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**Prevalence of Urinary Tract Infection Pathogens and Their Antimicrobial
Susceptibility Patterns at Choma General Hospital.**

By

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**A research dissertation submitted to the University of Lusaka in partial fulfilment of the
requirements of MSc Degree in Epidemiology and Biostatistics**

Declaration

I, Lillian Mbewe, declare that this research report is my own work. It is being submitted for the Master of Science in Epidemiology and Biostatistics at the University of Lusaka, Lusaka, Zambia. It has not been submitted either wholly or partially for any Masters at this or other university.

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Date: 20/08/2026

Dedication

I dedicate this work to my husband, Mr Baidon Z. Khosa for his encouragement and unwavering support throughout my academic journey. I also dedicate it to my mum and dad, Jester Bwalya and Martin Mbewe for their support and encouragements. Lastly, I dedicate this work to my family and friends that supported me throughout my academic journey.

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Abbreviations

AST	Antimicrobial susceptibility testing
AMR	Antimicrobial resistance
cUTIs	Complicated Urinary Tract Infections
CGH	Choma General Hospital
CLSI	Clinical and Laboratory Standards Institute.
<i>E. coli</i>	<i>Escherichia coli</i>
ESBLs	Extended-Spectrum Beta-Lactamases
MDR	Multidrug Resistance
UPEC	Uropathogenic <i>Escherichia coli</i>
UTIs	Urinary Tract Infections
uUTIs	Uncomplicated Urinary Tract Infections

Abstract

Introduction: Urinary tract infections (UTIs) are common bacterial infections that contribute substantially to patient morbidity and are increasingly complicated by antimicrobial resistance.

Method: This retrospective cross-sectional study analyzed urine culture and antimicrobial susceptibility data from 386 samples processed at Choma General Hospital between June 2024 and May 2026 using Stata version 14.

Results: Culture-confirmed UTIs were detected in 113 samples, giving a culture-confirmed UTI prevalence of 29.27%. *Escherichia coli* was the predominant uropathogen, accounting for 51.3% of all isolates, followed by *Enterobacter agglomerans* (15.9%) and *Staphylococcus aureus* (9.7%). Females had a significantly higher prevalence of culture-confirmed UTIs than males ($p = 0.003$), while patients aged 65 years and above exhibited the highest burden of infection ($p < 0.001$). Meropenem, ceftriaxone, nitrofurantoin and piperacillin-tazobactam demonstrated the highest effectiveness against most uropathogens, whereas substantial resistance was observed to ampicillin, trimethoprim-sulfamethoxazole, ciprofloxacin and several other commonly used antibiotics.

Conclusion: These findings highlight the need for routine surveillance of uropathogens and antimicrobial resistance patterns to guide empirical therapy, improve patient outcomes, and strengthen antimicrobial stewardship efforts at Choma General Hospital.

Keywords: Urinary tract infections, uropathogens, *Escherichia coli*, antimicrobial susceptibility testing, antimicrobial resistance, Zambia.

Chapter One: Introduction

1.0 Introduction

1.1 Background

Urinary tract infections (UTIs) are some of the most common bacterial infections worldwide. In many developing countries, including Zambia, UTIs are among the most common bacterial infections across all age groups, particularly among women, children, and the elderly (Mwang'onde and Mchami, 2022). Risk factors for UTIs include female anatomy, advanced age, family history, frequent sexual partners, immunosuppression, use of diaphragms or spermicides, menopause and chronic health issues such as diabetes (Mititelu *et al.*, 2024). The majority of UTIs occur when microorganisms ascend through the urethra and colonize the bladder, with uropathogenic *Escherichia coli* (UPEC) being the predominant causative organism (Flores-Mireles *et al.*, 2015).

UTIs may involve the lower urinary tract, such as cystitis (bladder infection), or progress to the upper tract, such as pyelonephritis (kidney infection), which can lead to severe health complications if not managed promptly (Flores-Mireles *et al.*, 2015). The main causative agent of UTIs is bacteria, although more rarely, other microorganisms such as fungi and some viruses, have been reported to be responsible for UTIs (Mancuso *et al.*, 2023). The distribution of uropathogens can vary based on factors such as age, gender and hospitalization status (Seifu and Gebissa, 2018). Most UTIs are caused by uropathogenic *Escherichia coli* (UPEC), although other pathogens also contribute to disease burden (Flores-Mireles *et al.*, 2015). UTIs may present as uncomplicated or complicated infections. If not treated or inadequately managed, the infection may ascend to the kidneys or spread into the bloodstream, leading to severe complications such as renal damage, bacteremia, urosepsis, septic shock and in some cases, death.

Despite the widespread availability of antimicrobial agents, the inappropriate use of antibiotics and delays in diagnosis have led to a rise in antimicrobial resistance (AMR), with patterns varying by region. The emergence of multidrug-resistant (MDR) strains has resulted in more frequent treatment failures and increased healthcare costs (Linhares *et al.*, 2013). To promote rational antibiotic use, many health facilities develop antibiograms to track susceptibility trends and guide empiric treatment, however their effectiveness is limited without regularly updated microbiological data (Ekwealor *et al.*, 2016). Monitoring uropathogen susceptibility is vital for

guiding empiric treatment and combating multidrug-resistant infections. Furthermore, strengthening local surveillance and conducting regional studies are key to improving treatment outcomes and informing antibiotic stewardship efforts (Sah *et al.*, 2023).

1.2 Statement of the Problem

UTIs are typically treatable with antibiotics, the choice of initial antibiotics is based on knowledge of common local pathogens and their susceptibility patterns, often drawn from a local antibiogram. However, the lack of up-to-date, area-specific data on local antibiogram severely limits healthcare providers' ability to prescribe appropriate empirical treatment choices and undermines the development of effective antibiotic stewardship programs. This contributes to inappropriate antibiotic use, increasing the risk of developing drug-resistant infections during empiric treatment, making the treatment of UTIs increasingly challenging, as antibiotics become less effective highlighting the need for current local susceptibility data. In Zambia, data from University Teaching Hospitals (2025) reported significant bacteriuria in 17.6% of urine specimens analyzed, with Gram-negative isolates demonstrating high resistance to commonly used antibiotics, including ampicillin (96.2%), trimethoprim-sulfamethoxazole (87.3%), and ciprofloxacin (64.2%). Resistance to nitrofurantoin was comparatively lower at 25.3%, while piperacillin-tazobactam showed 4.9% resistance. These findings demonstrate a burden of antimicrobial resistance among clinically important bacterial pathogens and highlight the limitations of relying on empirical therapy without current susceptibility data. As a result, patients experience longer durations of illness, increased risk of complications and higher treatment costs, placing additional strain on an already burdened healthcare system. Another contributing factor to this problem is the absence of systematic surveillance and monitoring of UTI pathogens and their susceptibility patterns. In the absence of adequate susceptibility data, it becomes difficult to develop reliable antibiograms or monitor the emergence of antibiotic resistance over time.

1.3 Justification of the Study

Empiric treatment is based on etiological microorganisms and available data reflecting antibiotic susceptibility and resistance. The causative organisms of urinary tract infections (UTIs) and their antibiotic susceptibility patterns show significant geographical variations, thus, regular

surveillance of susceptibility patterns at local level is necessary to guide clinicians in treatment and management of UTIs. Furthermore, the etiology and drug resistance patterns change through time, and as such, knowledge is required to trace any change that might have occurred in time so that updated recommendations for optimal empirical treatment of UTIs can be made. Thus, the study will provide data on the current prevalence and antimicrobial susceptibility patterns of UTI pathogens at Choma general hospital and provide evidence-based guidance for clinical management, enhance informed decision-making and encourage the rational use of antibiotics. In Zambia, a few studies have been done on the prevalence and antimicrobial resistance patterns of UTIs, however, there is scarce information reported from the present study area, hence the need to carry out the study to determine the prevalence of local bacterial isolates and susceptibility patterns of causative organisms.

1.4 Main Objective

- To assess the Prevalence of urinary tract infection pathogens and their antimicrobial susceptibility patterns at Choma General Hospital.

1.5 Specific Objectives

- To determine the prevalence of UTIs at Choma General Hospital.
- To identify the most common bacterial pathogens causing UTIs at Choma General Hospital.
- To assess the antimicrobial susceptibility patterns of common pathogens that cause UTIs.

1.6 Research Questions

- What is the prevalence of UTIs among patients presenting with symptoms at Choma General Hospital?
- Which bacterial pathogens are most commonly associated with UTIs?
- What is the susceptibility profile of common pathogens that cause UTIs.?

1.7 Scope of the study

This study was carried out at the Microbiology Department of Choma General Hospital in Southern Province, Zambia. It was a retrospective cross-sectional design to investigate the prevalence of urinary tract infections (UTIs), determine the distribution of common bacterial uropathogens, and evaluate their antimicrobial susceptibility patterns. The study utilized archived laboratory records of urine culture and antimicrobial susceptibility tests performed on specimens received between June 2024 and May 2026.

The study included urine specimens from both inpatients and outpatients of all ages and both sexes who underwent urine culture during the study period. Information extracted from the laboratory records included patient age, sex, patient status, urine culture results, bacterial isolates, and antimicrobial susceptibility profiles. Only records with complete laboratory data and significant bacterial growth were considered for analysis, whereas duplicate isolates, contaminated specimens, incomplete records, and specimens without significant bacterial growth were excluded. the analysis was based solely on information available in archived laboratory records, and no direct patient contact or follow-up was undertaken. Antimicrobial susceptibility results were interpreted using the laboratory's routine testing procedures and standard guidelines applied during the study period. The scope of this study was restricted to the analysis of routine microbiological laboratory data and did not include patients' clinical characteristics, treatment outcomes, associated risk factors, or molecular characterization of antimicrobial resistance. Therefore, the findings provide an overview of the prevalence of culture-confirmed bacterial UTIs, the distribution of uropathogens and their antimicrobial susceptibility patterns among patients at Choma General Hospital during the study period. Despite these limitations, the study provides valuable baseline data that can support local antimicrobial stewardship initiatives, inform empirical treatment decisions, and serve as a reference for future surveillance and research on urinary tract infections at Choma General Hospital.

