.,* 2018). When there is a placement or insertion of an indwelling urinary catheter or any medical device within the body, microorganisms can attach to the device, thereby forming colonies that are bound together and enclosed usually in a polymer matrix known as biofilms (Thomas-white *et al.,* 2016).

A biofilm is defined as microorganisms bound to a surface of each other with the presence of an extracellular matrix composed of products secreted by the organisms and/or of the components of the organisms themselves (Sayal *et al.,* 2014). The cells present within the biofilm may bound irreversibly to the surface and to each other via adhesive substances secreted (Sayal *et al.,* 2014). The microorganisms present within the biofilm usually display changes in gene expression that differs from their planktonic state (Trautner and Darouiche, 2014). The organisms in biofilm can be Gram-negative bacteria or yeasts and usually can be one or multiple species (Sayal *et al.,* 2014). The longer a urinary catheter is in place, the more likely it is for a biofilm to form on its surface and cause a CAUTI. Patients who are under short term catheterization (≤ 7days) experience 10 – 50% of the time biofilm formation while patients on long term catheterization (>28days) practically are found to present with biofilm formation (Yvonne *et al.,* 2018).

It is highly advantageous to microorganism for being a part of biofilm, as the group show high resistance and resilience than any singular planktonic organism (Ulett *et al.,* 2013). For an organism to be within a biofilm community, the advantages they derived include antimicrobial resistance, safety from phagocytosis by immune cells and protection from physical forces (Trautner and Darouiche, 2004). Cell-to-cell communication can occur within a biofilm in a process known as quorum sensing to choreograph changes across the community in the gene expression (Jacobsen *et al.,* 2008). The presence of urinary catheter biofilms has paramount and crucial implications for diagnosis, antimicrobial resistance, prevention and treatment of CAUTI (Talsma, 2007).

2.10 Clinical Presentation of Catheter-Associated Urinary Tract Infection (CAUTI)

According to centre for Disease Control Criteria, CAUTI may present as Asymptomatic Bacteriuria (ASB) or symptomatic urinary tract infection (SUTI) (Dudeck *et al.,* 2013). For urinary tract infection to be symptomatic, it must meet the following criteria; patient had an indwelling urinary catheter in place at the time of collection of sample, or onset of signs and symptoms and at least one of the following signs or symptoms with no other recognized cause fever (>38^{O}C), positive urine culture of $\geq 10^5$ colony forming units (cfu)/ml with no more than two species of organisms, costovertebral angle pain or tenderness and suprapubic tenderness, or patient had an indwelling urinary catheter removed within 48 hours prior to sample collection or onset of symptoms and at least one of the following signs or symptoms with no other recognized cause; fever (>38^{O}C), dysuria, costovertebral angle pain or tenderness, suprapubic tenderness and a positive urine culture of $\geq 10^3$ and $<10^5$ colony forming units (cfu)/ml with >2 species of microorganisms (Dudeck *et al.,* 2011; Rosenthal *et al.,* 2012).

Asymptomatic Bacteremic UTI (ABUTI) meet the following criteria: patient with an indwelling urinary catheter or had one in ICU in the past 48 hours with no symptoms but has a positive urine culture $>10^5$cfu/ml with not more than two uropathogenic species and a positive blood culture with at least one matching uropathogenic microorganism to urine culture (Rosenthal *et al.,* 2012).

2.11 Risk Factors of CAUTI

Significant risk factors for CAUTI have been identified by various studies as being, the female gender (Shuman and Chenoweth, 2010), prolonged duration of ICU admission (Abaeze and Abasiama, 2011), prolonged duration of catheterization (Abaeze and Abasiama, 2011). The study by Alavaren *et al.* (1993) identified risk factors, as open drainage system which was used in 31.5% while closed drainage was used in 68.5%. By the 3rd day of those on open drainage, bacteriuria was present in 88.5% and 100% on the 6th day, while only 38% among those with closed drainage system had bacteriuria on the 6th day of catheterization. Daily theoretical application of antimicrobial ointments and solutions and meatal care should prevent or delay onset of infection. This study showed that patients with daily meatal care have higher bacteriuria compared to those without catheter care. This could be due to mobilization of catheter during catheter care which seems to irritate the bladder mucosa thereby encouraging the ascending of microorganisms and invasion and proliferation of the mucosal epithelium (Newman, 2017). The average incidence of bacteriuria daily was 9.5%. The higher incidence of bacteriuria with longer duration was valid up to the 6th day of catheterization beyond which 100% of the patients had bacteriuria. In Zangudalkaemas University Hospital, Ekrem Temiz found that previous antibiotic usage, immune suppression and the presence of other site nosocomial infection were risk factors for acquiring CAUTI (Ekrem *et al.,* 2012). The duration of catheterization and the female gender were the risk factors for CAUTI alone in the absence of other site infection (Ekrem *et al.,* 2012). Duration of catheterization, the female gender and diabetes mellitus are the unalterable risk factors for CAUTI as found in the study by Karina Billote Domingo in the Philippines for patients with indwelling foley catheters inserted within

24 hours (in the emergency room) of admission. In their study, at an average of 4.1 days, bacteriuria developed 20.6% of the patients had acquired CAUTI after 2 days of catheterization, 36% after 4 days and 46.7% after 7 days. The most significant risk factors was duration of catheterization. The likelihood of microbes ascending to the bladder either via the intra or extra luminal route increases with increasing duration of catheterization. The next risk factor was the female gender probably because of the anatomy, leading to easier access of the perineal flora to the bladder along the catheter as it passes the shorter female urethra (Ekrem *et al.,* 2012).

The third risk factor was diabetes mellitus. Due to an increased ability of the urine to support microbial growth and increased prevalence of perineal colonization by potential pathogens, diabetes patients are at an increased risk of developing infections. The study by Bagchi *et al.* (2015) revealed that female gender, increasing age, duration of catheterization and diabetes mellitus were the risk factors for CAUTI in ICU. This study showed that higher incidence occurred in people above 75 years of age with 66.67% (2 out of 3) incidence rate while the lower incidence was found in the age group 18 – 25 years with 11.76% (2 out of 17) incidence rate. Also, in the same study, the incidence of CAUTI was 34.29% (36 out of 105 females) while in the males, the incidence was 28 out of 115 (24.35%). This shows that females were more vulnerable to acquiring CAUTI. On the third day, 10 (15.63%) were detected, 22 (34.38%) were detected within 56 days and 32 (50%) were found within 7 days. The incidence of 50% on the 7th day is closed to Domingo's 46.7% on the same day in their study. The study by Indranil also revealed that 21.88 % (14 out of 64) cases of CAUTI were diabetic patients. Only 10 diabetic patients were free from CAUTI in the same study, and this shows that diabetes mellitus predisposes a patient to developing CAUTI (Lundstorm and Sobel, 2001).

2.12 Infection Control in the Intensive Care Unit

Infection control is an application of epidemiology and scientific principles for prevention and reduction of infection. Hand washing, cleaning of environment and aseptic techniques are perhaps measures that are most important in infection control. Accreditation of health care organizations include infection control programs (Blouin, 2010). As a result of the 1950s *Staphylococcus aureus* pandemic, the first formal US infection control hospital surveillance project initiated it. A not-for profit organization called Institute for Healthcare Initiatives (IHI) reports how greater than 100,000 annual deaths can be avoided by quality initiative infection control measures. Depending upon type/site of infection, infection control consists of standard precautions with or without transmission-based isolation precautions. The infection control committee includes typically an infection control practitioner (physician or nurse), infectious disease or microbiology specialist and trained epidemiologist. The committee aims to develop policies for infection control, provide feedback of wound-infection to surgeons, educate hospital personnel, and investigate suspected outbreaks. For all hospitalized patients, standard (universal) precautions are recommended and these consist of hand hygiene with cough etiquettes, safe disposal of instruments and soiled linens. The most effective method for infection control is hand hygiene and this can be done by applying 60 – 95% alcohol-based hand rub or soap (Blouin, 2010). Hand hygiene is recommended before and after having a contact with a patient, before aseptic/clean procedures, and after exposure to body fluid (Boyce and Pittet, 2002). Examples of infection control bundles and urinary catheter bundles that can be used to reduce the incidence of CAUTI include; meticulous hand hygiene, daily surveillance regarding further need of catheter, maintenance of closed sterile drainage tubes, avoidance of prophylactic antibodies, proper securing of catheter on body, regular urine culture and aseptic techniques for obtaining urine samples (Boyce and Pittet, 2002).

2.13 Prevention Of Catheter-Acquired Urinary Tract Infections

2.13.1 Reducing Usage of Urinary Catheters and Minimizing Dwell Time

The recommendation by the Centers for Disease Control and Prevention (CDC) is to minimize the use and duration of urinary catheter, particularly in those at higher risk for CAUTI or mortality from catheterization such as in women, patients with impaired immunity and the elderly. The recommendation by the CDC include the following: (1) in operative patients who have an indication for an indwelling catheter, the Catheter should be removed postoperatively as soon as possible, preferably within 24 hours, (2) avoid urinary catheterization to manage incontinence in patients and nursing home residents, (3) the urinary catheter should be used only if necessary in operative patients, rather than routinely (Gould *et al.,* 2017).

2.13.2 Prophylactic Antibiotic Treatments

Due to the development and dissemination of antibiotic resistance among the bacteria that cause health care-associated infections (HAI), the control of CAUTIs has become a major challenge. The development of resistant organisms has been shown to be promoted through prophylactic antibiotics (Hootom *et al.,* 2010). Therefore, antibiotic stewardship initiatives have been developed to curb the development of resistant pathogens due to unnecessary use of antibiotics (Trautner *et al.,* 2018). The use of routine prophylaxis with systemic antibiotics was not recommended by the current CDC guidelines on CAUTI management for prevention of CAUTI in patients requiring short or long-term urinary catheterization, unless clinical indication e.g. in patients with bacteriuria upon removal of catheter in post urologic surgery exist (Gould *et al.,* 2017). Additionally, there is no recommendation at the time of catheter removal for the use of antimicrobial prophylaxis (Marschall *et al.,* 2013). Moreover, with antimicrobial agents, the CDC does not recommend the routine irrigation of the bladder (Gould *et al.,* 2017). Reducing unnecessary catheterization and minimizing dwell time is therefore the best practice.

2.13.3 Antimicrobial-Coated Urinary Catheters

The formation of microbial biofilm on the surface of the urinary catheters is the underlying cause that is most common in bacteriuria (Stickler, 2008). Biofilm formation is a microbial strategy to protect against host immune defences and antibiotic action (Thomas *et al.,* 2004). The use of silicone catheters over other materials was recommended by the current CDC guidelines, because the risk of encrustation in long-term catheterized patients who have frequent obstruction is reduced by using silicon catheters (Gould *et al.,* 2017). Therefore, efforts to prevent formation of biofilm have focused more on developing antiseptic/antimicrobial impregnated silicon-based urinary catheters (Singha *et al*., 2017).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Ethical Clearance

Ethical clearance for the research project work was obtained from Kwara State Ministry of Health, Ilorin after submitting the research proposal. Informed consent was obtained from the patients or relatives for the study. One patient declined the collection of her sample and was allowed to opt out.

3.2 Study Design

This was a prospective cross-sectional descriptive study in which patients who met the inclusion criteria were included.

3.3 Sample Size Estimation

The sample size was calculated using the formula for determining the minimum sample size for the prevalence rate of a condition in a population, assuming a confidence level of 95% and degree of accuracy (margin of error) of 0.05.

The formula is as follows:

$n=Z^2 P (1-P)/d^2$

Where:

n = the desired sample size

Z = 1.96 (a standard normal deviate, usually set at 1.96, which corresponds to the 95% confidence level).