Chapter Two: Literature Review

2.1 Literature Review

2.1.1 Epidemiology of Urinary Tract Infections (UTIs)

UTIs are one of the most prevalent types of bacterial infection affecting close to 400 million individuals and around 230,000 deaths each year globally in 2019 (Yang *et al.*, 2022). The cause of 95% of UTIs is bacterial infection (Muhammad, A *et al.*, 2020). UTIs can occur at all ages; however, they have a high prevalence in women, elderly, pregnant women, and those who have underlying diseases such as diabetes mellitus, abnormalities in the urinary tract, or those who require catheterization of the urinary tract. Gram-negative bacteria are the leading cause of UTIs, responsible for about 90% of cases, whereas gram-positive bacteria contribute to about 10% (Seifu and Gebissa, 2018). Among the gram negative bacteria, Uropathogenic *Escherichia coli* (UPEC) is the primary cause of UTIs worldwide, accounting for community-acquired cases and many complicated infections (Whelan, Lucey and Finn, 2023). Other commonly isolated pathogens include *Klebsiella pneumoniae*, *Proteus mirabilis*, *Enterococcus* species and *Staphylococcus saprophyticus* (Zhou *et al.*, 2023).

Distribution of uropathogens is dependent on various factors such as age, gender, catheterization, hospitalization, and history of antimicrobial usage (Seifu & Gebissa, 2018). In the last few years, the development of resistance to antibiotics has been identified as an important issue for public health. It includes resistance to ESBLs Enterobacterales, resistance to fluoroquinolones, and multidrug resistance of uropathogens (Bandy and Tantry, 2021).

Although the pathogens causing urinary tract infections (UTIs) are the same worldwide, there are marked differences in their susceptibility to antimicrobial drugs depending on the geographical area, hospital environment, and the populations that they infect (Pietrucha-Dilanchian and Hooton, 2016). This is largely because of different antibiotic prescription practices, antimicrobial stewardship policies, infection control practices, and even access to antibiotics. In addition, factors such as community versus hospital-acquired infections, age, underlying comorbidities, urinary catheterization and previous antimicrobial exposure contribute to differences in resistance profiles among uropathogens (Muhammad, A *et al.*, 2020).

2.1.2 Risk factors of UTIs

The risk of developing a urinary tract infection (UTI) is influenced by several intrinsic and acquired factors that increase bacterial colonization of the urinary tract. A combination of host-

related, behavioral, anatomical and healthcare-associated factors that increase the likelihood of bacterial entry, colonization and persistence within the urinary tract. These include urinary retention, frequent sexual activity, prostatic enlargement, vulvovaginal atrophy, a family history of UTIs and the use of spermicidal contraceptives(Mancuso *et al.*, 2023). Other important risk factors include pregnancy, hospitalization, urinary catheterization and chronic conditions such as diabetes mellitus, which impair host immune defenses and promote bacterial growth (Flores-Mireles *et al.*, 2015). Under normal conditions, several protective mechanisms, including continuous urine flow, bladder emptying and antimicrobial properties of urine, prevent infection(Munoz, Uhlemann and Barasch, 2022)

Even though these infections are highly prevalent, it is important to have an accurate diagnosis for proper patient care. The diagnosis mainly depends on the clinical presentation and supported by urinalysis and urine culture (Flores-Mireles *et al.*, 2015).). Although urinalysis helps confirm the presence of infection, urine culture with antimicrobial susceptibility test is the gold standard method. This approach improves treatment outcomes and supports antimicrobial stewardship by reducing inappropriate antibiotic use and limiting the development of antimicrobial resistance (Rana, Sharma and Sheerswal, 2025).

2.1.3 Pathogenesis of UTIs

The urinary system consists of the kidneys, ureters, bladder, and urethra, which collectively play a vital role in filtering blood, maintaining fluid and electrolyte balance and removing waste by means of urine production. In healthy state, the urinary tract is considered to be sterile thanks to various protection mechanisms, namely constant flow of urine, frequent bladder emptying, antibacterial properties of urine and the immune response of the host (Andrews *et al.*, 2023). Urinary tract infections (UTIs) are caused by pathogenic microorganisms that penetrate into the urinary system, attach themselves to the uroepithelium and multiply within it. Despite the fact that infection may occur at any site of the urinary system, UTIs occur predominantly in the urethra and bladder, while infection of the kidneys causes a more serious disorder known as pyelonephritis (Zhou *et al.*, 2023). The spread of uropathogens in the urinary tract is associated with their adherence to and invasion into host tissues, which are directly related to the presence of virulence factors(Mancuso *et al.*, 2023). The course of infection usually proceeds in several stages, starting from colonization of the urethra, followed by the bladder and the spread to the kidneys through

the ureters, resulting in cystitis and pyelonephritis (Flores-Mireles *et al.*, 2015). The development and severity of UTIs depend both on host-related risks and the ability of the uropathogens to adhere and invade the urinary system (Lewis, Richards and Mulvey, 2016). If the host immune system cannot kill these bacteria, they reproduce and produce toxins and enzymes, ensuring their survival (Mancuso *et al.*, 2023).

Although UTIs are effectively treated with antibiotics, recurrences are rather a common issue in medicine, which affects especially females, elderly patients, people who have anatomic abnormalities of the urinary system, indwelling urinary catheters and people with underlying chronic diseases such as diabetes mellitus (Mittal *et al.*, 2023).). Such a condition causes additional discomfort for the patients, worsens their quality of life and requires repeated treatment, thus contributing to the development of antibiotic-resistant organisms (Weichhart *et al.*, 2008).

2.1.4 Symptoms of Urinary Tract Infections

Symptoms of UTIs will depend on the location of the infection as far as anatomic sites are concerned, including minor urinary symptoms to major symptoms of a systemic disease when infection spreads to kidneys. Lower UTIs, such as cystitis, for instance, usually come with dysuria, urinary frequency, urinary urgency, nocturia, suprapubic discomfort, and sometimes hematuria (Rana, Sharma and Sheerswal, 2025). Symptoms such as cloudy urine, unpleasant smell of urine, and feeling of incomplete bladder emptying may occur because of inflammation of the mucosa of the urinary tract, which occurs due to bacteria invading and the ensuing immune response (Bilsen *et al.*, 2023)

When the infection ascends and reaches kidneys, the patient may experience pyelonephritis symptoms, including fever, shivers, flank pain, nausea, vomiting, and weakness of the body (Bilsen *et al.*, 2023). This shows a more profound inflammatory reaction and indicates a complex type of infection that requires urgent treatment. In severe cases, mainly in people with a urinary catheter, with poor immunity or those with other illnesses, UTIs may lead to the bloodstream infection, sepsis, and systemic complications (Rana, Sharma and Sheerswal, 2025).

The symptoms of UTIs will be different in various population groups. For instance, in elderly people, there may be no classical urinary symptoms but rather changes in cognitive functions, decline in performance and general deterioration. In young people, infection may present itself

through fever, irritability, vomiting, lack of appetite, abdominal pain, or even new urinary incontinence (Mancuso *et al.*, 2023)

In pregnant women and people with conditions such as diabetes mellitus or malformations of the urinary tract, symptoms may be atypical (Weichhart *et al.*, 2008). Although symptoms are useful in raising suspicion of UTI, clinical assessment alone cannot reliably confirm infection because similar symptoms may occur in other urinary and genital disorders. Laboratory confirmation through urinalysis, urine microscopy, urine culture, and antimicrobial susceptibility testing is therefore essential to identify the causative pathogen, determine antimicrobial sensitivity and guide appropriate treatment decisions

2.1.5 Routes of Urinary Tract Infection Spread

The hematogenous route is much less common and occurs when microorganisms circulating in the bloodstream affect the kidneys during episodes of bacteremia or systemic infection. This route is typically associated with pathogens such as *Staphylococcus aureus*, *Candida* species and *Salmonella* species, particularly in individuals with severe bloodstream infections or weakened immune systems (Belyayeva M *et al.* 2026). Although uncommon, hematogenous spread can result in renal abscesses and other serious complications. The lymphatic route is considered the rarest mechanism of UTI development. In this pathway, microorganisms spread through lymphatic vessels from adjacent infected organs or tissues to the urinary tract (Sujith, Solomon and Rayappan, 2024). While evidence supporting this route is limited, it may occur in the presence of severe pelvic or intra-abdominal infections where lymphatic drainage provides a pathway for bacterial dissemination.

The development of UTIs depends not only on bacterial invasion but also on host susceptibility. Several factors impair the body's natural defense mechanisms and increase the likelihood of infection. Pregnancy promotes urinary stasis due to hormonal and anatomical changes, facilitating bacterial growth. Diabetes mellitus predisposes individuals to UTIs through impaired immune function, glucosuria, and bladder dysfunction, while immunosuppression reduces the body's ability to eliminate invading microorganisms (Mancuso *et al.*, 2023). Additional risk factors such as advanced age, urinary tract instrumentation, recurrent catheterization, renal calculi and congenital urinary tract abnormalities further increase susceptibility to infection (Sujith, Solomon and Rayappan, 2024). Understanding these routes of infection and associated risk factors is essential

for developing effective prevention strategies and guiding appropriate clinical management of UTIs.

2.1.6 Classification of UTIs

Urinary tract infections (UTIs) can be classified according to the anatomical site of infection, the presence of underlying risk factors and the pattern of recurrence. Based on anatomical location, urethritis refers to inflammation of the urethra, ureteritis involves infection of the ureters, cystitis affects the urinary bladder and pyelonephritis is an infection of the kidneys (Dickson, Zhou and Lehmann, 2024). Lower UTIs, which include urethritis and cystitis, are generally associated with localized symptoms such as dysuria, urinary frequency, urgency and suprapubic discomfort. In contrast, upper UTIs, including pyelonephritis, are more severe and often present with systemic manifestations such as fever, chills, flank pain, nausea and vomiting (Belyayeva M *et al.* 2026). If left untreated, upper UTIs can result in serious complications, including renal scarring, abscess formation, bacteremia and sepsis. UTIs can also be classified according to the presence or absence of predisposing factors into uncomplicated and complicated infections (Pietrucha-Dilanchian and Hooton, 2016).

They can also be categorized based on presence or absence of predisposing factors (uncomplicated vs. complicated) or by occurrence type (primary vs. recurrent) (Storme *et al.*, 2019). Uncomplicated UTIs (uUTIs) typically occur in otherwise healthy individuals without structural or neurological abnormalities of the urinary tract. In contrast, complicated UTIs (cUTIs) are associated with conditions that increase susceptibility to infection. These conditions include urinary catheterization, urinary tract obstruction, renal calculi, congenital or acquired anatomical abnormalities, neurogenic bladder, immunosuppression, pregnancy and chronic diseases such as diabetes mellitus (Zagaglia *et al.*, 2022). These infections are often marked by higher treatment failure rates and may involve systemic spread or deeper tissue invasion (Flores-Mireles *et al.*, 2015).

Another classification is based on the pattern of occurrence. Primary UTIs represent the first documented episode of infection in an individual, whereas recurrent UTIs are defined as repeated symptomatic episodes occurring after complete resolution of a previous infection (Sujith, Solomon and Rayappan, 2024). Recurrent infections may result from bacterial relapse, where the same

organism persists despite treatment, or reinfection with a different strain or species after successful eradication of the initial infection (Storme *et al.*, 2019). Recurrent UTIs are particularly common among women and are associated with factors such as frequent sexual activity, postmenopausal hormonal changes, urinary tract abnormalities and incomplete bladder emptying (Sujith, Solomon and Rayappan, 2024). Community-acquired urinary tract infections occur outside healthcare settings and are mainly caused by uropathogenic *Escherichia coli* originating from the intestinal flora. Hospital-acquired urinary tract infections develop after hospital admission, most commonly following urinary catheterization (Andrews *et al.*, 2023). These infections are frequently caused by multidrug-resistant organisms, making them more difficult to treat and contributing to increased morbidity among hospitalized patients. Distinguishing between uncomplicated and complicated infections, as well as primary and recurrent UTIs, is important because these classifications influence diagnostic evaluation, treatment selection, duration of antimicrobial therapy and strategies for preventing recurrence (Dickson, Zhou and Lehmann, 2024).

2.1.7 Diagnosis of Urinary Tract Infections

Accurate diagnosis of urinary tract infections (UTIs) is essential for confirming infection, identifying the causative pathogen and guiding appropriate antimicrobial therapy (Mohan and Mitsakakis, 2026). Although clinical symptoms suggest a UTI, laboratory investigations are necessary to confirm the diagnosis and differentiate UTIs from other conditions with similar presentations (Abbott *et al.*, 2023).

. The diagnosis of UTIs is primarily based on urinalysis, urine microscopy, urine culture and antimicrobial susceptibility testing (AST) {Formatting Citation} . Urinalysis is commonly used as an initial screening investigation for suspected UTIs due to its rapid turnaround time and ability to detect indicators of infection. Chemical analysis of urine using dipstick methods identifies markers such as leukocyte esterase and nitrites. The presence of leukocyte esterase indicates pyuria resulting from an inflammatory response, while nitrite positivity suggests the presence of nitrate-reducing bacteria, particularly Gram-negative uropathogens such as *Escherichia coli*. Other parameters, including hematuria, proteinuria, urine pH, and specific gravity, may provide additional information regarding urinary tract abnormalities (Pietrucha-Dilanchian and Hooton, 2016). Microscopic examination of urine sediment provides further evidence of infection through the detection of white blood cells, bacteria, epithelial cells, and other abnormalities (Mohan and

Mitsakakis, 2026). Pyuria and bacteriuria are commonly associated with UTIs and support the diagnosis; however, microscopy alone has limitations because it does not accurately identify the causative organism or determine antimicrobial susceptibility. Therefore, additional microbiological investigations are required for definitive diagnosis and treatment guidance (Rana, Sharma and Sheerswal, 2025).

Urine culture remains the gold standard method for confirming bacterial UTIs. Culture results determine whether significant bacteriuria is present and allow identification of specific uropathogens (Mancuso *et al.*, 2023). Following isolation of a pathogen, antimicrobial susceptibility testing (AST) is performed to determine the effectiveness of available antibiotics against the organism. AST methods, such as the Kirby–Bauer disc diffusion technique, automated systems, and minimum inhibitory concentration testing, provide essential information on antimicrobial resistance patterns (Mohan and Mitsakakis, 2026). These results enable clinicians to select appropriate antimicrobial therapy, minimize treatment failure and support antimicrobial stewardship efforts by reducing unnecessary antibiotic use and limiting the spread of resistant organisms (Bandy and Tantry, 2021). In addition to conventional diagnostic methods, molecular techniques such as polymerase chain reaction (PCR) are increasingly being explored for rapid detection of uropathogens and antimicrobial resistance genes. However, their routine application remains limited in many healthcare settings due to cost, technical requirements, and availability (Flores-Mireles *et al.*, 2015). Therefore, a combination of urinalysis, urine microscopy, urine culture, and AST remains the most practical and reliable approach for diagnosing UTIs and ensuring effective patient management.

Antimicrobial resistance (AMR) is a major global public health challenge that complicates the treatment of urinary tract infections (UTIs). It occurs when microorganisms develop the ability to survive exposure to antimicrobial agents that were previously effective, resulting in treatment failure, prolonged illness, increased healthcare costs, and higher morbidity and mortality (Mohan and Mitsakakis, 2026).

2.1.8 Treatment and Management of Urinary Tract Infections

The primary goals of urinary tract infection (UTI) treatment are to eliminate the causative microorganism, relieve symptoms, prevent the spread of infection and reduce the risk of recurrence (Abbott *et al.*, 2023). Early and appropriate treatment helps shorten the duration of

illness, prevents complications such as pyelonephritis and urosepsis and improves patient recovery. In addition, effective management aims to preserve kidney function and limit the development and spread of antimicrobial resistance. Initial treatment is often started empirically and later modified based on urine culture and antimicrobial susceptibility test results to improve therapeutic effectiveness and promote appropriate antibiotic use (Goebel, Trautner and Grigoryan, 2021). The choice of treatment depends on several factors, including whether the infection is uncomplicated or complicated, the site of infection (lower or upper urinary tract), the severity of symptoms, the patient's age and sex, pregnancy status, underlying medical conditions, previous history of UTIs, recent antibiotic use and local antimicrobial resistance patterns (Flores-Mireles *et al.*, 2015). Patients with mild uncomplicated cystitis may be managed with oral antibiotics, whereas those with severe or complicated infections may require hospitalization, intravenous antibiotics and supportive care (Mittal *et al.*, 2023).

Uncomplicated UTIs are commonly treated with oral agents such as nitrofurantoin, Fosfomycin, or trimethoprim-sulfamethoxazole when the causative organism is susceptible (Goebel, Trautner and Grigoryan, 2021). However, complicated UTIs may require broader-spectrum antibiotics, intravenous therapy, hospitalization, and management of underlying conditions contributing to infection (Mittal *et al.*, 2023). Routine urine culture, antimicrobial susceptibility testing and antimicrobial stewardship programs play a critical role in guiding antibiotic selection, reducing the emergence of antimicrobial resistance and improving clinical outcomes (Goebel, Trautner and Grigoryan, 2021).

2.1.9 Antimicrobial Resistance in Urinary Tract Infections

The increase in resistance among uropathogens is attributed to various causes like incorrect administration of antibiotics, empiric therapy not based on culture and antimicrobial susceptibility testing, self-medication, non-compliance to the prescribed regimen, and poor infection control procedures. These aspects facilitate the emergence and spread of resistant strains of bacteria (Mancuso *et al.*, 2023). The most common uropathogen, *Escherichia coli*, together with *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Enterococcus species*, has shown increasing resistance to commonly used antibiotics, including ampicillin, trimethoprim-sulfamethoxazole, fluoroquinolones, and cephalosporins (Abbott *et al.*, 2023). The emergence of multidrug-resistant

and extended-spectrum β -lactamase (ESBL)-producing bacteria has further limited treatment options for UTIs(Mohan and Mitsakakis, 2026).

Antimicrobial susceptibility testing (AST), performed according to standardized guidelines such as those of the Clinical and Laboratory Standards Institute (CLSI), is essential for guiding appropriate antibiotic therapy and monitoring resistance trends(Flores-Mireles *et al.*, 2015). Continuous surveillance of local antimicrobial susceptibility patterns is therefore necessary to support effective empirical treatment, antimicrobial stewardship and the control of antimicrobial resistance(Abbott *et al.*, 2023) .

2.1.10 Prevalence and Susceptibility Patterns of Uropathogens

The incidence of UTIs around the world is very diverse depending on the country or region in question due to disparities in demographic factors, healthcare practice, diagnostic techniques, and antimicrobial resistance patterns(Flores-Mireles *et al.*, 2015). Despite these geographical variations, *Escherichia coli* remains the predominant uropathogen worldwide, accounting for approximately 80–90% of UTIs (Kaur *et al.*, 2022). A number of studies have demonstrated that while the bacterial species responsible for UTIs are relatively consistent across different settings, antimicrobial susceptibility patterns vary substantially. Increasing resistance to commonly prescribed antibiotics has become a major public health concern, emphasizing the need for continuous local and regional surveillance to guide empirical antibiotic therapy(Flores-Mireles *et al.*, 2015). Worldwide research studies regarding UTIs indicate differing patterns of resistance to certain commonly used antibiotics.

In Senegal, Barry et al. (2017) reported a UTI prevalence of 26.7%, with Gram-negative bacteria accounting for more than 95% of all isolates. *Escherichia coli* was the predominant organism, representing 50.3% of isolates, followed by *Klebsiella species* (14.3%), *Pseudomonas aeruginosa* (9.5%), and *Enterobacter cloacae* (6.8%). The study demonstrated that imipenem was the most effective antimicrobial agent, with resistance observed in less than 3% of isolates. Amikacin and cefotaxime also showed good activity, with susceptibility rates of 70% and 67%, respectively, while cefixime was identified as the most effective orally administered antibiotic, demonstrating a susceptibility rate of 61%. In contrast, trimethoprim-sulfamethoxazole, nalidixic acid, and fluoroquinolones exhibited poor activity, with resistance rates of 73%, 69%, and 60%,

respectively. These findings indicate that although carbapenems and aminoglycosides remain highly effective against uropathogens, resistance to commonly prescribed oral antibiotics is widespread, limiting their usefulness for empirical treatment.