P = the proportion in the target population estimated to have a particular characteristic. This is the proportion of catheterized inpatients admitted in hospital wards. From a previous study carried out in the ICU of 8 developing countries, the prevalence of CAUTI among critically ill patients admitted into the ICU was 4.2% (Pappas *et al*., 2004). So P=4.2% was assumed (i.e. 0.042).

1- P = 1 - 0.042 = 0.958

d = 0.05(degree of accuracy desired)

Therefore substituting the figures into the formula, the minimum sample size was

$n=Z^2P (1-P)/d^2$

$n = 1.96^2 \times 0.042 \times 0.958 / 0.05^2$

n=61.83 approximately 62.

200 patients who met the inclusion criteria were enrolled into the study.

3.4 Inclusion Criteria

Patients (11 – 90 years old) who were catheterized and admitted into the hospital wards were included. Urinary tract infection (UTI) was diagnosed as per CDC definition. The presence of at least two of the following features with no other recognized cause: fever, urgency of micturition, dysuria or suprapubic tenderness, and pyuria or positive urine culture (CDC, 2016).

3.5 Study Population

A cross sectional study was carried out among 200 inpatient that was under urinary catheterization between the ages 11 - 90 years. They all had indwelling urinary catheters inserted under aseptic condition for various medical and surgical conditions. Both males and females urine samples were included in the study group.

3.6 Sample Collection

A total of 200 urine samples were collected from male and female medical wards with verbal consent of the clinicians and the patients. Also before catheter change or removal from each patient, 10 ml of urine samples was collected aseptically using a sterile needle and syringe from the distal edge of catheter tube into a sterile universal container. After collection, the urine samples were labeled, age and sex of patient, and the duration of the catheter was recorded.

The samples were then transported to the medical microbiology laboratory of the hospital for analysis with minimum delay.

3.7 Sterilization of Glass wares

The glass wares used includes: Conical flask, beakers, slant bottles, McCattney bottles, and measuring cylinder. The glass wares were thoroughly washed in water containing detergent using a bottle brush cleaner, and then rinsed with distilled water. The glass wares were then allowed to drain and air dry before sterilizing them in the autoclave at 15 Ibs for 20 minutes (Fawole and Oso, 2007). After sterilization, they were offloaded and placed on the work bench which was firstly sterilized using cotton wool soaked with 70% ethanol to prevent re-contamination. Inoculating needle and loop was flamed to red-hot using the blue-flame from the Bunsen burner and it was allowed to cooled before use (Fawole and Oso, 2007).

3.8 Media Preparation

The culture media used for this study were MacConkey agar, Blood agar, Cystine lactose electrolyte deficient (CLED) agar and Mueller-Hinton agar. These media were prepared and sterilized according to manufacturer's instruction, they were sterilized by autoclaving at 121^{O}C for 15minutes (Fawole and Oso, 2007).

3.8.1 Preparation of MacConkey Agar

Following the manufacturer's instruction, fifty two grams (52 g) of the agar powder was weighed and suspended in one (1) litre of distilled water in a conical flask and thoroughly mixed. Complete dissolution was ensured, the mixture was then placed in boiling water for few minutes and was sterilized by autoclaving at 121^{O}C for 15 mins. Thereafter, it was allowed to cool slightly before being dispensed into sterile disposable Petri dishes and left to set (solidify) at room temperature. The media were later stored at $4^{O}C$ in refrigerator for later use (Fawole and Oso, 2007).

3.8.2 Preparation of Blood Agar

Following the manufacturer's instruction, forty grams (40 g) of the prepared medium was weighed and suspended in one (1) litre of distilled water in a conical flask and thoroughly mixed. The suspension was then heated to dissolve the medium completely. It was then sterilized by autoclaving it at 15 Ibs pressure and $121^{O}C$ for about 15minutes. The medium was then taken out of the autoclave and cooled to about 40 - $45^{O}C$. To this, 5 % v/v sterile defibrinated blood was added aseptically and mixed well. The media were then poured into sterile disposable Petri plates under sterile conditions. The media were stored at $4^{O}C$ in refrigerator until it was to be used (Fawole and Oso, 2007).

3.8.3 Preparation of Cystine Lactose Electrolyte Deficient (CLED) Agar

Following the manufacturer's instruction, thirty six grams (36 g) of the agar powder was weighed and suspended in one (1) litre of distilled water in a conical flask and thoroughly mixed. Complete dissolution was ensured by placing the mixture in boiling water for few minutes and was later sterilized by autoclaving at $121^{O}C$ for 15 mins at fifteen (15) Ibs pressure. It was allowed to cool slightly before dispensing into sterile Petri dishes and left to set (solidify) at room temperature. The media were stored at $4^{O}C$ in refrigerator until it was to be used (Fawole and Oso, 2007).

3.8.4 Preparation of Muellar-Hinton Agar

Following the manufacturer's instruction, thirty-eight grams (38 g) of the agar powder was weighed and suspended in one (1) litre of distilled water in a conical flask and thoroughly mixed. Complete dissolution was ensured, the mixture was placed in boiling water for few minutes and was sterilized by autoclaving at $121^{O}C$ for 15 mins at fifteen (15) Ibs pressure. It was allowed to cool slightly before dispensing into sterile Petri dishes and left to set (solidify) at room temperature. The media were stored at $4^{O}C$ in refrigerator until it was to be used (Fawole and Oso, 2007).

3.9 Analysis of Urine Samples

3.9.1 Macroscopic Examination

The urine samples were examined macroscopically to ascertain the colour and the appearance. The presence and absence of blood and cloudiness of the urine samples were also noted.

3.9.2 Microscopic Examination

Ten (10) mls of each urine sample was centrifuged at 3000 rev / min, after which the supernatant was discarded, deposits was re-suspended by tapping the bottom of the test tubes. A drop of the deposits for each sample was placed on a clean grease free slide and then covered with cover slip, followed by examination under the microscope using the x10 and x40 objectives with condenser iris sufficiently closed to give good contrast. This is to check for the presence and amount of pus cells, epithelial cells, yeast cells, red blood cells, white blood cells, crystals and cast.

3.9.3 Cultural Analysis of Bacterial Isolates

The sterile urine universal containers were tapped to homogenize the urine samples. After which a loopful (0.01 ml) of the urine was collected with a sterile wire loop and inoculated on already prepared Blood, MacConkey and Cystine Lactose Electrolyte Deficient (CLED) media using streak method of Fawole and Oso (2007). After inoculation, the plates were incubated aerobically at $37^{O}C$ for 24 - 48 hours.

3.10 Identification of Bacterial Isolates

Identification of the bacterial isolates started by grouping the bacteria into lactose fermenters and non-lactose fermenters, and this was done by observing the colonies. The bacteria colonies that appeared after incubation were identified using their colonial morphology, for properties such as size, shape, colour, elevation, consistency and so on. They were further identified by Gram-staining, motility test, and oxidase test. The Gram-staining was carried out as described by Oyeleke and Manga (2008). This was then followed by biochemical tests with methods described by Cheesbrough (2000) and Fawole and Oso (2004).

3.11 Maintenance of Bacterial Isolates

The colonies that developed after 24 hours of incubation were continually sub-cultured until a pure culture was obtained. The pure cultures were then sub-cultured on nutrient agar slants, incubated for 24hours and refrigerated. The isolates were maintained on the slant until required.

3.12 Gram Staining

This was carried out as described by Oyeleke and Manga, (2008). A drop of water was placed on a clean glass slide, and speck of bacteria growth was taken from 24 hours old culture, to make a thin smear. The smear was allowed to air dry. It was flooded with crystal violent for 60 seconds, washed with distilled water and lugol's iodine was added for 1min, washed again and then decolorized with 95% ethanol for 1-3seconds. The smear was finally flooded with safranin for 2 mins, washed and viewed under the oil immersion objective. Gram positive cells stain purple while red denotes Gram negative (Oyeleke and Manga, 2008).

3.13 Motility

This was done as described by Singleton, (1997). Motility can sometimes be inferred from the way an organism grows on solid media. Motile species may tend to spread outwards from the inoculated area as organism swim in the thin layer of surface moisture (Singleton, 1997). A speck of each isolate was stab onto triple sugar iron agar and incubated at 37^{O}C for 24hours. Motility was observed by the spread of the organism outwards from the stab area (Singleton, 1997).

3.14 Biochemical Tests

The following biochemical tests were done according to clinical laboratory standard guild lines to further confirm the isolates from the urine samples.

3.14.1 Coagulase Test

Using an inoculating loop, a heavy milky suspension of the organism was made on a microscopic slide. The organisms were homogenized using a drop of distilled water. A flame cooled sterile loop was used to make a loopful of rabbit plasma to the suspension and mixed. Coagulase production is denoted by almost immediate clumping of the suspension (Cheesbrough, 2006).

3.14.2 Catalase Test

A drop of 3% hydrogen peroxide was added to a microscopic slide. A loopful of organism isolated is touched to the drop of hydrogen peroxide. Foaming or bubbing will indicate a positive test due to evolution of water and oxygen (WHO, 2014).

3.14.3 Urease Test

Urea agar was inoculated and incubated at 30^{O}C for 24 hours. Urease activity was observed by change of colour (red) of the indicator as a result of production of ammonia. Positive test (pink colour) in 2-4 hours on the urea agar at 30^{O}C usually is a comfirmatory test for proteus species while it is 2 - 4 hours for *Klebsiella pneumoniae.* No colour change observation indicates Urease negative (Cheesbrough, 2006).

3.14.4 Methyl Red Test

Dextrose broth medium was inoculated with the suspension colonies for 48 hrs to 96 hrs. After incubation, 5 drops of methyl red was added, red colour indicates positive test while yellow colour indicates negative result immediately after addition of the indicator (Cheesbrough, 2006).

3.14.5 Voges-Proskauer Test

A quantity of six (6) drops of VP reagent I (alpha napthol) and two (2) drops of VP reagent II (40% KOH) was added to a 2 day dextrose broth culture of the organisms under test. This was then left at room temperature for 1 hr. Pink colour indicates positive reaction while no change in colour indicates negative reaction (Cheesbrough, 2006).

3.14.6 Oxidase Test

A loopful of the reagent (1% tetramethyl-phenylenediamine aqueous solution) stored in dark bottle at $4^{O}C$ was added to a filter paper in a Petri dish. With the aid of a platinum loop, the suspected colony was smeared across the moist paper, and then the colour change for positive reaction was indicated by a purple colour appearing across the filter paper within 10 seconds (Cheesbrough, 2006).

3.14.7 Indole Test

A volume of 0.5ml of Kovac's reagent was added to the tryptophan broth and if indole is present, then a red coloration forms at the top (Cheesbrough, 2006).

3.14.8 Citrate Utilization Test

Citrate utilization test was used to detect the presence of bacteria that utilize citrate as the sole source of carbon. Simon's citrate medium was put in Bijou bottles in a slant position to prepare slopes. A straight wire was sterilized, and then the slant streaked after the test organism was suspended in normal saline and the butt stabbed. Incubation was done at 35°C for 48 hrs. Change in colour of the medium to bright blue was considered citrate positive (Cheesbrough, 2006).

3.14.9 Sugar Fermentation Test

A quantity of 1% of the sugar was prepared by dissolving 1 g of the sugar in distilled water. A volume of 1 ml of peptone was then prepared by dissolving 1.5 g of peptone into 100 ml of phenol red into the prepared peptone water. Then, 9 ml of the mixture of the solution of peptone water and phenol red was pipette into each test tube and later 1ml of sugar solution was also added to each test tube. The test tube was corked with cotton wool and then autoclaved. The medium was allowed to cool and organisms to be tested were then inoculated using flamed inoculating loop into each test tube. The media were at 37°C for 48 hours. The change in the medium from red colour to yellow is indication of fermentation process (positive) while no change means negative (Cheesbrough, 2006).