Similarly, Ben Ashur *et al.* (2021) reported an overall UTI prevalence of 55%, with Gram-negative bacteria accounting for the majority of isolates. *Escherichia coli* was the most frequently isolated organism, constituting 55.68% of Gram-negative isolates, followed by *Klebsiella pneumoniae* (20.46%), *Pseudomonas aeruginosa* (10.23%), *Proteus mirabilis* (9.09%), *Enterobacter aerogenes* (2.27%), and *Citrobacter freundii* (2.27%). Among Gram-positive bacteria, *Staphylococcus aureus* accounted for 90.91% of isolates, while *Staphylococcus saprophyticus* represented 9.09%. The study further demonstrated high levels of antimicrobial resistance among the major uropathogens. *Escherichia coli*, *Klebsiella pneumoniae*, and *Staphylococcus aureus* exhibited considerable resistance to nitrofurantoin, trimethoprim-sulfamethoxazole, tetracycline, ciprofloxacin, and metronidazole. However, these organisms remained relatively susceptible to cefixime, followed by doxycycline and ceftriaxone. The authors concluded that the increasing resistance to frequently prescribed antibiotics underscores the importance of performing culture and antimicrobial susceptibility testing before initiating treatment whenever possible (Ben Ashur *et al.*, 2021)

Comparable findings were reported by Seifu and Gebissa (2018), who reported a high UTI prevalence of 90.1%. *Escherichia coli* remained the predominant pathogen, accounting for 39.3% of all isolates. Other organisms recovered included *Staphylococcus species* (20.2%), *Leuconostoc species* (11.4%), *Raoultella terrigena/Klebsiella species* (8.4%), *Salmonella typhimurium* (6.3%), *Demacoccus nishinomiyaensis* (6.3%), *Citrobacter freundii* (5.2%), and *Issatchenkia orientalis/Candida krusei* (2.7%). Gentamicin demonstrated the highest antimicrobial activity, with approximately 93.3% of isolates remaining susceptible. Chloramphenicol and nitrofurantoin also showed moderate effectiveness, with susceptibility rates of about 60%, while ciprofloxacin, trimethoprim-sulfamethoxazole, ceftriaxone, and nalidixic acid demonstrated lower susceptibility rates ranging from 40% to 56.6%. Only 20% of isolates were susceptible to vancomycin, tetracycline, and cephalixin. Notably, none of the isolates were susceptible to amoxicillin, which exhibited an exceptionally high resistance rate of 96.6%, followed by vancomycin (80%) and

cephalexin (70%)(Seifu and Gebissa, 2018). These findings further illustrate the growing challenge of antimicrobial resistance among uropathogens and reinforce the importance of regular antimicrobial surveillance to guide treatment decisions.

Similarly, a 2023 study in Pakistan by Khatoon et al. (2023) reported a UTI prevalence of 65.1% in Pakistan. Gram-negative bacteria accounted for 76.9% of all isolates, while Gram-positive bacteria constituted 23%. Among the Gram-negative organisms, *Escherichia coli* was the predominant pathogen, accounting for 48.8% of isolates, followed by *Pseudomonas aeruginosa* (12.7%), *Klebsiella pneumoniae* (8.36%) and *Proteus mirabilis* (7%). Among Gram-positive bacteria, *Staphylococcus aureus* was the most common isolate (17.3%), followed by *Staphylococcus saprophyticus* (5.68%). Antimicrobial susceptibility testing revealed that *Escherichia coli* exhibited high resistance to ampicillin (86.3%), nitrofurantoin (82.2%), and cefixime (47.9%), while demonstrating relatively higher susceptibility to cefoperazone (58.9%) and imipenem (52.1%). *Klebsiella pneumoniae*, *Pseudomonas species*, and *Proteus species* were all completely resistant to ampicillin (100%) but retained high susceptibility to imipenem and cefoperazone, with *Pseudomonas* and *Proteus* showing complete susceptibility to cefoperazone and several additional antimicrobial agents. Among Gram-positive organisms, *Staphylococcus aureus* demonstrated complete resistance to amoxicillin (100%) but remained fully susceptible to linezolid (100%), while *Staphylococcus saprophyticus* showed high resistance to penicillin (82.3%) and excellent susceptibility to linezolid (100%) and amoxicillin (94.1%)(Khatoon *et al.*, 2023). These findings emphasize the persistence of high resistance to older antibiotics while demonstrating that selected broad-spectrum agents continue to retain significant activity against common urinary pathogens.

Evidence from Zambia demonstrates a similar pattern of pathogen distribution and antimicrobial resistance. Kapesa (2025), in a study conducted at the University Teaching Hospital (UTH), reported an overall UTI prevalence of 17.6%. Gram-negative bacteria accounted for 75% of all isolates, while Gram-positive organisms represented the remaining 25%. *Escherichia coli* was the predominant pathogen, accounting for 41.7% of isolates, followed by *Klebsiella pneumoniae* at 19.4%. Gram-negative isolates exhibited very high resistance to ampicillin (96.2%), trimethoprim-sulfamethoxazole (87.3%), and ciprofloxacin (64.2%). However, resistance to nitrofurantoin was relatively low (25.3%), while piperacillin-tazobactam showed only 4.9% resistance. Notably, all

isolates demonstrated 100% susceptibility to imipenem. These findings highlight the continued effectiveness of carbapenems in the treatment of complicated UTIs while illustrating the declining effectiveness of several first-line antibiotics commonly used in routine clinical practice.

Overall, findings from different studies conducted consistently demonstrate that *Escherichia coli* remains the leading cause of urinary tract infections, followed by *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Proteus species* and various Gram-positive organisms such as *Staphylococcus aureus* and *Staphylococcus saprophyticus*. Although the prevalence of UTIs differs considerably between countries, a common trend is the increasing resistance of uropathogens to frequently prescribed antibiotics, particularly ampicillin, trimethoprim-sulfamethoxazole, nalidixic acid, tetracyclines, and fluoroquinolones. Conversely, antimicrobial agents such as imipenem, amikacin, cefoperazone, piperacillin-tazobactam, linezolid, and, in some settings, nitrofurantoin continue to demonstrate relatively good activity against most uropathogens. These regional differences in antimicrobial susceptibility highlight the necessity of routine urine culture and antimicrobial susceptibility testing, as well as continuous surveillance of resistance patterns, to ensure appropriate empirical treatment.

2.2 Conceptual Framework

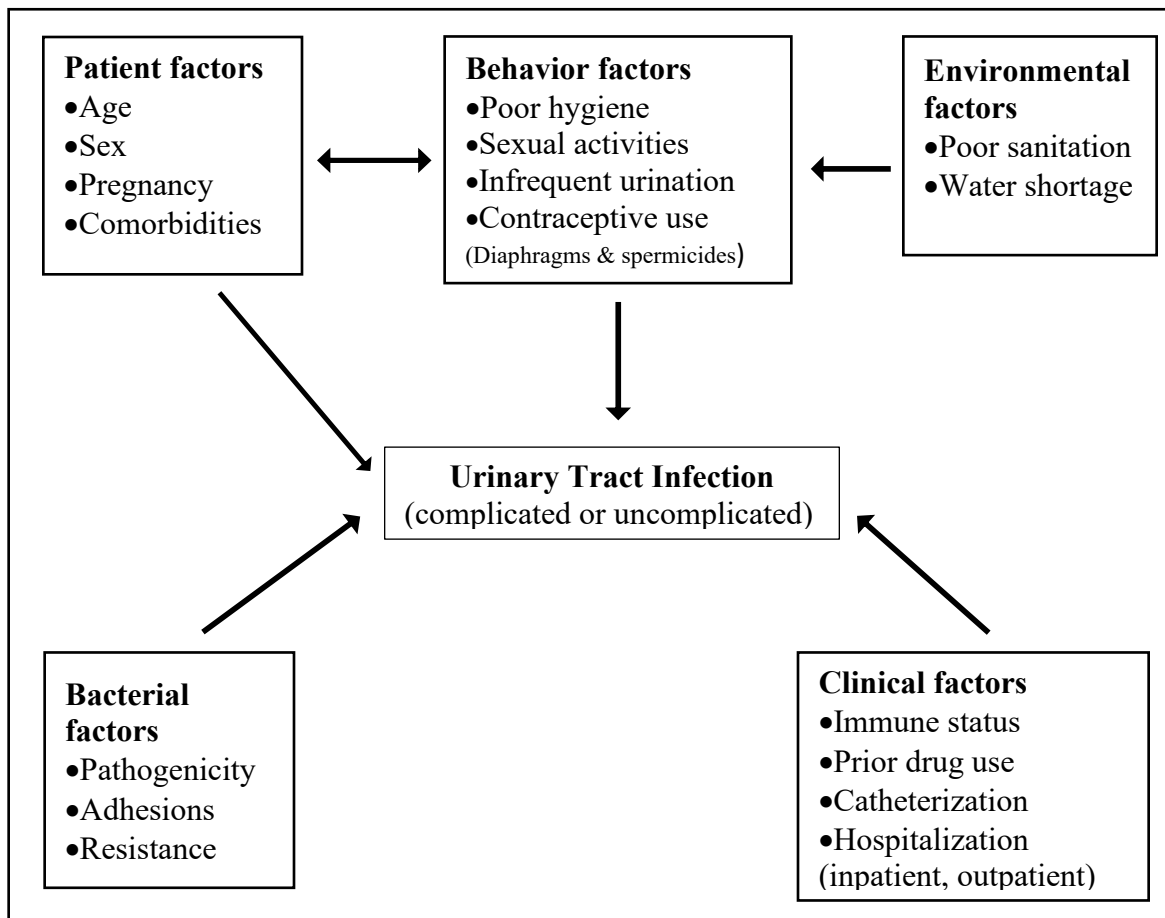


Figure 1: Conceptual Framework of risk factors associated with UTI

This retrospective cross-sectional study at Choma General Hospital was structured around a framework that connects patient, behavior, environmental, bacterial, and clinical factors as shown in figure 1. The framework shows that urinary tract infections (UTIs) result from the interaction of many factors which can increase the risk of infection. Bacteria are the direct cause of UTIs; however, several interrelated factors determine an individual's susceptibility and the severity of the infection. The pathogenic traits of bacteria, including adhesion, virulence, and antibiotic resistance, determine how severe an infection becomes and how it can be managed. Patient factors, such as age, sex, pregnancy, and underlying health conditions, are among the determinants of UTI risks. For example, women are more prone to UTIs due to a shorter urethra, and individuals with weakened immune systems or chronic illnesses, such as diabetes, are more likely to develop UTI. Behavioral factors interact closely with patient factors and increase the risk of developing

infections. Poor hygiene, retention of urine, usage of contraceptives, infrequent urination, and sexual activities contribute to the creation of an environment which is conducive to the growth of bacteria. The above-mentioned behaviors may be a result of environmental determinants such as lack of clean water and crowded and unhygienic living environments. Overall, both environmental and behavioral determinants contribute to the probability of bacteria entering the urinary tract. Clinical factors such as low immunity, prior UTIs, previous antibiotic use, catheterization, hospitalization and recent surgical procedures play a major role in the development of complicated UTIs. These factors can disrupt the urinary tract's natural defenses and provide direct pathways for bacterial entry, thereby increasing susceptibility to urinary tract infection. These factors interact as environmental conditions direct behavior, behavior reveals patient vulnerabilities, bacteria take advantage of these conditions and clinical factors intensify the risk. Understanding this interconnection is important for identifying individuals at risk, developing effective prevention strategies, promoting proper hygiene and ensuring timely clinical interventions to manage urinary tract infections effectively.

Chapter Three: Methodology

3.0 Methodology

3.1 Study Design

This study was a laboratory based retrospective cross-sectional study.

3.2 Study Approach

A quantitative research approach was employed in this study as it involved the collection and analysis of numerical data to determine the prevalence of urinary tract infections (UTIs), identify bacterial pathogens and assess their antimicrobial susceptibility patterns among patients at Choma General Hospital. The quantitative approach enabled the made it possible to measure the frequency of culture-confirmed UTIs, determine the distribution of bacterial isolates and quantify the proportions of isolates that were susceptible, intermediate or resistant to the antimicrobial agents tested. A quantitative approach was used through the analysis of numerical data extracted from existing patient laboratory records.

3.3 Research Setting

The study was conducted in the Department of Microbiology at Choma General Hospital, located in Choma District, Southern Province, Zambia. The hospital is a level 2 referral facility that caters to a vast population, and urine specimens are analyzed regularly for the diagnosis of UTIs in the patients. The Microbiology department was chosen as the source of information since it has complete laboratory records of the patient demographic characteristics, culture and identification of bacteria, and the sensitivity pattern of the isolates.

3.4 Study Population

The study population comprised of all patients who submitted urine specimens for culture and antimicrobial susceptibility testing at the Microbiology Department of Choma General Hospital between 01/06/2024 and 31/05/2026. The population included both males and females of all age groups from inpatient and outpatient departments. Laboratory records were reviewed to obtain demographic information, bacterial isolates and antimicrobial susceptibility results

3.4.2 Inclusion criteria

Patients' records whose urine culture results indicated significant bacterial growth ($\geq 10^5$ CFU/ml) were included in the study. Only those with complete demographic information and microbiological data, including pathogen identification and antimicrobial susceptibility profiles, were considered.

3.4.1 Exclusion criteria

Patients' records with urine culture results indicating contamination or insignificant bacterial growth were excluded. Records lacking complete demographic information or microbiological data were also not be considered.

3.5 Study Sample

The study sample comprised urine culture records from patients of all ages and sexes who attended Choma General Hospital between June 2024 and May 2026. The sample included both inpatient and outpatient records that met the eligibility criteria for inclusion in the study. Only urine specimens that demonstrated significant bacterial growth, defined as a bacterial colony count of $\geq 10^5$ CFU/ml, were considered for analysis. The selected records contained complete demographic and microbiological information, including patient characteristics, identification of bacterial pathogens isolated from urine cultures and corresponding antimicrobial susceptibility profiles. The inclusion of records with complete laboratory information ensured the reliability and accuracy of the study finding

3.6 Sample Size

The sample size was calculated using Cochran's formula for cross-sectional studies estimating population proportions (Prevalence). where, n was the sample size, z was the selected critical value of desired confidence level, p was the estimated proportion of an attribute that is present in the population, q = 1 – p and e was the desired level of precision

$$n = Z^2 pq / e^2$$

$$n = Z^2 p(1-p) / e^2$$

$$n = 1.96^2 \times 0.5(1-0.5) / 0.05^2$$

$$n = 384.16$$

$$n = 384$$

3.7 Sampling Strategy

In this study, purposive sampling technique was employed. Urine culture records that fit into predetermined inclusion criteria during the study period were reviewed and included in the study. This made sure that only data that are relevant and valid, namely those which have considerable bacterial growth along with demographic and microbiological data, were included in the sample. Those records which were incomplete and those which had some other forms of bacteria along with the ones that were of interest were excluded. A complete list of all urine culture requests processed at the Microbiology Department of Choma General Hospital between 01/06/2024 and 31/05/26 was obtained from the archived patient request forms and electronic records (DISA). This was the sampling frame from which eligible records were drawn. The eligibility assessment was performed to filter out all the records which satisfied the inclusion criteria specified, requiring substantial bacterial growth ($\geq 10^5$ CFU/ml) along with complete demographic and microbiology data, including the organism identity and antibiotic sensitivity profile. Contaminated records, which showed mixed growth of more than two organisms, were also excluded, along with those lacking demographic and laboratory details.

3.8 Data Collection Techniques

Data for this study were collected retrospectively through a review of archived microbiology laboratory records, electronic medical records and relevant hospital databases at Choma General Hospital. Since the study involved previously collected patient information, no direct interaction with patients was required. A structured data extraction tool developed in Microsoft Excel was used to ensure uniformity, accuracy and systematic collection of all variables required for the study objectives. The extracted data included demographic characteristics such as age, sex and patient status (inpatient or outpatient). Microbiological data obtained included urine culture results, bacterial species identified and antimicrobial susceptibility testing results. Antimicrobial susceptibility profiles were interpreted according to the Clinical and Laboratory Standards Institute (CLSI) guidelines to classify isolates as susceptible, intermediate, or resistant to the tested antimicrobial agents. Where available, additional clinical information such as underlying comorbidities and history of previous antibiotic use was also extracted to provide further context regarding factors that may influence urinary tract infections and antimicrobial resistance patterns. Quality assurance activities were carried out via verification of data obtained through the

extraction process, involving comparison of 10% of randomly chosen records with the original source in the laboratory to reduce any data input error.

Data extraction included several stages that ensured its comprehensiveness and accuracy. First, eligible laboratory records were selected on the basis of defined inclusion and exclusion criteria. Then, the necessary data were systematically extracted from the records using the data extraction tool and verified for its completeness and consistency. To respect the privacy of patients, no personal identifier was retained during data extraction. Each laboratory record was provided with a unique study ID number, and the data were kept safe for research purposes only. These measures ensured the protection of patient privacy while maintaining the integrity and reliability of the study data.

3.9 Data Analysis

The data was analyzed using STATA version 14. Descriptives statistics was performed and Pearson Chi square test was used to evaluate the association between demographic variables and UTIs. A level of 0.05 was used to indicate statistical significance

3.10 Validity and Reliability

In this study, validity and reliability were ensured by using existing laboratory records generated through standardized procedures for urine culture, bacterial identification and antimicrobial susceptibility testing. The extraction of data was done through the use of structured data collection tool in order to ensure accuracy. The reliability of the data collected was guaranteed through proper quality control procedures in the laboratory. Extracted data were reviewed for completeness and accuracy before analysis to minimize errors and improve the quality of the findings.

3.11 Ethical Considerations

This study was a retrospective, laboratory-based study with no direct contact with patients. Ethical clearance was obtained from the Ethics Committee and permission to access archival UTI records was granted by the Senior Medical Superintendent and the Head of the Department of Microbiology at Choma General Hospital (CGH). Patient confidentiality was maintained through the use of serial numbers generated from the information collected since names and laboratory numbers were not used. There were no risks to the subjects in this study as there were no physical

experiments or tests conducted on the patients and hence did not pose any form of harm. All the eligible records were included in the study in an unbiased manner. Since only archived records were used, no direct consent was sought

Chapter Four: Results

4.0 Results

4.1 Determination of prevalence of UTI

A total of 386 urine culture indicating significant bacterial growth, while 273 (70.73%) had negative culture results. Therefore, the overall prevalence of culture-confirmed urinary tract infection among patients investigated was 29.27% as shown in table 1.

Table 1: Prevalence of Urinary Tract Infection

Variable	Frequency (n)	Percentage (%)	95% CI
Negative	273	70.7	66.0–75.1
Positive	113	29.3	24.8–34.1
Total	386	100.0	

Table 2: Association Between Sex and UTIs

Sex	Positive n (%)	Negative n (%)	Total	χ^2	p-value
Female	85 (34.4)	162 (65.6)	247	8.75	0.003
Male	28 (20.1)	111 (79.9)	139		
Total	113	273	386		

The prevalence of UTI was significantly higher among females than males (34.4% vs. 20.1%, $\chi^2 = 8.75$, $p = 0.003$).

Table 3: Association Between Age Group and Urinary Tract Infection Status

Age group (years)	UTI Positive n (%)	UTI Negative n (%)	Total (n)	χ^2	p-value
0–14	17 (23.0)	57 (77.0)	74	21.23	<0.001
15–24	11 (19.0)	47 (81.0)	58		
25–44	32 (26.4)	89 (73.6)	121		
45–64	22 (29.3)	53 (70.7)	75		
65 and above	31 (53.4)	27 (46.6)	58		
Total	113 (29.3)	273 (70.7)	386		

A significant association was identified between age group and culture-confirmed UTI status among the study participants ($\chi^2 (4) = 21.23$, $p < 0.001$). The prevalence of culture-confirmed UTIs

differed across the various age categories, with the highest proportion of positive cultures observed among patients aged 65 years and above (53.4%), while the lowest prevalence was recorded among those aged 15–24 years (19.0%).

Table 4: Distribution of Bacterial Pathogens Isolated from Positive Urine Cultures

Organism isolated	Frequency (n)	Percentage (%)
<i>Escherichia coli</i>	58	51.3
<i>Enterobacter agglomerans</i>	18	15.9
<i>Staphylococcus aureus</i>	11	9.7
<i>Staphylococcus saprophyticus</i>	9	8.0
<i>Enterobacter cloacae</i>	5	4.4
<i>Klebsiella pneumoniae</i>	4	3.5
<i>Enterobacter aerogenes</i>	2	1.8
<i>Pseudomonas</i> spp.	2	1.8
<i>Acinetobacter</i> spp.	1	0.9
<i>Enterococcus</i> spp.	1	0.9
<i>Proteus vulgaris</i>	1	0.9
<i>Streptococcus agalactiae</i>	1	0.9
Total	113	100.0

Among the 113 urine culture-positive specimens, 12 different bacterial species were isolated. *Escherichia coli* was the most frequently isolated organism, accounting for 57 (50.44%) of all positive urine cultures, followed by *Enterobacter agglomerans* with 18 (15.93%) isolates and *Staphylococcus aureus* with 12 (10.62%) isolates. Other Gram-positive organisms isolated included *Staphylococcus saprophyticus* 9 (8.0%), *Enterococcus* spp. 1 (0.88%) and *Streptococcus agalactiae* 1 (0.88%).

Among the Gram-negative isolates, *Enterobacter cloacae* accounted for 5 (4.42%) isolates, *Klebsiella pneumoniae* for 4 (3.54%), while *Enterobacter aerogenes* and *Pseudomonas* spp. each contributed 2 (1.77%) isolates. Less frequently isolated organisms included *Acinetobacter* spp., *Proteus vulgaris* and other organisms, each accounting for 1 (0.88%) isolate.