3.15 Antibiotic Susceptibility Testing

Antibiotic susceptibility was performed on pure colonies of each species using the disc diffusion method on Mueller-Hinton agar. The zone diameter of inhibition for each antibiotic was compared with the National Committee for Clinical Laboratory Standards (NCCLS) interpretive table (NCCLS, 2002) to determine the degree/extent of sensitivity or resistance. The following antibiotic disc were used for the disc diffusion tests: Augmentin (AUG) 30µg, Imipenem (IM) 10µg, Gentamycin (G) 10µg, Ofloxacin (OFL) 5µg, Ciprofloxacin (CPR) 5µg, Cotrimoxazole (COT) 25µg,, Ceftazidime (CAZ) 30µg, Nitrofuration (NIT) 30µg (NCCLS, 2002; Beyene and Tsegaye, 2011).

3.16 Statistical Analysis

The percentage frequency of occurrence of the bacteria isolated from the urine samples of the catheterized patients was calculated using

Frequency (%) = n/N X 100

Where n = Number of occurrence of bacteria species, N = Total number of bacteria isolated.

CHAPTER FOUR

4.0 RESULTS

4.1 Distribution of Catheterized Patients Examined in Relation to Gender

Among the 200 catheterized urine specimens examined, 85 (42.5%) were from catheterized male patients while 115 (57.5%) were from female catheterized patients. Out of the 85 (42.5%) male specimen examined, 24 (28.2%) were found with a growth of at least one significant pathogen while 61 (71.8%) showed no pathogen incident. Out of the 115 (57.5%) female specimen examined, 53 (46.0%) were found with a growth of at least one significant pathogen while 62 (53.9%) showed no pathogen growth. These make a total of 77 (38.5%) positive and 123 (61.5%) negative cases from all the urine samples analysed (Table 1).

4.2 Distribution of Various Bacterial Isolates in Relation to Age

The age range is 11 – 90 years with a mean age of 55 years. The finding showed that out of the 77 (38.5%) positive group, age group 51 – 60 years had the highest 26 (33.8%) incidence of significant pathogenic bacteria > age group 61 – 70 years with 18 (23.4%) > age group 71 – 80 years with 12 (15.6%) > by 81 – 90 years with 10 (13.0%) > 21 – 30 years with 4 (5.2%) > 31 – 40 years with 3 (3.9%) while age group 11 – 20 years and 41 – 50 years had the least with 2(2.6%) each (Table 2).

Table 1: Bacteriuria Incidence Evaluation of Catheterized Patients Based on Gender of Sampled Population

Sex	Number Examined (%)	Number Positive (%)	Number Negative (%)
Male	85 (42.5%)	24 (28.2%)	61 (71.8%)
Female	115 (57.5%)	53 (46.0%)	62 (53.9%)

Total	200 (100%)	77 (38.5%)	123 (61.5%)

Table 2: Bacteriuria Incidence Evaluation of Catheterized Patients based on Age of the Sampled Population

	Bacterial Isolates / Percentage Distribution in Age							
Age Range	B1	B2	B3	B4	B5	B6	B7	Total (%)
11-20	1(3.7)	1(6.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(2.6)
21-30	2(7.4)	1(6.3)	1(9.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	4(5.2)
31-40	2(7.4)	0(0.0)	0(0.0)	1(12.5)	0(0.0)	0(0.0)	0(0.0)	3(3.9)
41-50	1(3.7)	1(6.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(2.6)
51-60	8(29.6)	6(37.5)	4(36.4)	2(25.0)	2(33.3)	2(40.0)	2(50.0)	26(33.8)
61-70	6(22.2)	3(18.8)	2(18.2)	3(37.5)	2(33.3)	1(20.0)	1(25.0)	18(23.4)
71-80	4(14.8)	2(12.5)	2(18.2)	1(12.5)	1(16.7)	1(20.0)	1(25.0)	12(15.6)
81-90	3(11.1)	2(12.5)	2(18.2)	1(12.5)	1(16.7)	1(20.0)	0(0.0)	10(13.0)
Total	27(35.1)	16(20.8)	11(14.3)	8(10.4)	6(7.8)	5(6.5)	4(5.2)	77

KEY:

B1 – B7 = Bacterial Isolates

4.3 Identification of Bacterial Isolates

4.3 1 Gram stain

A total of 4 Gram-negative and 3 Gram-positive bacteriuria were isolated. The Gram-negative bacteria were *Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus mirabilis* while the Gram-positive isolates were *Staphylococcus aureus, Streptococcus* species and *Enterococcus* species.

4.3.2 Biochemical tests

Escherichia coli changed the colour of the cystine lactose electrolyte deficient (CLED) media to yellow to confirm lactose fermentation. Indole, methylated, motility and Voges Proskauer tests were positive while urease and citrate tests were negative.

Klebsiella pneumoniae being a lactose fermenter changed the CLED media to yellow. Indole, methylated, motility and Voges Proskauer tests were negative while both citrate and urease tests were positive.

Staphylococcus aureus was a non-lactose fermenter, catalase and coagulase tests were positive. Indole, methylated, motility and Voges Proskauer tests were negative.

Pseudomonas aeruginosa was a non-lactose fermenter showing a translucent blue colour on the media, meaning that lactose was not fermented. Indole, methylated, motility and Voges Proskauer tests were negative while the catalase and the citrate tests were positive.

Proteus mirabilis was also a non-lactose fermenter due to a translucent blue colour on the media and this means lactose was not fermented. Oxidase, coagulase and the indole tests were all negative while citrate and urease tests were positive.

Streptococcus sp. and *Enterococcus* sp. are both lactose fermenters. *Streptococcus* sp. was indole negative while *Enterococcus* sp. was indole positive. *Streptococcus* and *Enterococcus* species were catalase negative, which differentiate them from *Staphylococcus* which is catalase positive (Table 3).

4.4 Incidence of Bacterial Isolates in Catheterized Urine Samples of the Patients

Among the 77 (38.5%) of the sampled population that were positive for bacteriuria, *Escherichia coli* had the highest incidence rate of 35.1%. This was followed by *Klebsiella pneumoniae* (20.8%) > *Staphylococcus aureus* (14.3%) > *Pseudomonas aeruginosa* (10.4%) > *Proteus mirabilis* (7.8%) > *Streptococcus* (6.5%) > *Enterococcus* 5.2% respectively (Table 4).

Table 3: Results of Identification Techniques Used for Isolates

Morphological Characterization			Gram Reaction					Biochemical Tests					Sugar fermentation			Probable organism
Bacterial isolates	**Colonial morphology**	**Cellular Morphology**	**Gram reaction**	**Oxidase Test**	**Catalase Test**	**Coagulase Test**	**Citrate Test**	**Methylated**	**Indole Test**	**Voges**	**Motility Test**	**Urease Test**	**Glucose**	**Lactose**	**Fructose**	
B1	White	Small rough raised surface	-	-	+	-	-	+	+	+	+	-	(+)	+	-	*Escherichia coli*
B2	Pink	Mucoid colonies	-	+	-	+	-	-	-	-	+	-	(+)	+	+	*Klebsiella pneumoniae*
B3	Creamy	Raised / Smooth edge	+	-	+	+	+	-	-	-	-		+	-	-	*Staphylococcus aureus*
B4	Light yellow	Slightly raised	-	+	+	-	+	-	-	-	-		+	-	-	*Pseudomonas aeruginosa*
B5	Bluish green	Small round colonies	-	-	+	-	+	+	-	-	+	+	+	-	+	*Proteus mirabilis*
B6	Colourless	Small smooth colonies	+	-	-	-	+	+	-	+	-		+	+	+	*Streptococcus* sp.
B7	White mucoid	Small smooth colonies	+	-	-	-	+	+	+	-	-		+	+	+	*Enterococcus* sp.

KEY:

B1 - B7 = Bacterial Isolates

Table 4: Incidence of Bacterial Isolates from Catheterized Urine Samples of the Patients Positive to Bacteriuria

Bacterial Isolates	**Number of Isolates**	**Incidence Rate (%)**
Escherichia coli	27	35.1
Klebsiella pneumoniae	16	20.8
Staphylococcus aureus	11	14.3
Pseudomonas aeruginosa	8	10.4
Proteus mirabilis	6	7.8
Streptococcus sp	5	6.5
Enterococcus sp	4	5.2
Total	77	100

4.5 Incidence of Isolates Based on Gender

It was observed from this study that the females were more vulnerable to catheter-related urinary infection with 53 (68.8%) while the male had 24 (31.2%). Also, the number of occurrence of bacteria that were found in the female were higher than that in the male (Table 5).

4.6 Antibiotic Sensitivity Pattern of the Identified Bacteria

The most effective antibiotics against the bacterial isolates was Ciprofloxacin, followed by Nitrofurantoin and Ofloxacin respectively. The bacterial isolates exhibited high resistant to Ceftazidime and Augmentin. However, the sensitivity of *Streptococcus* was 100% to Nitrofurantoin (Figure 1). The bacterial isolates displayed different sensitivity patterns to the various antibiotics used in this study (Table 6.1 to 6.7).

Table 5: Incidence of Isolates Based on Gender

Bacterial isolates	Males n(%)	Females n(%)	Total n(%)
Escherichia coli	12 (50.0)	15 (28.3)	27 (35.1)
Klebsiella pneumoniae	2 (8.3)	14 (26.0)	16 (20.8)
Staphylococcus aureus	3 (12.5)	8 (15.0)	11 (14.3)
Pseudomonas aeruginosa	3 (12.5)	5 (9.4)	8 (10.4)
Proteus mirabilis	2 (8.3)	4 (7.5)	6 (7.8)
Streptococcus sp.	1 (4.2)	4 (7.5)	5 (6.5)
Enterococcus sp.	1 (4.2)	3 (5.6)	4 (5.2)
Total	24 (31.2)	53 (68.8%)	77(100)

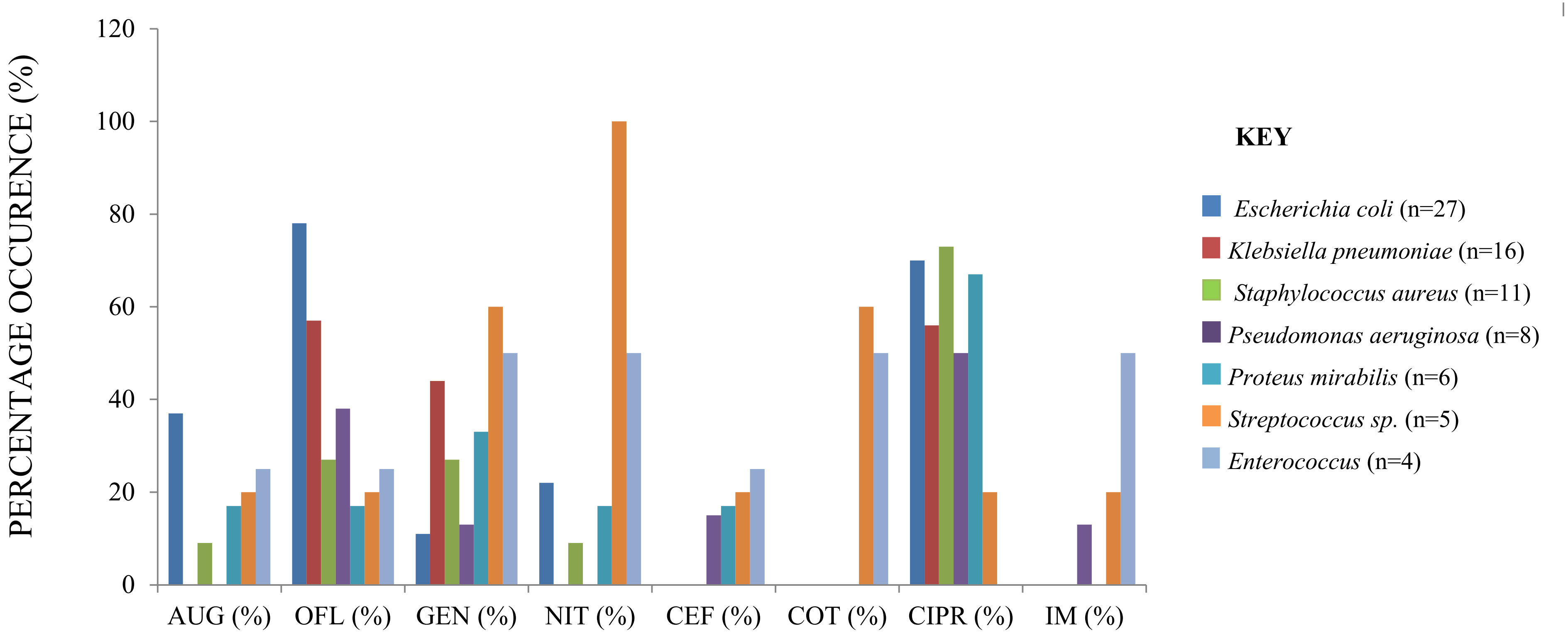

Figure 1: Antibiotic Sensitivity Pattern of Bacterial Isolates

KEY:

AUG: Augmentin, OFL: Ofloxacin, GEN: Gentamycin, NIT: Nitrofuration, CEF: Ceftazidime, COT: Cotrimoxazole, CIPR: Ciprofloxacin, IM: Imipenem

4.6.1 Antibiotic Susceptibility of *Escherichia coli*

Escherichia coli showed sensitivity to Ofloxacin (77.78%) and Ciprofloxacin (70.37%). High resistant was displayed by Ceftazidime (100%), Cotrimoxazole (100%) and Imipenem (100%). This was followed by Gentamycin (88.89%) and Nitrofuratoin (77.78%) while moderate resistant was exhibited for Augmentin (62.96%).

Table 6.1: Antibiotic Susceptibility Profile of *Escherichia coli*

***Escherichia coli* (n=27)**	**Sensitivity n(%)**	**Resistant n(%)**
Augmentin	10 (37.03)	17 (62.97)
Ofloxacin	21 (77.78)	6 (22.22)
Gentamycin	3 (11.11)	24 (88.89)
Nitrofurantoin	6 (22.22)	21 (77.78)
Ceftazidime	0 (0.00)	27 (100.00)
Cotrimoxazole	0 (0.00)	27 (100.00)
Ciprofloxacin	19 (70.37)	8 (29.63)
Imipenem	0 (0.00)	27 (100.00)

4.6.2 Antibiotic Susceptibility of *Klebsiella pneumoniae*

Klebsiella pneumoniae showed moderate sensitivity to Ofloxacin (56.25%) and Ciprofloxacin (56.25%). High resistant was to Augmentin (100%), Nitrofuratoin (100%), Ceftazidime (100%), Cotrimoxazole (100%) and Imipenem (100%). It also exhibited moderate resistant to Gentamycin (56.25%).

Table 6.2: Antibiotic Susceptibility Profile of *Klebsiella pneumoniae*

***Klebsiella pneuminiae* (n=16)**	**Sensitivity n (%)**	**Resistant n (%)**
Augmentin	0 (0.00)	16 (100)
Ofloxacin	9 (56.25)	7 (43.75)
Gentamycin	7 (43.75)	9 (56.25)
Nitrofurantoin	0 (0.00)	16 (100)
Ceftizidime	0 (0.00)	16 (100)
Cotrimoxazole	0 (0.00)	16 (100)
Ciprofloxacin	9 (56.25)	7 (43.75)
Imipenem	0 (0.00)	16 (100)

4.6.3 Antibiotic Susceptibility of *Staphylococcus aureus*

Staphylococcus aureus showed high sensitivity to Ciprofloxacin (72.73%) but resistant to Ceftazidime (100%), Cotrimoxazole (100%), Imipenem (100%), Augmentin (90.90%), Nitrofurantoin (90.90%), Ofloxacin (72.73%) and Gentamycin (72.72%).

Table 6.3: Antibiotic Susceptibility Profile of *Staphylococcus aureus*

***Staphylococcus aureus* (n=11)**	**Sensitivity n(%)**	**Resistant n(%)**
Augmentin	1 (9.10)	10 (90.90)
Ofloxacin	3 (27.27)	8 (72.73)
Gentamycin	3 (27.27)	8 (72.73)
Nitrofurantoin	1 (9.10)	10 (90.90)
Ceftazidime	0 (0.00)	11 (100)
Cotrimoxazole	0 (0.00)	11 (100)
Ciprofloxacin	8 (72.73)	3 (27.27)
Imipenem	0 (0.00)	11 (100)

4.6.4 Antibiotic Susceptibility of *Pseudomonas aeruginosa*

Pseudomonas aeruginosa displayed moderate sensitivity to Ciprofloxacin (50.0%). It showed high resistant to Augmentin (100%), Nitrofurantoin (100%), Cotrimoxazole (100%), Gentamycin (87.50%) and Imipenem (87.5%) as well as moderate resistant to Ceftazidime (85.0%) and Ofloxacin (62.5%).

Table 6.4: Antibiotic Susceptibility Profile of *Pseudomonas aeruginosa*

***Pseudomonas aeruginosa* ((n=8)**	**Sensitivity n(%)**	**Resistant n(%)**
Augmentin	0 (0.00)	8 (100)
Ofloxacin	3 (37.50)	5 (62.50)
Gentamycin	1 (12.50)	7 (87.50)
Nitrofurantoin	0 (0.00)	8 (100)
Ceftazidime	2 (15.00)	6 (85.00)
Cotrimoxazole	0 (0.00)	8 (100)
Ciprofloxacin	4 (50.00)	4 (50.00)
Imipenem	1 (12.50)	7 (87.5)

4.6.5 Antibiotic Susceptibility of *Proteus mirabilis*

Proteus mirabilis showed moderate sensitivity to Ciprofloxacin (66.67%). It displayed high resistant to Cotrimoxazole (100%), Imipenem (100%), Augmentin (83.33%), Ofloxacin (83.33%), Nitrofurantoin (83.33%) and Ceftazidime (83.33%). It showed moderate resistant to Gentamycin (66.67%).

Table 6.5: Antibiotic Susceptibility Profile of *Proteus mirabilis*

Proteus mirabilis **(n=6)**	**Sensitivity n(%)**	**Resistant n(%)**
Augmentin	1 (16.67)	5 (83.33)
Ofloxacin	1 (16.67)	5 (83.33)
Gentamycin	2 (33.33)	4 (66.67)
Nitrofurantoin	1 (16.67)	5 (83.33)
Ceftazidime	1 (16.67)	5 (83.33)
Cotrimoxazole	0 (0.00)	6 (100)
Ciprofloxacin	4 (66.67)	2 (33.33)
Imipenem	0 (0.00)	6 (100)

4.6.6 Antibiotic Susceptibility of *Streptococcus* species

Streptococcus sp. showed high sensitivity to Nitrofurantoin (100%), followed by Gentamycin (60.0%) and Cotrimoxazole (60.0%). It showed high resistant to Augmentin (80.0%), Ofloxacin (80.0%), Ceftazidime (80.0%), Ciprofloxacin (80.0%) and Imipenem (80.0%).

Table 6.6: Antibiotic Susceptibility Profile of *Streptococcus* sp.

Streptococcus **sp. (n=5)**	**Sensitivity n(%)**	**Resistant n(%)**
Augmentin	1 (20.00)	4 (80.00)
Ofloxacin	1 (20.00)	4 (80.00)
Gentamycin	3 (60.00)	2 (40.00)
Nitrofurantoin	5 (100.00)	0 (0.00)
Ceftazidime	1 (20.00)	4 (80.00)
Cotrimoxazole	3 (60.00)	2 (40.00)
Ciprofloxacin	1 (20.00)	4 (80.00)
Imipenem	1 (20.00)	4 (80.00)

4.6.7 Antibiotic Susceptibility of *Enterococcus* species

Enterococcus sp. showed moderate sensitivity to Gentamycin (50.0%), Nitrofurantoin (50.0%), Cotrimoxazole (50.0%), Ciprofloxacin (50.0%), Imipenem (50.0%). It displayed high resistant to Augmentin (75.0%), Ofloxacin (75.0%) and Ceftazidime (75.0%). The least sensitivity was showed to Augmentin (25.0%), Ofloxacin (25.0%) and Ceftazidime (25.0%).

Table 6.7: Antibiotic Susceptibility Profile of *Enterococcus* sp.

***Enterococcus* sp. (n=4)**	**Sensitivity n(%)**	**Resistant n(%)**
Augmentin	1 (25.00)	3 (75.00)
Ofloxacin	1 (25.00)	3 (75.00)
Gentamycin	2 (50.00)	2 (50.00)
Nitrofurantoin	2 (50.00)	2 (50.00)
Ceftazidime	1 (25.00)	3 (75.00)
Cotrimoxazole	2 (50.00)	2 (50.00)
Ciprofloxacin	2 (50.00)	2 (50.00)
Imipenem	2 (50.00)	2 (50.00)

CHAPTER FIVE

5.0 DISCUSSION

The study investigated 200 urine samples from catheterized male and female patients between the ages of 11 – 90 years at University of Ilorin Teaching Hospital (UITH). The study assessed the incidence of bacteriuria associated with urinary catheter, identify the isolated bacterial pathogens and their susceptibility patterns on different antibiotics.

In this study, it was observed that number of bacteriuria in urine specimens of catheterized patients examined was 38.5 % which is in consonance with reports from previous studies (Olaniran *et al.,* 2016; Saint *et al.,* 2000). This incident rate was high and may be due to the use of non-sterile practices during the insertion of the catheter, not applying disinfectant while cleaning the meatus area, introduction of microorganisms from the hand of the operator as a result of improper or failure to wash the hands properly with soap, long term impregnation of catheter-use, and also from healthcare workers in charge due to technical errors (Olaniran *et al.,* 2016). Zarb *et al*. (2012) also reported an incidence that is lower than that found in this study. The explanation of this difference is that, in Europe where there are reports of lower incidence/prevalence, there are more rigorous hygiene practices than in developing countries (Dougnon *et al.,* 2016).

The distribution among the different age groups with bacteriuria was varied. Also, in this study, it was observed that the mean age was 55 years where the majority of the patients between the age of 51 – 60 years presented with the highest rate of bacteriuria, followed by age group 61 – 70 years, while the patients between the age of 11 – 20 years and 41 – 50 years constitute the smallest groups with the lowest rate of bacteriuria. This result corresponds to a study carried out in Ladoke Akintola University Teaching Hospital, Osogbo, Nigeria which also revealed that catheterized patients of age groups above 60 years constitutes the largest group with highest incidence of bacteriuria (Taiwo and Aderounmu, 2006). As contrasted to this study, the research done at Federal Medical Centre, Abeokuta, Nigeria, where age group 26 – 35 years and 36 – 45 years have the highest prevalence rate while age group 86 – 95 years had the least (Olaniran *et al.,* 2016).

The fact that the minimal age of patient with bacteriuria in this study was 11 years and the maximal 90 years reveals that any category of age can be affected with catheter UTIs. However, greater exposure to the risk of catheter associated UTIs is attributed to patients older than 60 years of age. This might be as a result of low immune status observed in these categories of patients. Also, it was reported that among the factors that encourage the apparition of bacteriuria is an older age (Flores-mireles *et al.,* 2014).

In this study, there is higher incidence of Gram-negative bacteria compared to Gram positive bacteria. The highest incidence of Gram-negative bacteria in this study is in agreement with the study reported by Mirzarazi *et al. (*2013).