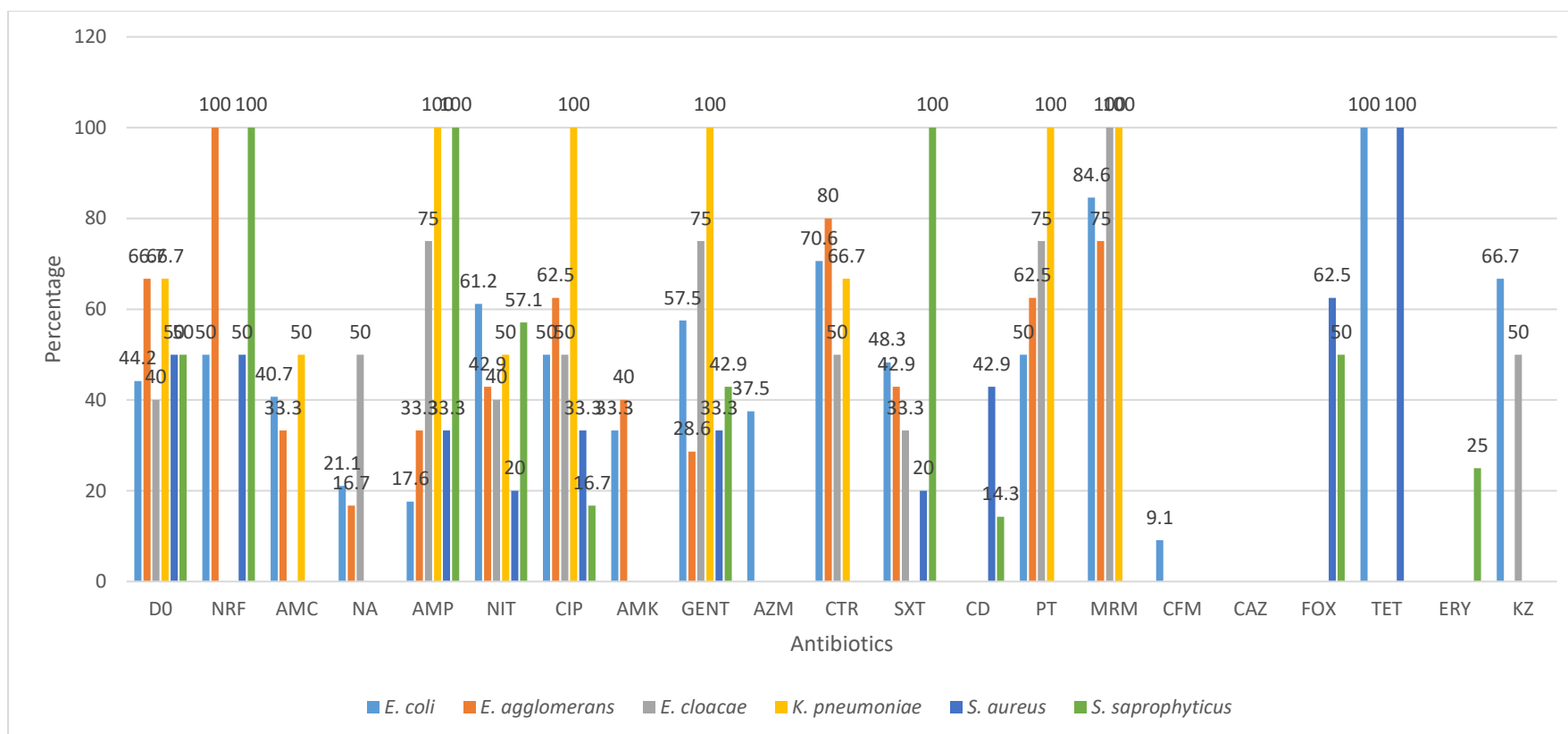


Figure 2: Antimicrobial Susceptibility Patterns of Urine Isolates.

Doxycycline-DO, Norfloxacin-NRF, Amoxicillin/clavulanic acid-AMC, Nalidixic acid-NA, Ampicillin-AMP, Nitrofurantoin-NIT, Ciprofloxacin-CIP, Amikacin-AMK, Gentamicin-GENT, Azithromycin-AZM, Ceftriaxone-CTR, Trimethoprim/sulfamethoxazole-SXT, Clindamycin-CD, P.Tazobactam-PT, Meropenem-MRM, Cefepime-CFM, Ceftazidime-CAZ, Tetracycline-TET, Erythromycin-ERY, Cephazolin--KZ, Cefoxitin-FOX

The antimicrobial susceptibility patterns varied among the bacterial isolates. Overall, ceftriaxone was the most effective antibiotic, demonstrating the highest susceptibility against *Escherichia coli* (70.6), *Enterobacter cloacae* (50%), *Klebsiella pneumoniae* (66.7) and *Enterobacter agglomerans* (80%) .

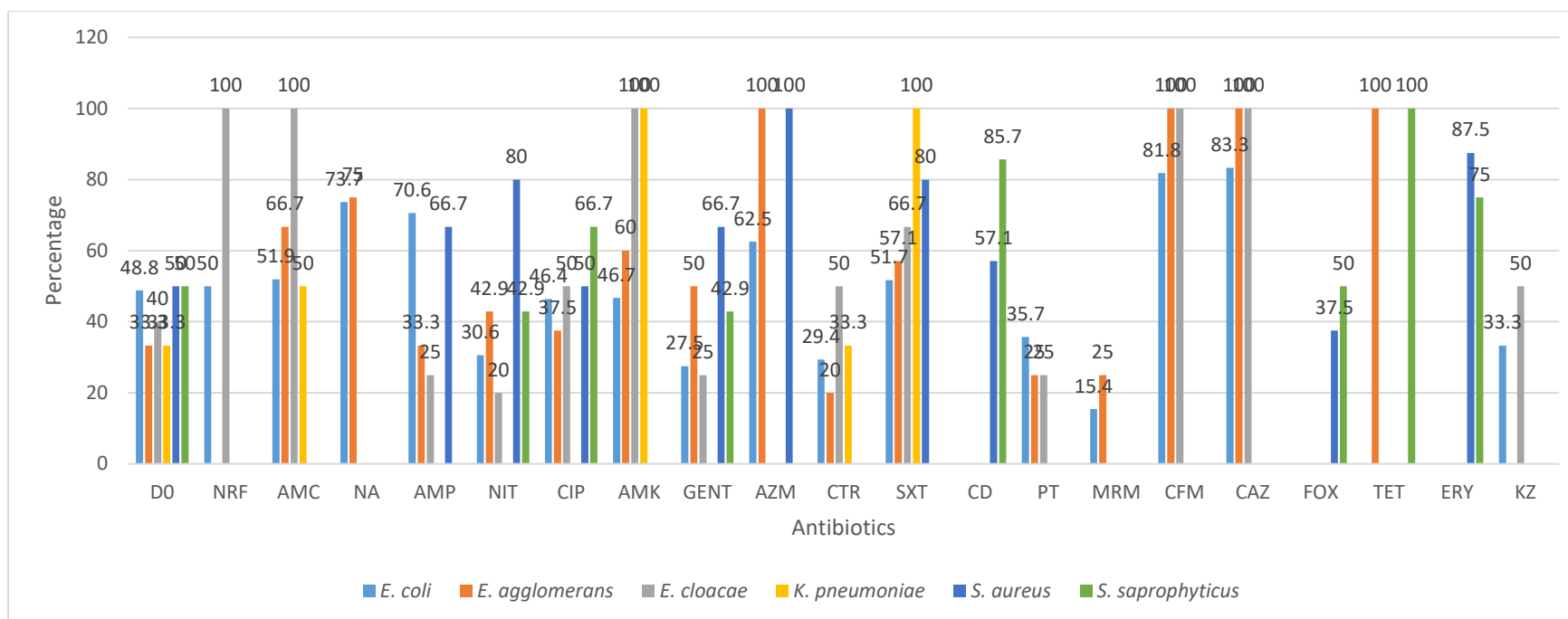


Figure 3:Antimicrobial Resistance Patterns of Urine Isolates

Doxycycline-DO, Norfloxacin-NRF, Amoxicillin/clavulanic acid-AMC, Nalidixic acid-NA, Ampicillin-AMP, Nitrofurantoin-NIT, Ciprofloxacin-CIP, Amikacin-AMK, Gentamicin-GENT, Azithromycin-AZM, Ceftriaxone-CTR, Trimethoprim/sulfamethoxazole-SXT, Clindamycin-CD, P.Tazobactam-PT, Meropenem-MRM, Cefepime-CFM, Ceftazidime-CAZ, Tetracycline-TET, Erthromycin-ERY, Cephazolin-KZ, Cefoxitin-FOX

Antimicrobial resistance patterns varied among the major uropathogens isolated in this study. *Klebsiella pneumoniae* exhibited the resistance to several antibiotics, including amoxicillin-clavulanic acid, amikacin, trimethoprim-sulfamethoxazole and ceftriaxone. *Escherichia coli* demonstrated relatively high resistance to doxycycline (48.8%), Nalidixic Acid (73.7%), trimethoprim-sulfamethoxazole (51.7%), nitrofurantoin (30.7%), ciprofloxacin (46.4%), ceftazidime (83.3%), cefipime (81.3%) and gentamicin (27.5%). *Enterobacter agglomerans*, *Staphylococcus aureus*, *Staphylococcus saprophyticus* and *Enterobacter cloacae* also showed varying levels of resistance to the antibiotics tested.