Also observed in this study, was the predominance of *Escherichia coli* among the Gram-negative bacilli isolated with an incidence rate of 35.1%. This study confirms the work of Kocak *et al.* (2016) who reported that this bacterium isolated in catheter-associated UTIs was the most implicated (Kocak *et al.,* 2016). The predominance might be as a result of the natural way possessed by *E. coli* in colonizing the urinary tract and evading the immune system, as well as its ability to move from the area contaminated with fecal matter which is the perineum area into the vaginal or penile region (Nayareen, 2016). Similar finding was observed in a study carried out by Karkee *et al*. (2017) where the most common isolate was *E. coli* (Karkee *et al.,* 2017).

The second most common Gram-negative was *Klebsiella pneumoniae*, followed by *Pseudomonas aeruginosa* and then *Proteus mirabilis*. This finding is similar to previous finding reported by Harper and Fowlis, 2007; Foxman, 2010; Noor *et al.* 2013; Seifu and Gebissa, 2018. The presence of *Klebsiella* sp*., Pseudomonas* sp. and *Proteus* sp. in the urine specimen indicates their implication in nosocomial infections. This result is also in accordance with the report of Daza *et al.* (2001); Naeem *et al.* (2010) and Okonko *et al.* (2010) who reported the presence of these organisms in urine samples of UTI patients. In contrast to this, Taiwo and Aderounmu, (2006) reported *Klebsiella* sp. as the commonest pathogen, followed by *Pseudomonas* sp. and then *Escherichia coli* (Taiwo and Aderounmu, 2006).

Staphylococcus aureus was the most isolated among the Gram-positive cocci in this study. The predominance of this bacterium among the Gram-positive was reported by Gaynes and Edwards (2005) which may be due to the lipoteichoic acid present in its cell wall and this served as an adherence factor in the urinary tract for this bacterium to survive. The Gram-positive bacteria isolated (*Staphylococcus aureus, Streptococcus* sp. and *Enterococcus* sp.) were fewer compared to the Gram-negative isolates. Gram positive bacteria are less commonly implicated in UTI (Hamdan *et al*., 2015).

Furthermore, this study reveals that gender is a risk factor that is important for catheter-associated UTIs. As observed in this study, bacteriuria in indwelling catheters occurs in both male and female but the incidence was found to be higher in females than in males. This is probably due to multiple factors contributing to the issues among females. The first possible reason could be as a result of the anatomical features of the female urethra which appears to be shorter compared to male's urethra. Pathogens gain easy access to the bladder due to the shortness of the female urethra and this result in increased bacterial counts in the bladder after encountered (Seifu and Gebissa, 2018). In addition, this study is similar to previous study by Olaniran *et al.* (2016) that reported higher incidence of bacteriuria in female than male due to shortness of the female urethra (Olaniran *et al.,* 2016).

Regarding sensitivity patterns of the antibiotics, it is a well-known fact that the same species of bacteria can have different sensitivity patterns depending on region and time as postulated by Copan *et al*. (2016). It therefore underscores the importance of antibiotic susceptibility testing to distinguish the pattern of antibiotic resistance among uropathogens and thereby provide accurate treatment regimes. It was observed in this study that all Gram-negative isolates were highly resistant to Cotrimoxazole and Imipenum but these two antibiotics showed moderate sensitivity to Gram positive bacterial isolates except *Staphylococcus aureus* among the Gram positive bacterial isolates that displayed to these antibiotics. This was in concordance with findings of Olaniran *et al*. (2016) who confirmed that Cotrimoxazole was resistant to all Gram negative bacteria and to *Staphylococcus aureus* among the Gram positive bacteria. It was also observed in this study that Cotrimoxazole displayed moderate sensitivity to *Streptococcus* sp. and *Enterococcus* sp. This is contrary to previous study by Nwankwo and Godwin (2014) where Cotrimoxazole showed high degree of resistant to *Streptococcus* species and *Enterococcus* species. The most sensitive antibiotics to Gram negative bacterial isolates in this study was Ofloxacin. This was consistent with a study done in Federal Medical Centre, Abeokuta, Nigeria, where the sensitivity pattern of Ofloxacin was found to be the highest (Olaniran *et al*., 2016).

However, sensitivity pattern was different in Gram-positive bacterial isolates. The most sensitive antibiotic among the Gram-positive bacteria isolated in this study was Nitrofurantoin, followed by Ciprofloxacin. It was also observed that Cotrimoxazole demonstrated moderate sensitivity to *Streptococcus* and *Enterococcus* species but displayed high degree resistant to *Staphylococcus aureus*. This is contrary to a study by Sandhur *et al*. (2018) where Gram-positive isolates were highly resistant to Nitrofurantoin, Ciprofloxacin and Cotrimoxazole. In this study, Imipenum was highly resistant to both Gram-positive and Gram-negative bacteria isolated but displayed moderate sensitivity to *Enterococcus* species. This is contrary to a study by Aly *et al*. (2016) where Imipenem was the most active drug against *Klebsiella* and *Enterococcus* species. Also, a study by Iregbu and Nwajiobi-Princewill (2013) showed that Imipenem was broadly the most sensitive drug to the bacteria isolated in their study which was contrary to findings in this study. These variations in susceptibility may be due to the prescription habits in different localities as inappropriate exposure to antibiotics drive development of resistance (Iregbu and Nwajiobi-Princewill, 2013).

Hence, the sensitivity pattern of the antibiotics in this study confirmed that most of the urinary pathogens in our environment are resistant to the commonly used antibiotics. The high-level resistance development by these uropathogens could be as a result of repeated use or prolonged exposure of these uropathogens to the antibiotics (Seifu and Gebissa, 2018). The use of antibiotics repeatedly can cause damage to peri-urethral flora and this allows the colonization of the uropathogens thereby infection of the urinary tract. Hence, for the treatment of UTI, the clinicians are left with very few choices of antibiotics (Seifu and Gebissa, 2018). The results of this study ascertained that choosing drugs for empiric treatment will be challenging as no single common drug can conveniently be prescribed or recommended. This reinforces the need for mandatory urine culture for catheterized patients to properly guide therapy.

In this study, there was no deliberate attempt to test for extended spectrum beta lactamase (ESBL) in the isolates and this is the limitation. Judging this by the high level of resistance of some of the antibiotic, one can safely assume that they are present. Also, there are several documentation of extended spectrum beta-lactamase (ESBL) in uropathogen (Onipede *et al.,* 2010).

5.1 CONCLUSION

It was evident in this study that bacteriuria occur among the catheterized patients attending UITH and the incidence was found to be about 38.5%. The bacteria isolated were *E. coli, K. Pneumoniae, S. aureus, P. aeruginosa, P. mirabilis, Streptococcus* sp. and *Enterococcus* sp. The most predominant among the bacterial isolates was *E. coli* with an incidence of 35.1% whereas *Enterococcus* sp. was the least with an incidence of 5.2%. High level of resistance exist among the bacterial isolates in this study. Therefore, it is essential to limit all cases of urinary infections during all stages of catheterization by promoting an essential rigorous hygiene practices and regular surveillance/research of antibiotic use in the management of catheter-associated UTI to avoid multidrug resistance.

5.2 RECOMMENDATIONS

This study has shown that, indwelling catheter is a source of urinary infections among patients in UITH and since bacteriuria is inevitable on long term catheterization, the following recommendations are given;

- Unnecessary use of catheter as far as possible should be avoided, if necessary then it should be used for minimum period.
- Urine culture and sensitivity should be done among catheterized patients on regular basis to reduce catheter-related complications.
- Catheter should be changed periodically to prevent obstruction and formation of concretions that can lead to infection.
- Strict aseptic precaution has to be taken prior to catheter insertion and care after to prevent infection.
- Treatment of bacteriuria in these categories of patients should be guided by the result of susceptibility test of the isolated organisms.

CONTRIBUTIONS TO KNOWLEDGE

- This research work has affirmed that the use of urinary catheter is one of the major factors that predispose patients at UITH to urinary tract infection.
- Furthermore, it revealed that gender is a risk factor for developing bacteriuria associated with catheter-use, and that female are more prone to UTI associated with indwelling catheter.
- Due to high incidence of bacteriuria demonstrated in this study, there is need for the establishment of multidimensional infection control approach on catheter associated urinary tract infection.
- The most predominant bacteria responsible for catheter-related UTI is *Escherichia coli* and by *Klebsiella pneumoniae*.
- Nitrofurantoin, Ofloxacin and Ciprofloxacin are suggested to be the best antibiotic for UTI associated with catheter-use due to the sensitivity response of the bacteriuria.

REFERENCES

Abaeze, S. and Abasiama, J.S. (2011). The prevalence of urinary catheter-related infection in Federal Medical Centre Abeokuta, Nigeria. *International Journal of Pharmaceutical Biomedical Sciences* 2 (3) : 81 – 85.

Abejew, A.A., Denboba, A.A. and Mekonnen, A.G. (2014). "prevalence and antibiotic resistance pattern of Urinay tract bacterial infections in Dessie area, North-East Ethiopia", *BMC Research Note* 7(1) : 687.

Adjei, O. and Opoku, C. (2004). Urinary tract infections in African infants. *International Journal of Antimicrobial Agents*. 1 : 32 - 4.

Alavaren, H.F., Lim, J.A., Velmonte, M.A. and Mendoza, M.T. (1993). Urinary Tract Infection in Patients with Indwelling Catheter. *Journal of Microbial Infectious Diseases*. 22 (2) : 65 – 74.

Aly, S.A., Tawfeek, R.A. and Mohamed, I.S. (2016). Bacterial catheter-associated urinary tract infection in the Intensive Care Unit of Assiut University Hospital. *Al-Azhar Assiut Medical Journal.* 14 (2) : 52 – 58.

Ana, F., Walker, J.C., Hultgren, S. (2015). "Urinary Tract Infections; epidemiology, mechanisms of infection and treatment options" *Nature Review Microbiology*. 57 – 61.

Anandkumar, H., Kapur, I. and Dayanand, A. (2003). Increasing Prevalence of Antibiotic Resistance and Multi-drug Resistance Among Uropathogens. *Journal of Community Diseases*. 35: 102-8.

Armbruster, C.E., Prenovost, K., Mobley, H.L.T. and Mody, L. (2017). How Often Do Clinically Diagnosed Catheter-Associated Urinary Tract Infections in Nursing Home Residents Meet Standardized Criteria? *Journal of American Geriatric Society*. 65(2) : 395–401.

Armbruster, C., Mobley, H. and Pearson, M. (2018). Pathogenesis of Proteus mirabilis Infection. *EcoSal Plus.* 8(1) : 10

Arnoldo, L., Migliavacca, R., Raglio, A., Pagani, L., Nucleo, E., Spalla, M., Vailati, F., Agodi, A., Mosca, A., Zotti, C., Tardivo S., Bianco, I., Rulli, A., Gualdi, P., Panetta, P., Pasini, C., Pedroni, M. and Brusaferro, S. (2013). Prevalence of urinary colonization by extended spectrunbeta-lactamase Enterobacteriaceae among catheterized inpatients in italian long term care facilities. *BMC Infectious Diseases.* 13 : 124.

Averch, T.D., Stoffel, J., Goldman, H.B., Griebling, T.L., Lerner, L., Newman, D.K. and Peterson, A.C. (2015). AUA White Paper on Catheter Associated Urinary Tract Infections: Definitions and Significance in the Urological Patient. *Urology Practice*. 2(6) : 321–8.

Bagchi, I., Jaitly, N.K. and Thombare, V.R. (2015). Microbiological Evaluation of Catheter-Associated Urinary Tract Infection in a Tertiary Care Hospital. *People's Journal of Science.* 8 : 23-29.

Behzadi, P., Behzadi, E., Yazdanbod, H., Agapour, R., Akbari, M., and Salehian Omran, D. (2010). "A survey on urinary tract infections associated with the three most common uropathogenic bacteria". *Maedica.* 5(2) : 719 – 724.

Bergamin, P., and Kiosoglous, A., (2017). "Surgical management of recurrent urinary tract infections, a review". *Translational Andrology and Urology.* 6(2) : 153 – 162.

Beyene, G. and Tsegaye, W. (2011). Bacterial uropathogens in urinary tract infection and antibiotic susceptibility pattern in Jimma University Specialized Hospital, Southwest Ethiopia. *Ethiopia Journal of Health Sciences.* 21(2) : 44 – 56.

Blouin, A.S. (2010). Helping to solve health care most critical safety and quality problems. *Journal of Nursing Care Quality.*25(2) : 95 - 99.

Bootsma, A.M., Buurman, B.M., Geerlings, S.E. and de Rooij, S.E. (2013). Urinary incontinence and indwelling urinary catheters in acutely admitted elderly patients: relationship with mortality, institutionalization, and functional decline. *Journal of American Medical Dir Association*. 14(2) : 147 e7–12.

Boyce, J.M. and Pittet, D. (2002). Guideline for Hand Hygiene in Health-Care Settings: Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Infection Control Hospital Epidemiology*. 51(16) : 1 – 45.

Brennan, B.M., Coule, J.R., Marchaim, D., Pogue, J.M., Boehme, M., Finks, J., Malani, A.N., Verhec, K.E., Buckley, B.O., Mollon, N., Surdin, D.R., Washer, L.L. and Kaye, K.S. (2014). Statewide surveillance of carbapenem-resistant Enterobacteriaceae in Michigan. *Infection Control Hospital Epidemiology*. 35(8) : 342 – 349.

Brown, A. and Smith, H. (2014). "Microbiological Application". *Laboratory Manual in General Microbiology*. 2012: 74 – 78.

Brusch, J.L. (2017). Catheter-related urinary tract infection published by Medscape.

Centers for Disease Control and Prevention. (2002). Guidelines for the Prevention of Intravascular Catheter-Related Infections. http://www.cdc.gov/infectioncontrol.

Centers for Disease Control and Prevention. (2009). The direct medical costs of healthcare associated infections in U.S. hospital and the benefits of prevention. Retrieved from http:// www.cdc.gov/ncidod/dhqp/pdf/scott cost paper.pdf.

Centers for Disease Control and Prevention (CDC). (2013). National Healthcare Safety Network (NHSN) Report, Data Summary for 2011, Device-Associated Module, Atlanta.

Centers for Disease Control and Prevention (CDC). (2014). Hospital acquired infections data and statistics.

Centers for Disease Control and Prevention. (2015). Catheter-associated Urinary Tract Infections (CAUTI).Retrieved from http://www.cdc.gov/HAI/cauti/uti.html.

Centre for Disease Control and Prevention. (2016). Protocol for Reporting Catheter-Associated Urinary Tract Infections to the National Healthcare Safety Network. Centre for Disease Control and Prevention; January, 2016.

Chapple, C. (2011). Overview on the lower urinary tract. *Handbook of Experimental Pharmacology.* 202:1 – 14.

Chatterjee, S., Maiti, P., Dey, R., Kundu, A., and Dey, R. (2014). Biofilms on indwelling urologic devices : microbes and antimicrobial management prospect. *Annals of Medical and Health Science Research.* 4(1) : 100.

Chatterjee, S., Maiti, P., Dey, R., Kundu, A., Dey, R. (2014). Biofilms on indwelling urologic devices : microbes and antimicrobial management prospect. *Annals of Medical and Health Sciences Research.* 4(1): 100.

Cheesbrough and Monica. (2006). District Laboratory Practice in Tropical Countries Cambridge University Press. Pp 60 – 68.

Cheesebrough, M. (2000). District Laboratory Practice for Tropical Countries, Cambridge. Cambridge University Press. Low price edition Pp 62 – 70.

Cheesbrough, M. (2006). Examination of urine. In: Cheesebrough Monica, editors. District Laboratory practice in tropical countries. Part 2. *Cambridge University press* 2006: 105 - 114.

Clinical and Laboratory Standards Institute. (2012). Performance Standards for Antimicrobial Susceptibility Testing; Twenty-Second Informational Supplement. CLSI document M100-S21. Wayne, PA: Clinical and Laboratory Standards Institute.

Copan, K., Mehmet, T., Fatih, U., Sadik, A., Habib, A., Ibrahim, H. and Yeliz, G. (2016). "Antibacterial resistance patterns of pediatrics community-acquired urinary infection: Overview." *Pediatrics International*. 59(3) : 309 - 315.

Daniels, K.R., Lee, G.C. and Frei, C.R. (2014). Trends in catheter-associated urinary tract infections among a national cohort of hospitalized adults. *American Journal of Infection Control*. 42(1):17–22.

Daza, R., Gutierrez, J. and Pie drola, G. (2001). Antibiotic susceptibility of bacterial strains isolated from patients with community acquired urinary tract infections. *International Journal of Antimicrobial Agents*. 18 : 211 – 215.

Dougnon, T.V., Bankole, H.S., Johnson, R.C., Houmanou, G., Moussa, T.I., Houessou, C., Boko, M., and Baba, M.L. (2016). Catheter-Associated Urinary Tract Infections at a Hospital in Zinvie, Benin (West Africa). *International Journal of Infection.* 3(2) : 34141.

Drekonja, M.D., Kuskowski, M.A., Wilt, T.J. and Johson, B.R. (2008). Antimicrobial Urinary Catheter. A systematic Review. *Expert Review Medical series*. 5: 495-506.

Dudeck, M.A., Horan, T.C., Peterson, K.D., Allen-Bridson, K., Morrel, G. and Pollock, D. (2011). National Health Care Safety Network (NHSN). Report data summary of 2010. Device-associated module. *American Journal of Infection Control*. 39:798 – 816.

Dudeck, M.A., Weiner, L.M., Allen-Bridson, K., Malpiedi, P.J., Peterson, K.D., Pollock, D.A., Sievert, D.M. and Edwards, J.R. (2013). Catheter-associated urinary tract infection in adults. *American Journal of Infectious Control.* 41(12) : 1148 – 1166.

Dudeck, M.A., Edwards, J.R., Allen-Bridson, K., Gross, C., Malpiedi, P.J., Peterson, K.D., Pollock, D.A., Weiner, L.M. and Sievert, D.M. (2015). National Healthcare Safety Network report, data summary for 2013, Device-associated Module. *America Journal of Infection Control*. 43(3):206–21.

Ekrem, T., Nihal, P., Hande, A., Nefise, O. and Kokturk. (2012). Factors associated with catheter associated urinary tract infections and the effects of other concomitant nosocomial infections in intensive care. *Scand Journal of Infectious Diseases*. 44(5):344 – 349.

Esquevel, J., Aregein L., Sandoral, L., Guante, Q. and Enciso, I. (2009). Urinary Bacterial Sensitivity and Resistance in patients with Chronic Catheter. *The Internet Journal of Infectious Diseases.* 7 : 1 – 3.

Fawole, M.O. and Oso, B.A. (2004). Characterization of Bacteria Laboratory Manual of Microbiology. 4th Edition, Spectrum Book Ltd., Ibadan, 24 – 33.

Fawole and Oso (2007). Laboratory Manual of Microbiology. 1st Edition. Spectrum Books Limited, Ibadan, Nigeria, 34 - 35.

Fekete, T. (2020). Catheter-associated urinary tract infection in adults. https://www.uptodate.com/contents/catheterassociated- urinary-tract-infection-in-adults.

Feneley, R.C.L., Hopley, I.B. and Wells, P.N.T. (2015). Urinary Catheters history, current status, adverse events and research agenda. *Journal of Medical Engineering and Technology.* 39 (8): 459-470.

Flores-Mireles, A.L., Pinkner, J.S., Caparon, M.G. and Hultgren, S.J. (2014). EbpA vaccine antibodies block binding of *Enterococcus faecalis* to fibrinogen to prevent catheter-associated bladder infection in mice. *Science Translation Medicine*. 6(254).

Fourcade, C., Canini, L., Lavigne, J.P. and Sotto, A. (2015). A comparison of monomicrobial versus polymicrobial *Enterococcus faecalis* bacteriuria in a French University Hospital. *Europsean Journal Clinical Microbiology of Infectious Diseases*. 34(8): 1667–73.

Foxman, B. (2010). "The epidemiology of urinary tract infection". *Natures review*. 7 : 653 – 660.

Garcia, M.M., Gulati, S., Liepmann, D., Stackhouse, G.B., Greene, K. and Stoller, M.L. (2007). Traditional Foley Drainage Systems—Do They Drain the Bladder? *The Journal of Urology*. 177(1) : 203–7.

Gaynes, R. and Edwards, J.R. (2005). National Nosocomial Infections Surveillance S. Overview of nosocomial infections caused by gram-negative bacilli. *Clinical Infectious Diseases*. 41(6) : 848 – 854.

Geffers, C. and Gastmeier, P. (2011). Nosocomial infections and multiresistant organisms in Germany: Epidemiological data from KISS (The hospital Infection Surveillance). *Disch Arzetbel International*. 108 : 87 – 93.

Goossens, H., Ferech, M., Vander Stichele, R. and Elseviers, M. (2005). ESAC project Group. Outpatient antibiotic use in Europe and association with resistance : A cross – national database study. 365 : 579 – 87.

Grabe, M., Bjerklund-Johansen, T., Botto, H., Cek, M., Naber, R., Pickard, P., Tenke, P., Wagenheiler, F. and Wullt, B. (2013). "Guideline on urologic infections" *European Associated of Urology".* 5(2) : 435 – 440.

Guler, S., Ural, O., Fundic, D. and Arslan, U. (2006). Risk factors for nosocomial candiduria. *Saudi Medical Journal.* 27 (11) : 1706 – 1710.

Ha, U.S. and Cho, Y.H. (2006). Catheter-associated urinary tract infections: New aspects of novel urinary catheters. *International Journal of Antimicrobial Agents*. 28(6):485–490.

Hamdan, H., Kubarr, E., Adam, A., Hassan, O., and Sulman, S. (2015)."Urinary tract infections and antimicrobial sensitivity among diabetic patients at Khartoum, Sudan". *Annals of Clinical Microbiology and Antimicrobials.* 12 – 14.

Harper, M., and Fowlis, G. (2007). "Management of urinary tract infections in men". *Trends in Urology Gynecology Sexual Health.* 12 : 30 – 35.

Hootom, T.M., Bradley, S.F., Cardenas, D.D., Colgan, R., Geerlings, S.E., Rice, J.C., Saint, S., Schaeffer, A.J., Tambayh, P.A., Tenke, P. and Nicolle, L.E. (2010). Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 International Clinical Practice Guidelines from the Infective Diseases Society of America. *Clinical Infectious Diseases*. 50 (5) : 625 – 663.

Indranil Bagchi, Jaintly, N.K. and Thombare, V.R. (2012). Microbiological Evaluation of Catheter Associated Urinary Tract Infection in a Tertiary Care Hospital. *International Journal of Biological and Health Sciences*. 1 (2) : 1 – 10.

Iregbu, K.C. and Nwajiobi-Princewill, P.I. (2013). Urinary Tract Infection in a Tertiary Hospital in Abuja, Nigeria. *African Journal of Clinical and Experimental Microbiology*. 14 (3) : 169 – 173.

Jacobsen, S.M., Stickler, O.J., Mobley, H.L.T. and Shirtling, M.E. (2008). Complicated Cathteter-associated Urinary Tract Infections Due to *Escherichia coli* and *Proteus mirabilis*. *Clinical Microbiology Reviews*. 21 (1) : 26-59.