Table 5: Antimicrobial Patterns of Common Isolated Uropathogens

	<i>E. coli</i>	R	I	S	<i>E. agglomerans</i>	R	I	S	<i>E. cloacae</i>	R	I	S
	n	%	%	%	n	%	%	%	n	%	%	%
Doxycycline	43	48.8	7	44.2	12	33.3		66.7	5	40	20	40
Norfloxacin	8	50		50	1			100	1	100		
Amoxicillin/ Clavulanic-acid	27	51.9	7.4	40.7	2	66.7		33.3	1	100		
Nalidic acid	19	73.7	5.2	21.1	12	75	8.3	16.7	2		50	50
Ampicillin	17	70.6	11.8	17.6	3	33.3	33.4	33.3	4	25		75
Nitrofurantoin	49	30.6	8.2	61.2	14	42.9	14.3	42.9	5	20	40	40
Ciprofloxacin	28	46.4	3.6	50	8	37.5		62.5	2	50		50
Amikacin	15	46.7	20	33.3	5	60		40	1	100		
Gentamicin	40	27.5	15	57.5	14	50	21.4	28.6	4	25		75
Azithromycin	8	62.5		37.5	1	100						
Ceftriaxone	34	29.4		70.6	10	20		80	2	50		50
Trimethoprim/ Sulfamethoxazole	29	51.7		48.3	7	57.1		42.9	3	66.7		33
Clindamycin												
Piperacin Tazobactam	14	35.7	14.3	50	8	25	12.5	62.5	4	25		75
Meropenem	14	15.4		84.6	4	25		75	1			100
Cefepime	11	81.8	9.1	9.1	2	100			2	100		
Ceftazidime	12	83.3	16.7		1	100			2	100		
Cefoxitin												
Tetracycline	1			100	2	100						
Erythromycin												
Cephazolin	6	33.3		66.7					2	50		50
	<i>K. pneumoniae</i>	R	I	S	<i>S. aureus</i>	R	I	S	<i>S. saprophyticus</i>	R	I	S
	n	%	%	%	n	%	%	%	n	%	%	%
Doxycycline	3	33.3		66.7	8	50		50	6	50		50
Norfloxacin					2		50	50	1			100

Amoxicillin/ Clavulanic-acid	2	50		50								
Nalidic acid												
Ampicillin	2			100	3	66.7		33.3	1			100
Nitrofurantoin	2	50		50	5	80		20	5	42.9		57.1
Ciprofloxacin	1			100	6	50	16.7	33.3	6	66.7	16.7	16.7
Amikacin	1	100										
Gentamicin	3			100	3	66.7		33.3	7	42.9	14.3	42.9
Azithromycin					1	100			1			100
Ceftriaxone	3	33.3		66.7								
Trimethoprim/ Sulfamethoxazole	1	100			5	80		20	1			100
Clindamycin					7	57.1		42.9	7	85.7		14.3
Piperacin Tazobactam	2			100								
Meropenem	1			100								
Cefepime												
Ceftazidime												
Cefoxitin					8	37.5		62.5	2	50		50
Tetracycline					1			100	4	100		
Erythromycin					8	87.5	12.5		4	75		25

R-Resistant I-Intermediate S-Susceptible

Chapter Five: Discussion

5.0 Discussion

In this study, the prevalence of culture-confirmed urinary tract infections (UTIs) was 29.27%, indicating that approximately one in three patients who underwent urine culture had a confirmed bacterial infection. This finding demonstrates that UTIs remain a significant cause of bacterial infections among patients presenting with symptoms suggestive of urinary tract disease at Choma General Hospital. The prevalence observed suggests a considerable burden on healthcare services, as UTIs are among the most common infections requiring laboratory diagnosis and antimicrobial treatment. The high proportion of confirmed cases also highlights the importance of urine culture and antimicrobial susceptibility testing in guiding appropriate clinical management and reducing inappropriate antibiotic use.

The prevalence observed in this study was higher than that reported at the University Teaching Hospitals in Lusaka, Zambia, where Kapesa C *et al.* (2025) found a prevalence of 17.6% significant bacteriuria among urine specimens analyzed. The difference between the two studies may be explained by variations in the study populations, healthcare settings, patient demographics, clinical characteristics, specimen selection criteria and inclusion and exclusion criteria. Patients attending a provincial referral hospital such as Choma General Hospital may present with more severe or complicated urinary symptoms, increasing the likelihood of positive urine cultures. Differences in health-seeking behavior, previous antibiotic exposure, referral patterns and laboratory testing practices may also have contributed to the variation in prevalence.

The findings of the present study are, however, comparable to those reported by Mwang'onde *et al.* (2022), who reported a UTI prevalence of 32.12%. The similarity between these findings suggests that UTIs continue to represent a substantial public health problem across healthcare facilities in sub-Saharan Africa. Comparable prevalence rates may reflect similar epidemiological patterns, healthcare infrastructure and risk factors, including poor hygiene practices, underlying medical conditions such as diabetes, urinary catheterization, pregnancy, and increasing antimicrobial resistance, all of which contribute to the persistence of UTIs.

Overall, the prevalence reported in this study is consistent with evidence from regional studies indicating that UTIs remain among the most frequently encountered bacterial infections requiring

laboratory diagnosis. These findings emphasize the need for continued surveillance of UTI prevalence and antimicrobial susceptibility patterns to inform empirical treatment guidelines, strengthen antimicrobial stewardship programs, and improve patient outcomes through timely diagnosis and appropriate therapy.

These findings indicate that UTIs represent a significant clinical concern within the study setting and highlight the importance of microbiological investigation in guiding appropriate patient management. The proportion of culture-positive cases demonstrates that a number of patients with suspected UTIs had laboratory-confirmed infections, emphasizing the critical role of urine culture and antimicrobial susceptibility testing (AST) in ensuring accurate diagnosis and informing effective antimicrobial therapy. The prevalence observed in this study may have been influenced by several factors, including patient demographic characteristics, clinical presentation, healthcare-seeking behaviour, specimen selection criteria and local epidemiological variations.

The high proportion of negative urine cultures (70.73%) could be attributed to several possible explanations, such as urinary symptoms caused by non-bacterial conditions, prior antimicrobial use before sample collection, improper specimen collection practices, bacterial counts below the level required for significant growth, or infections caused by pathogens that are not easily identified using conventional culture methods (Olaru et al., 2021).

The findings of this study indicate that urinary tract infections (UTIs) at Choma General Hospital were predominantly caused by Gram-negative bacteria, with members of the *Enterobacterales* accounting for 76.1% (86/113) of all positive cultures. Among these, *Escherichia coli* was the most frequently isolated uropathogen, representing 51.3% of all bacterial isolates. This finding is consistent with global and regional evidence identifying *E. coli* as the predominant cause of UTIs due to its gastrointestinal reservoir, virulence factors and its ability to colonize the periurethral area and ascend the urinary tract (Flores-Mireles et al., 2015). Similar findings have been reported by Bosco *et al.*, (2020) who found *E. coli* to account for 57% of urinary isolates and by Mwang'onde and Mchami, (2022) who reported a prevalence of 46.8%. The consistency of these findings across different settings highlights the established role of *Enterobacterales*, particularly *E. coli*, as the leading causative agents of UTIs. These results further emphasize the importance of continuous microbiological surveillance and routine antimicrobial susceptibility testing to monitor

evolving resistance patterns and guide evidence-based empirical treatment of urinary tract infections.

The second most common isolated pathogen in this study was *Enterobacter agglomerans*, accounting for 15.9% of all isolates. Although *Enterobacter species* are less commonly reported compared with *E. coli*, they are recognized as important opportunistic causes of urinary tract infections, particularly among hospitalized patients, older adults and individuals with underlying medical conditions or urinary catheterization (Nimmana and Tobin, 2025). Collectively, *Enterobacter species* contributed 22.1% of the isolates, comprising *Enterobacter agglomerans* (15.9%), *Enterobacter cloacae* (4.4%) and *Enterobacter aerogenes* (1.8%). This notable contribution of *Enterobacter species* suggests a significant role of opportunistic and potentially healthcare-associated pathogens among the study population, particularly among patients with increased healthcare exposure. The relatively high proportion of *Enterobacter species* observed may reflect local epidemiological patterns, patient characteristics and healthcare-related factors, highlighting the need for further investigation and continuous antimicrobial resistance surveillance.

Gram-positive organisms were isolated less frequently; however, the identification of *Staphylococcus aureus*, *Staphylococcus saprophyticus* and other Gram-positive bacteria indicates their contribution to the burden of urinary tract infections in this setting. *Staphylococcus aureus* (9.7%) and *Staphylococcus saprophyticus* (5.3%) were also important pathogens. *S. saprophyticus* is a recognized cause of uncomplicated UTIs, particularly among young sexually active women. In contrast, *S. aureus* is less commonly isolated from urine and may be associated with complicated UTIs, urinary tract instrumentation, or, in some cases, bloodstream infection. Clinical correlation is therefore important when interpreting its isolation from urine specimens.

Furthermore, the identification of organisms such as *Klebsiella pneumoniae*, *Pseudomonas spp.*, and *Acinetobacter spp.* is of clinical importance due to their frequent association with antimicrobial resistance, healthcare-associated infections and increased challenges in antimicrobial treatment. The presence of these pathogens is of clinical significance as these pathogens are commonly associated with antimicrobial resistance, healthcare-associated infections and more complex treatment challenges. The observed distribution of bacterial pathogens provides an important foundation for assessing antimicrobial susceptibility patterns and developing

appropriate empirical treatment guidelines and antimicrobial stewardship interventions at Choma General Hospital.

The findings showed a significant association between sex and culture-confirmed UTI status. The Pearson chi-square analysis showed that sex was significantly related to UTI occurrence ($\chi^2(1) = 8.7468$, $p = 0.003$), indicating that females were significantly more likely to have a positive urine culture than male patients. Since the p-value was below the significance level of 0.05, the observed difference in UTI positivity between males and females is unlikely to have occurred by chance. Therefore, the null hypothesis that there is no association between sex and UTI occurrence was rejected. This difference may be attributed to anatomical and physiological factors that increase female susceptibility to UTIs, including a shorter urethra and proximity of the urethral opening to the anus. The findings emphasize the need for targeted prevention, early diagnosis and appropriate antimicrobial management, while also recognizing the importance of evaluating UTIs in males due to their potential association with underlying urological conditions.

The significant association between age and culture-confirmed UTI status suggests that age is an important factor influencing susceptibility to urinary tract infections. The highest prevalence was observed among patients aged 65 years and above, which may be attributed to age-related changes such as weakened immunity, impaired urinary function, chronic illnesses and increased exposure to healthcare-related risk factors (Rowe and Juthani-Mehta, 2012). Younger age groups showed a lower UTI prevalence, which may be attributed to fewer underlying medical conditions, stronger immune responses, better urinary tract function and reduced exposure to healthcare-associated risk factors. Although UTIs remain common among younger adults, particularly women of reproductive age, the overall burden observed in this study was lower than that seen among the elderly. This suggests that while behavioural and anatomical factors contribute to UTI occurrence in younger populations, age-related physiological changes become increasingly important determinants of infection in older adults.

The antimicrobial susceptibility patterns observed in this study demonstrated considerable variation among the major uropathogens, highlighting the importance of culture and antimicrobial susceptibility testing in guiding appropriate treatment of urinary tract infections (UTIs). Overall, the findings indicate that some commonly prescribed antibiotics remain effective against certain pathogens, while others showed substantial levels of resistance, suggesting the need for regular surveillance of local resistance patterns.