Jordan, R.P., Malic, S., Waters, M.G., Stickler, D.J. and Williams, D.W. (2015). Development of an antimicrobial urinary catheter to inhibit urinary catheter encrustation. *Microbiology Discovery.* 3 (1).

Juthani-Mehta, M., Quagliarello, V., Perrelli, E., Towle, V., Van Ness, P.H. and Tinetti, M. (2009). Clinical Features to Identify Urinary Tract Infection in Nursing Home Residents: A Cohort Study. *Journal of the American Geriatrics Society*. 57(6) : 963–70.

Juthani-Mehta, M., Tinetti, M., Perrelli, E., Towle, V., Van Ness, P.H. and Quagliarello, V. (2008). Interobserver variability in the assessment of clinical criteria for suspected urinary tract infection in nursing home residents. *Infection Control and Hospital Epidemiology*. 29(5) : 446–9.

Karkee, P., Dhital, D., Madhup, S.K. and Sherchan, J.B. (2017). Catheter Associated Urinary Tract Infection : Prevalence, Microbiological profile and Antibiogram at a Tertiary care Hospital. *Annual Clinical and Chemical Laboratory Medicine.* 3(2) : 3 – 10.

Kauffman, C.A. (2005). Candidurias. *Clinical Infectious Diseases*. 41 (6) : 371 – 376.

Khorvash, F., Mostafavizadeh, K., Mobasherizadeh, S. and Behjati, M. (2009). A comparison of antibiotic susceptibility patterns of *Klebsiella* associated urinary tract infection in spinal cord injured patients with nosocomial infection. *Acta Medica Iranica*. 47(6) : 447 – 450.

Kizilbash, Q.F., Petersen, N.J., Chen, G.J., Naik, A.D. and Trautner, B.W. (2013). Bacteremia and mortality with urinary catheterassociated bacteriuria. *Infection Control and Hospital Epidemiology*. 34(11) : 1153–9.

Kobayashi, C.C., de Fernandes, O.F., Miranda, K.C., de Sousa, E.D. and Silva Mdo, R. (2004). Candiduria in hospital patients: A study prospective. *Mycopathologia.* 158(1) : 49 – 52.

Kocak, M., Buyukkaragoz, B., Celebi Tayfur, A., Calt, K.A., Koksoy, A.Y. and Cizmeci, Z. and Gunbey, S. (2016). Causative pathogens and antibiotic resistance in children hospitalized for urinary tract infectons. *Pediatric International*. 58(6) : 467 – 471.

Kolawole, A.S., Kolawole, O.M., Kandaki – olukemi, Y.T., Babatunde, S.K., Durowade, K.A. and Kolawole, C.F. (2009). Prevalence of urinary tract infections (UTI) among patients attending Dalhatu Araf Specialist Hospital, Lafia, Nasarawa State, Nigeria. *International Journal of Medical Sciences.* 1 (5) : 163 – 167.

Kramer, A., Swebble, L. and Kampt, G. (2006). How long do nosocomial pathogens persist on inanimate surfaces? A systemic review. *BMC Infectious Diseases.* 130(6) : 1471 – 2334.

Lee, M.J., Kim, M., Kim, N., Kim, C., Song, K., Choe, P.G., Park, W.B., Bang, J., Kim, E., Park, S.W., Kim, N.J., Oh, M. and Kim, H.B. (2015). Why is asymptomatic bacteriuria over-treated? : A tertiary care institutional survey of resisent physicians. *BMC Infectious Diseases.* 15(289) : 463 - 707.

Leuck, A.M., Wright, D., Elligson, L., Kraemer, L., Kuskowski, M.A and Johnson, J.R. (2012). Complications of Foley catheters – is infection the greatest risk? *Journal of Urology.* 187(9) : 1662 – 1666.

Lo, E., Nicolle, L.E., Coffin, S.E., Gould, C., Maragakis, L., Meddings, J., Pegues, D.A., Pettis, A.M., Saint, S. and Yokoe, D.S. (2014). Strategies to prevent catheter-associated urinary tract infections in acute care hospitals. *Infection Control Hospital Epidemiology.* 35 : 464 – 479.

Lorente, L. (2015). The Role of Antimicrobial-Impregnated Catheters on Catheter- Related Bloodstream Infection Prevention. *International Journal of Infection*. 2(4) : 32568

Lundstorm, T. and Sobel, J.D. (2001). Nosocomial Candiduria: *A Review of Clinical Infectious Diseases*. 32(11) : 1602 – 1607.

Mabbette, A.N., Uleh, G.C., Watts, R.E., Tree, J.J., Totsika, M. and Wood, J.M. (2009). Virulence properties of asymptomatic bacteriuria *Escherichia coli*. *International Journal of Medical Microbiology*. 299(1) : 53 – 63.

Magill, S.S., Edwards, J.R., Bamberg, W., Beldaus, Z.G., Dumyati, G., Kainer, M.A., Lynfield, R., Maloney, M., McAllister-Hollod, L., Nadle, J., Ray, S.M., Thompson, D., Wilson, L.E. and Fridkin, S.K. (2014). Multistate point – prevalence survey of health care-associated infections. *England Journal of Medicine.* 370 : 1192 – 1208.

Mahshid, T.T. and Ali, G.P. (2009). Symptomatic nosocomial urinary tract infection in ICU patients. Identification of microbiologic resistance pattern. *Iranian Journal of Clinical Infectious Diseases*. 4(1) : 25 – 29.

Marschall, J., Carpenter, C.R., Fowler, S., and Trautner, B.W. (2013). Program CDCPE Antibiotic prophylaxis for urinary tract infections after removal of urinary catheter: Metaanalysis. *Britain Medical Journal*. 346 : 3147.

Mc Lellan, L., and Hunstad, D. (2016). "Urinary tract infections; pathogenesis and outlook". *Trends in Molecular Medicine.* 22(11) : 946 – 957.

Mirzarazi, M., Rezatofighi, S.E., Pourmahdi, M., and Mohajeri, M.R. (2013). Antibiotic resistance of isolated gram negative bacteria from urinary tract infections (UTI) in Isfahan. *Jundishapur Journal of Microbiology.* 6(8) : 6883

Mody, L., Krein, S.L., and Saint, S., Min, L.C., Montoya, A., Lansing, B., McNamara, S.E., Symons, K., Fisch, J., Koo, E., Rye, R.A., Galecki, A., Kabeto, M.U., Fitzgerald, J.T., Olmsted, R.N., Kauffman, C.A. and Bradley, S.F. (2015). A targeted infection prevention intervention in nursing home residents with indwelling devices: A randomized clinical trial. *JAMA Internal Medicine*. 175(5):714–23.

Naeem, M., Khan, M.A. and Qazi, S.M. (2010). Antibiotic susceptibility pattern of bacterial pathogens causing urinary tract infection in a tertiary care hospital. *Annals of Pakistan Institute of Medical Sciences*. 6 (4) : 214 – 218.

Najar, S., Saldahna, L., Banday, K. (2009). "Approach To urinary tract infections". Indian Journal of Nephrology. 19(4) : 129 – 139.

Narayanan, A., Nair, M.S., Muyyarikkandy, M.S. and Amalaradjou, M.A. (2018). Inhibition and activation of uropathogenic *Escherichia coli* biofilms on urinary catheters by sodium selenite. *International Journal of Molecular Science.* 19(6) : 1703

National Committee for Clinical Laboratory Standards. (2002). Performance standards for antimicrobial disc susceptibility tests. NCCLS document M2-A6. Approved Standards, 6th edition, Wayne, PA.

Nayareen, A., Rezwanur, R., and Shahin, R. (2016). “Antimicrobial sensitivity pattern of *Escherichia coli* causing Urinary Tract Infection in Bangladeshi patients” *American Journal of Microbiological Research.* 4(4) : 122 – 124.

Newman, D.K. and Wein, A.J. (2009). Managing and Treating Urinary Incontinence, 2nd Ed. Balhimore, MD : Health Professions Press. 365 – 483.

Newman, D. (2017). The indwelling urinary catheter. Principles for best practice. *Journal of Wound Ostomy and Continence Nursing.* 24 (6) : 655 – 661.

Nicolle, L.E. (2012). Urinary Catheter-Associated Infections. *Infectious Disease Clinics of North America*. 26(1):13–27.

Nicolle, L.E. (2014). Catheter associated urinary tract infections. *Antimicrobial Resistance and Infeection Control* 3:23.

Nicolle, L.E. (2014). Catheter-related urinary tract infection: practical management in the elderly. *Drugs Aging.* 31(1) : 1-10.

Nicolle, L.E., Gupta, K., Bradley, S.F., Colgan, R., DeMuri, G.P. and Drekonja, D., Eckert, L.O., Geerlings, S.E., Koves B., Hooton, T.M., Juthani-Mehta, M., Knight, S.L., Saint, S., Schaeffer, A.J, Trautner, B., Wullt, B. and Siemieniuk, R. (2019). Clinical Practice Guideline for the Management of Asymptomatic Bacteriuria: 2019 Update by the Infectious Diseases Society of America. *Clinical Infectious Diseases*. 68(10) : 1611–5.

Nieuwkoop, C., Van, S., Van der Stalenhoef, J., Aertrijk, A., Van reijden, T., Vander Vollard, A., and Knol, M.(2017). Treatment duration of Febril Urinary tract infections; a pragmatic randomized, double-trial in and women. *BMC Medicine.* 15(70) : 1 – 9.

Noor, F., Shams, F., Kishore, S., Hassan, M., and Noor, R. (2013). "Prevalence and antibiogram profile of uropathogens isolated from hospital and community patients with urinary tract infections". *Journal of Bangladesh Academy of Sciences.* 1 : 57 – 63.

Norsworthy, A.N., and Pearson, M.M. (2017). From catheter to kidney stone : the uropathogenic lifestyle of *Proteus mirabilis. Trends in Microbiology.* 25(4) : 304 – 315.

Nwankwo, I.U., Godwin, C.T. (2014). Evaluation of the Antibacterial susceptibility patterns in patients with Indwelling Urinary Catheters at Federal Medical Centre, Umuahia, Abia State. *Journal of Pharmacy and Biological Sciences.* 9(3) : 19 – 22.

Okonko, I.O., Ijandipe, L.A., Ilusanya, A.O., Donbraye-Emmanuel, O.B., Ejembi, J., Udeze, A.O., Egun, O.C., Fowotade, A. and Nkang, A.O. (2010). Detection of Urinary Tract Infection (UTI) among pregnant women in Oluyoro Catholic Hospital, Ibadan, South-Western Nigeria. *Malaysian Journal of Microbiology* 6(1) : 16 – 24.

Olaniran, O., Osevwe, J.A., Oyewole, O.C., Hassan, O.R., Eghogho. O., Odetoyin, W.B., Adefusi, O.F. and Awoyeni, E.A. (2016). The prevalence of urinary catheter Related Infections in Federal Medical Centre, Abeokuta, Nigeria. *Journal of Medical Science and Clinical Research.* 4(7) : 11486 – 11491.

Onipede, A., Oyekale, T.O., Olopade, B., Olaniran, O., Oyelese, A., and Ogunniyi, T.A. (2010). Urinary pathogens and their Antimicrobial susceptibility in patients with indwelling urinary catheter. *Sierra Leone Journal of Biomedical Research.* 2 (1) : 47 – 53.

Oyeleke, S.B. and Manga, S.B. (2008). Essentials of laboratory Practical in Microbiology. To best publisher, Minna, Nigeria. Pp. 20-80.

Pappas, P.G., Rex, J.H., and Sobel, J.D., Filler, S.G., Dismukes, W.E., Walsh, T.J. and Edwards, J.E. (2004). Guidelines for treatment of candidiasis. *Clinical Infectious Diseases*. 38(2) : 161-169.