The predominant uropathogen, *Escherichia coli*, demonstrated favourable susceptibility to several antibiotics. The highest susceptibility was observed with meropenem (84.6%), ceftriaxone (70.6%), nitrofurantoin (61.2%) and piperacillin-tazobactam (100.0%). The preserved susceptibility to nitrofurantoin is significant because it is widely recommended as a first-line treatment for uncomplicated lower UTIs due to its high urinary concentration and limited systemic effects. Similarly, the high susceptibility to ceftriaxone suggests that this antibiotic remains an effective option for the management of complicated UTIs requiring parenteral therapy. Meropenem demonstrated the greatest activity against *E. coli*, indicating that carbapenems remain highly effective against resistant Gram-negative organisms in this setting. Nevertheless, because carbapenems are considered reserve antibiotics, their use should be restricted to severe infections or confirmed multidrug-resistant organisms in order to preserve their efficacy and minimise the emergence of carbapenem-resistant *Enterobacterales*. Piperacillin-tazobactam also retained moderate activity and may provide an alternative treatment option for selected complicated infections.

Despite the favourable susceptibility to these antibiotics, *E. coli* exhibited resistance to several commonly used antimicrobial agents. High resistance was observed to ceftazidime (83.3%), cefepime (81.8%), ampicillin (70.6%), trimethoprim-sulfamethoxazole (51.7%), amoxicillin-clavulanic acid (51.9%), doxycycline (48.8%), ciprofloxacin (46.4%) and nalidixic acid (73.7%). These findings suggest that empirical treatment with these antibiotics may result in poor clinical outcomes and increased risk of treatment failure. The high resistance to ampicillin and trimethoprim-sulfamethoxazole is consistent with their prolonged and widespread use in many healthcare settings, which has contributed to increasing selective pressure and the emergence of resistant strains. Resistance to fluoroquinolones such as ciprofloxacin and nalidixic acid is concerning because these agents have traditionally been important alternatives for treating UTIs.

The observed resistance may be attributed to inappropriate antibiotic prescribing, over-the-counter access to antibiotics, self-medication, incomplete treatment courses and repeated antimicrobial exposure, all of which contribute to the development and spread of antimicrobial resistance.

Among the other Gram-negative organisms, *Enterobacter agglomerans* demonstrated good susceptibility to ceftriaxone (80.0%), meropenem (75.0%), ciprofloxacin (62.5%) and piperacillin-tazobactam (62.5%). These findings indicate that these antibiotics remain effective therapeutic options for infections caused by this organism. However, the organism showed high resistance to nalidixic acid (75.0%) and gentamicin (50.0%), suggesting that these agents may be less reliable for empirical treatment. Resistance in *Enterobacter species* is particularly important because these organisms possess inducible chromosomal AmpC β -lactamases that can confer resistance to several β -lactam antibiotics during therapy, making antimicrobial susceptibility testing essential before treatment.

Similarly, *Enterobacter cloacae* demonstrated complete resistance to cefepime and ceftazidime among the isolates tested, indicating limited usefulness of these cephalosporins for treating infections caused by this organism. However, the isolates remained susceptible to meropenem, piperacillin-tazobactam, ampicillin, and gentamicin. The retained activity of these antibiotics suggests that they remain appropriate treatment options when supported by culture and susceptibility results. The observed resistance to third- and fourth-generation cephalosporins may reflect the production of extended-spectrum β -lactamases (ESBLs) or AmpC enzymes, both of which are increasingly recognised among *Enterobacter species*.

Klebsiella pneumoniae also exhibited some susceptibility patterns. Most isolates remained susceptible to meropenem, piperacillin-tazobactam, ceftriaxone, gentamicin and ampicillin, indicating that these antibiotics continue to provide effective therapeutic options for infections caused by this organism within the study setting. Although the number of *Klebsiella pneumoniae* isolates was relatively small, the preserved susceptibility to carbapenems and β -lactam/ β -lactamase inhibitor combinations is of clinical significance. Continued surveillance is nevertheless required because *Klebsiella pneumoniae* is recognised globally as an important reservoir for ESBL-producing and carbapenem-resistant strains.

The Gram-positive organisms also demonstrated distinct antimicrobial susceptibility patterns. *Staphylococcus aureus* retained susceptibility to selected antibiotics; however, resistance was observed against several commonly prescribed agents. The organism exhibited particularly high resistance to erythromycin (87.5%), nitrofurantoin (80.0%), trimethoprim-sulfamethoxazole (80.0%) and clindamycin (57.1%). The high resistance to macrolides and sulfonamides may limit their effectiveness for empirical treatment of UTIs caused by *S. aureus*. Furthermore, resistance to clindamycin raises concern because this antibiotic is frequently used in the treatment of Gram-positive bacterial infections. These findings reinforce the importance of culture-directed therapy whenever *S. aureus* is isolated from urine specimens.

Staphylococcus saprophyticus, an important cause of uncomplicated UTIs in young women, showed favorable susceptibility to a limited number of antibiotics but demonstrated considerable resistance to several others. Complete resistance was observed to tetracycline (100%), while high resistance was also noted for clindamycin (85.7%), erythromycin (75.0%), ciprofloxacin (66.7%), and doxycycline (50.0%). The high resistance to tetracycline and clindamycin suggests that these antibiotics may no longer be appropriate empirical treatment options for infections caused by this organism in the study setting. The observed resistance emphasises the importance of antimicrobial susceptibility testing, particularly in recurrent or persistent infections.

Overall, the antimicrobial susceptibility findings indicate that meropenem, ceftriaxone, nitrofurantoin and piperacillin-tazobactam remain the most active antibiotics against the majority of uropathogens isolated at Choma General Hospital. These agents demonstrated consistent activity across both Gram-negative and selected Gram-positive organisms, making them valuable therapeutic options when clinically indicated. However, high resistance to ampicillin, nalidixic acid, trimethoprim-sulfamethoxazole, erythromycin, clindamycin, cefepime and ceftazidime suggests that these antibiotics should be used cautiously and preferably only after antimicrobial susceptibility testing. The findings emphasize the need for routine urine culture and susceptibility testing before initiating treatment whenever possible, regular monitoring of local resistance patterns, periodic review of empirical treatment guidelines and strengthened antimicrobial stewardship programs. Such measures are essential to optimise patient outcomes, preserve the effectiveness of existing antibiotics and slow the progression of antimicrobial resistance within the hospital and the community.

Chapter Six: Conclusions

6.1 Conclusions

This study established the prevalence of urinary tract infection (UTI) pathogens and their antimicrobial susceptibility patterns among patients attending Choma General Hospital. The prevalence of culture-confirmed UTIs was 29.72%, with *Escherichia coli* identified as the predominant uropathogen, followed by *Enterobacter agglomerans*, *Staphylococcus aureus*, *Staphylococcus saprophyticus* and other Gram-negative and Gram-positive organisms. Female patients and individuals aged 65 years and above were significantly more likely to have culture-confirmed UTIs, highlighting these groups as important targets for preventive interventions.

The antimicrobial susceptibility patterns demonstrated that meropenem, ceftriaxone, nitrofurantoin and piperacillin-tazobactam remained the most effective antibiotics against the majority of uropathogens isolated during the study period. However, high resistance was observed to ampicillin, trimethoprim-sulfamethoxazole, nalidixic acid, ciprofloxacin, cefepime, ceftazidime, erythromycin and clindamycin. The high resistance to several commonly prescribed antibiotics suggests that empirical treatment based solely on historical prescribing practices may no longer provide optimal clinical outcomes. These findings demonstrate the growing challenge of antimicrobial resistance among urinary pathogens at Choma General Hospital and highlight the importance of evidence-based antimicrobial prescribing. The findings emphasize the need for continuous antimicrobial surveillance, development of local antibiograms and implementation of antimicrobial stewardship practices to support effective empirical management of UTIs and reduce the spread of resistant pathogens.

6.2 Recommendations

Based on the findings of this study, it is recommended that Choma General Hospital strengthen the routine use of urine culture and antimicrobial susceptibility testing to ensure that antibiotic therapy is guided by laboratory evidence rather than empirical prescribing alone, particularly in patients with complicated, recurrent, or treatment-resistant urinary tract infections. The hospital should also establish and regularly update a local antibiogram to provide clinicians with current information on antimicrobial susceptibility patterns and support evidence-based empirical treatment decisions. Furthermore, antimicrobial stewardship activities should be strengthened through regular review of prescribing practices and the promotion of rational antibiotic use. Antibiotics such as nitrofurantoin, ceftriaxone and piperacillin-tazobactam, which demonstrated good activity against the majority of isolates, should continue to be considered where clinically appropriate, while reserve antibiotics such as meropenem should be used with caution and primarily for severe or multidrug-resistant infections to minimise the emergence of carbapenem-resistant organisms.

Healthcare workers should promote rational antibiotic use by prescribing antibiotics in accordance with culture and susceptibility results whenever available and by educating patients on the importance of completing prescribed treatment regimens. Public health education should also be strengthened to increase community awareness regarding the prevention of urinary tract infections, the dangers of self-medication and the consequences of inappropriate antibiotic use in the development of antimicrobial resistance.

Finally, further research involving larger sample sizes and multiple healthcare facilities is recommended to provide more representative data on the epidemiology of urinary tract infections and antimicrobial resistance in Zambia. Future studies should also investigate the molecular mechanisms of antimicrobial resistance, including the occurrence of extended-spectrum β -lactamase (ESBL)-producing and carbapenem-resistant organisms, as well as patient-related risk factors associated with multidrug-resistant urinary tract infections. Such studies would provide valuable evidence for improving clinical management and informing national antimicrobial resistance control strategies.

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APPENDICES

1.0 Research Ethical Clearance



UNIVERSITY of LUSAKA

Passion for Quality Education: Our Driving Force

**UNIVERSITY OF LUSAKA RESEARCH ETHICS COMMITTEE
(UNILUS-REC)**

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UNILUS-RESEARCH ETHICS COMMITTEE

Ref no: FWA00033228-1200(08)/(08)/{2024}

Date: 20 November 2025

STUDENT NAME: **Mrs. Lillian Mbewe**

Prevalence of urinary tract infection pathogens and their antimicrobial susceptibility patterns at Choma General Hospital.

The above research was submitted to the research ethics committee for review. The study has no major ethical problems and is approved subject to the following:

1. The study cannot be changed without express permission of the UNILUS research ethics committee.
2. Approval from the necessary authority should be sought.

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Chairman- UNILUS REC

Professor of Urology and Consultant Urologist

Deputy Vice-Chancellor – Research and Innovation

Executive Dean - School of Medicine and Health Sciences

2.0 National Health Research Authority Certificate



3.0 Data Extraction Tool

Data Extraction Tool: Prevalence of urinary tract infection pathogens and their antimicrobial susceptibility patterns at Choma General Hospital							
SN	Study ID	Age	Sex	Patient Status(Inpatient/Outpatient)	Drug History	Organism Isolated	Antimicrobial Susceptibility Results
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