Pikard, R., Lam, T., MacLennan, G., Starr, K., Kilonzo, M., Mcpherson, G., Gillies, K., McDonald, A., Walton, K., Buckley, B., Glazenger, C., Boachie, C., Burr, J., Norrie, J., Vale, L., Grant, A., and Nidow, J. (2012). Types of urethral catheter for reducing symptomatic urinary tract infections in hospitalized adults requiring short-term catheterization. *Health Technological Assess*. 16 (47) : 1 – 197.

Pratt, R.J., Pellowe, C., Wilson, J., Loveday, H., Harper, P., Jones, S. (2007). Epic 2 : national evidence-based guidelines for preventing health-care-associated infections in NHS hospitals in England. *Journal of Hospital Infection.* 65 : 1 – 9.

Rane, A., Dasgupta, R. and Springer-Link. (2013). Urinary Tract Infection: Clinical Perspectives on Urinary Tract Infection. London: Springer London. Pp 45.

Rogers, M.A.M., Mody, L., Kaufman, S.R., Fries, B.E., McMahon, L.F. and Saint, S. (2008). Use of Urinary Collection Devices in Skilled Nursing Facilities in Five States. *Journal of the American Geriatrics Society***.** 56(5) : 854–61.

Rosen, D. (2008). "Utilization of an intracellular bacteria community pathway in *Klebsiella pneumoniae* urinary tract infection and the effects of fink on type1 pilus expression". *Infection and Immunity.* 76(7) : 3337 – 3345..

Rosenthal, V.D., Maki, D.G., Salomao, R., Moreno, C.A., Mehta, Y., Higuera, F., Cuellar, L.E., Arikan, O.A., Abouqal, R. and Leblebicoglu, H. (2009). International Nosocomial Infection Control Consortium Device-associated nosocomial infections in 55 intensive care units of 8 developing countries. *Annual International Medicine*. 145: 582 – 591.

Rosenthal, V.D., Todi, S.K., Alvarez-moreno, C., Pawar, M., Karlekar, A., Zeggwagh, A.A., Mitrev, Z., Udwadia, F.E., Navoa-Ng, J.A., Chakravarthy, M., salomao, R., Sahu, S., Dilek, A., Kanj, S.S, Guanche-Garcell, H., Cuellar, L.E., Ersoz, G., Nevzat-Yolein, A., Jagg, N., Madeiros, E.A., Ye, G., Akan, D.A., Mapp, T., Castenada Sabogal, A., Matta – cortes, L.,Sirmate, I.F., Olark, N., Torres-Hernandes, H., Barahona-Guzman, N. and Fernandez-Hidalgo, R. (2012). Impact of a multidimensional infection control strategy on catheter-associated urinary tract infection rates in the adult intensive care units of 15 developing countries : findings of the international Nosocomial Infection Control Consortium. 40 : 517 – 526.

Saint, S., Wiese, J. and Amory, J.K., Bernstein, M.L., Patel, U.D., Zemencuk, J.K., Bernstein, S.J., Lipsky, B.A. and Hofer, T.P. (2000). Are Physicians Aware of which of their Patients have Indwelling Urinary Catheter ? *American Journal Medicine.* 109 (6) : 476 – 480.

Sandberg, T., Hansson, S. and Nyman, J. (2014). In Lakemedelsboken: Uppsala.

Sandhu, R., Sayal, P., Jakkhar, R. and Sharma, G. (2018). Catheter-associated urinary tract infections: Epidemiology and Incidence from tertiary care hospital in Haryana. *Journal of Health Research and Reviews in Developing Countries*. 5(3) : 135 – 141.

Sayal, P., Singh, K., and Devil, P. (2014). Detection of bacterial biofilm in patients with indwelling urinary catheters. *CIBTech Journal of Microbiology.* 3(3) : 9 – 16.

Sayyed,B., Jeremy, L., Mouslah, M., Barnache, B., Ren, J., Richard, T. and Meenaskshy, A. (2019). Uncomplicated urinary tract infection in ambulating primary care pediatries : are we using antibiotics appropriately? *Journal of Pediatric Pharmacology and Therapeutics* 24(1) : 39 – 44.

Sehulster, L.M., Chrinn, R.Y.W. and Ardurin, M.I. (2003). Guidelines for environmental Infection Control in healthcare facilities. Recommendations from CDC and the Health Care Infection Control Practices Advisory Committee (HICPAC). *MMWR Morbidity Mortal Weekly Report*. 52 : 1 – 4.

Seifu, W.D., and Gebissa, A.D. (2018). Prevalence and Antibiotic susceptivity of Uropathogens from cases of Urinary Tract Infection (UTI) in Shashemene referral hospital, Ethiopia. *BMC Infection Diseases.* 18 – 30.

Sekhsokh, Y., Chadli, M. and Hamzaoui, S.A. (2008). Frequency and antibiotic susceptibility of bacteria identified in urine. *Medical Manual of Infection*. 38(6) : 324-7.

Shuman, E.K. and Chenoweth, C.E. (2010). Recognition and Prevention of healthcare – associated urinary tract infections in the intensive care unit. *Critical Care Medicine.* 38 (8) : 373 – 379.

Singha, P., Locklin, J. and Handa, H. (2017). A review of the recent advances in antimicrobial coatings for urinary catheters. *Acta Biomaterialia*. 50 : 20–40.

Singleton, P. (1997). The identification and classification of Bacteria. In: Bacteria in Biology, Biotechnology and Medicine. 4th edition. John Wiley and Sons, England. Pp 340 – 348.

Sing-on Teng, Wensenlee, Tsong-Yih, O., Yu-chia Hsieh, Wuan-Lee and Yi-chun Lin. (2009). Bacterial contamination of patient's medical charts in a surgical ward and the intensive care unit: impact on nosocomial infections. *Journal of Microbiology and Immunology of Infections.* 42(1) : 86 – 91.

Stickler, D.J. (2008). Bacterial biofilms in patients with indwelling urinary catheters. *National Clinical Practice of Urology*. 5(11) : 598–608.

Stickler, D.J. (2012). 11-surface coatings in urology. *Coatings for Biomedical Applications*. 1st Cambridge, UK : woodhead publishing. 304 – 335.

Stone, N.D., Ashraf, M.S., Calder, J., Crnich, C.J., Crossley, K. and Drinka, P.J., Gould, C.V., Juthani-Mehta, M., Lautenbach, E., Loeb, M., Maccannell, T., Malani., P.N., Mody, L., Mylotte, J.M., Nicolle, L.E., Smith, P.W., Stevenson, K.B. and Bradley, S.F. (2012). Surveillance definitions of infections in long-term care facilities: revisiting the McGeer criteria. *Infection Control Hospital Epidemiology*. 33(10) : 965–77.

Taiwo,S.S., and Aderuomu, A.O.A. (2006). Catheter-Associated Urinary Tract Infection : Aetiologic Agents and Antimicrobial susceptibility pattern in Ladoke Akintola University Teaching Hospital, Oshogbo, Nigeria. *African Journal of Bio-medical Research*. 9 : 141 – 148.

Talsma, S.S. (2007). Biofilms on Medical devices. *Home Healthcare Nurse.* 25 (9) : 589 – 594.

Tambekar, D.H. and Shirsat, S.D. (2009). Handwashing; A cornerstone to prevent transmission of Diarrhoeal Infection. *Asian Journal of Medical Science*.

Thomas, W.E., Nilsson, L.M., Forero, M., Sokurenko, E.V., Vogel, V. (2004). Shear-dependent "stickand- roll" adhesion of type 1 fimbriated *Escherichia coli*. *Molecular Microbiology*. 53(5) : 1545–1557.

Thomas-white, K., Brady, M., Wolfe, A.J., and Mueller, E.R. (2016). The bladder is not sterile : history and current discoveries on the urinary microbiome. *Current Bladder Dysfunction Report.* 11(1) : 18 – 24.

Totsika, M., Moriel, G., Roger, A., Wurpel, J., Phan, D., Paterson, D., and Schembri, A. (2012). "Uropathogenic *Escherichia coli* mediated urinary tract infections". *Current Drug Targets*. 13(11) : 1386 - 1399.

Trautner, B.W., and Darouiche, R.O (2004). Role of biofilm in catheter-associated urinary tract infection. *American Journal of Infection Control.* 32(3) : 177 – 183.

Trautner, B.W., Prasad, P., Grigoryan, L., Hysong, S.J., Kramer, J.R., Rajan, S., Petersen, N.J., Rosen, T., Drekonja, D.M., Graber, C., Patel, P., Lichtenberger, P., Gauthier, T.P., Wiseman, S., Jones, M., Sales, A., Krein, S. and Naik, A.D. (2018). Protocol to disseminate a hospital-site controlled intervention using audit and feedback to implement guidelines concerning inappropriate treatment of asymptomatic bacteriuria. *Implementation Sci*ence 13(1) : 16 - 21.

Tsan, L., Langberg, R., Davis, C., Phillips, Y., Pierce, J., Hojlo, C., Gibert, C., Gaynes, R., Montgomery, O., Bradley, S., Danko, L. and Roselle, G. (2010). Nursing home-associated infections in Department of Veterans Affairs community living centers. *American Journal of Infection Control*. 38(6) : 461–466.

Ulett, G.C., Totsika, M., Schaale, K., Carey, A.J., Sweet, M.J. and Schembri, M.A. (2013). Uropathogenic *Escherichia coli* virulence and innate immune responses during urinary tract infection. *Current Opinion in Microbiology.* 16 (1) : 100 – 107.

Van Aarle,, S., Arents, L. and de Laet, K. (2013). "Actinobaculum Schaalii causing epididymitis in an elderly patient." *Journal of Medical Microbiology*. 62 : 1092 – 1093.

WHO. (2014). "Antimicrobial resistance : Global report on surveillance". https://apps.who.int/iris/handle/10665/112642.

WHO. (2018). WHO: Global action plan on antimicrobial resistance. http://www.who.int/antimicrobial resistance/publications/global-action-plan/en/.

Yvonne, J.C., Victoria, E.W., Morgan, T., Declan, D. and Andrew, F. (2018). Review of Catheter-Associated Urinary Tract Infections and Invitro Urinary Tract Models. *Journal of Healthcare Engineering.* 2018(3) : 1 – 16.

Zarb, P., Coignard, B., Griskeviciene, J., Muller, A., Vankerckhoven, V. and weist, k. (2012). The European Centre for Disease Prevention and Control (ECDC) pilot point prevalence survey of healthcare-associated infections and antimicrobial use. *European surveillance.* 17(46) : 1 – 16.

Appendix

Ethical Approval of the Kwara State Ministry of Health

Appendix II: Ethical Approval of the Kwara State Ministry of Health

MINISTRY OF HEALTH
KWARA STATE GOVERNMENT

MOH/KS/EU/777/489 **15th April, 2021.**

ISIAKA HABEEB SALMAN

Department of Bioscience and Biotechnology,
Faculty of Pure and Applied Sciences,
Kwara State University,
Malete, Kwara State.

APPROVAL TO CARRY OUT A RESEARCH TITLED: "Prevalence and Antibiotic Susceptibility of Bacterial Urinary Tract Infections in Patients with indwelling Urinary Catheter."

Sequel to your request and the interest of the State Ministry of Health in Health-related research activities to improve the health of the citizens. I am directed to forward to you the approval of the Ministry of Health to carry out the dissertation as itemized in your protocol.This approval dates from 15th April, 2021 to 15th April, 2022.

2. You are mandated to acknowledge the State Ministry of Health by your presentations/publications and deposition of the final copy of the research findings/publications.

3. Best wishes in your research project.

Alhaji Sidiq Abdulwahab Abubakar
For: Permanent Secretary

CMD/Officer in charge.

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Above for your information and necessary action, please.

P.M.B 1386, Fate Road, Ilorin, Kwara State
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