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AETIOLOGY AND ANTIMICROBIAL RESISTANCE PATTERNS OF BACTERIAL MENINGITIS IN ADULTS PATIENTS ADMITTED AT PARIRENYATWA GROUP OF HOSPITALS FROM JANUARY 2023 TO DECEMBER 2024

BY

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A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUREMENTS FOR THE DEGREE OF BACHELOR OF MEDICAL LABORATORY SCIENCES IN THE COLLEGE OF HEALTH, AGRICULTURE AND NATURAL SCIENCES

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Abstract

Background: Meningitis is a significant cause of morbidity and mortality, particularly among HIV patients. While cryptococcal meningitis is more commonly recognized in Zimbabwe, bacterial meningitis (BM) remains underdiagnosed and is often missed in cerebrospinal fluid (CSF) cultures due to limited diagnostic capacity. The recent acquisition of a PCR-based BioFire system at Parirenyatwa Hospital promises to transform CSF processing and provide clearer insights into BM.

Methodology: This retrospective cross-sectional study evaluated 447 CSF samples collected at Parirenyatwa Hospital between January 2023 and December 2024. The BioFire system was employed for meningitis syndromic testing to identify bacterial pathogens responsible for BM.

Results: BM was confirmed in 7.8% of the samples. Streptococcus pneumoniae was the predominant pathogen, accounting for 54.2% of cases, followed by *Neisseria meningitidis* (28.9%), *Haemophilus influenzae* (11.4%), *Streptococcus agalactiae* (2.9%), and *Escherichia coli* (2.9%). Demographic analysis revealed that the highest incidence occurred in the 18–29-year age group, likely reflecting increased exposure in crowded settings, while older adults, despite being a larger part of the study population, exhibited a lower incidence. No statistically significant gender differences were observed. Seasonally, BM cases peaked in March during Zimbabwe's dry season, a time when environmental conditions favor pathogen transmission. Antimicrobial susceptibility testing showed high efficacy for penicillin (94%), ampicillin (91%), and ceftriaxone (88%), whereas meropenem exhibited a lower susceptibility rate (75%), suggesting emerging resistance trends.

Conclusion: Although the overall prevalence of BM in this setting is lower compared to regions within the African meningitis belt, the study highlights important age-related trends, seasonal variations, and evolving antimicrobial resistance. These findings emphasize the urgent need for increased focus on Bacterial cultures diagnosis in CSF for laboratories that do not have PCR and targeted public health interventions to improve BM management in resource-limited settings.

Declaration

I, Tatenda Hove student number 210602 do hereby declare that this research project is my original work except where sources have been cited and acknowledged. The work has never been submitted, nor will it ever be submitted to another university for the award of a Bachelor of Science degree.

Tatenda Hove

12 April 2025

Student's Full Name

Student's Signature (Date)

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12 April 2025

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ABBREVIATIONS AND ACRONYMS

AMB	African Meningitis Belt
AMR	Antimicrobial Resistant
BM	Bacterial Meningitis
CN	Cryptococcus Neofromans
CSF	Cerebra-Spinal Fluid
MDR	Multiple Drug Resistance
IMD	Invasive Meningococcal Disease
WHO	World Health Organization

CHAPTER 1 INTRODUCTION

1.1 Introduction

The following chapter will highlight the problem that bacterial meningitis is causing to the Zimbabwean population. It will also highlight how this study intends to unearth the current gaps and how studying this issue can be of benefit to the medical community and the patients themselves.

1.2 Study Background

Bacterial meningitis is a critical infectious disease characterized by inflammation of the protective membranes covering the brain and spinal cord. It poses a significant health threat due to its rapid progression and high mortality rate if not promptly treated. In sub-Saharan Africa, bacterial meningitis remains a major public health concern, particularly among adult patients (Nhantumbo, 2022). Parirenyatwa Group of Hospitals, one of the largest referral centers in Zimbabwe, frequently encounters cases of bacterial meningitis. However, there is a paucity of published data on the specific bacterial pathogens involved and their resistance patterns to commonly used antibiotics.

Meningitis is defined as the inflammation of meninges, which are membranes surrounding the brain and the spinal cord. Current information indicates that meningitis is primarily caused by *Cryptococcus neoformans* more particularly in immunocompromised individuals such as those with HIV/AIDS. Studies have indicated that cryptococcal meningitis accounts for 68.5% of meningitis among patient with HIV (Veltman, Bristow, & Klausner, 2014). Cryptococcal meningitis accounts for an estimated 181,000 annual deaths globally, mostly among people living with HIV. In sub-Saharan Africa, the case fatality rate for cryptococcal meningitis ranges from 35-65% in HIV-positive patients, compared to 14-26% in high-income countries (Veltman, Bristow, & Klausner, 2014)

Meningitis can also be caused by bacterial infection, which occurs when bacteria that enters into the blood stream travels to the brain and spinal cord. In some cases, the bacteria can invade the meninges directly due to an ear or sinus infection. There are about 50 different types of bacteria that cause bacterial meningitis. The most common are *Streptococcus pneumonia*, *Neisseria meningitides* and *Haemophilus influenza* (WHO, 2023).Understanding the causative agents and their resistance patterns in bacterial meningitis is crucial for several reasons one being to optimize treatment. Identifying the specific bacteria that is responsible for meningitis allows clinicians to be able to prescribe targeted antibiotics. In addition, understanding the resistance patters helps avoid prescription of ineffective treatments and minimizes the risk of treatment failure. Furthermore, an understanding of the resistance patters in bacterial meningitis prevents the misuse of antibiotics, which can cause antimicrobial resistance.

A study showed that meningitis caused 318,000 deaths worldwide in 2016 (Barichello et al., 2023). The incidence and case fatality of bacterial meningitis differs across the globe. Africa has recorded the highest incidence of bacterial meningitis. The largest burden of meningitis occurs at an area known as the meningitis belt, which is an area in Sub-Saharan Africa that stretches from Senegal to Ethiopia (WHO, 2024). Roughly 30 000 cases of bacterial meningitis are reported in the meningitis belt. The primary causative agents of bacterial meningitis in adults and children older than one are *Streptococcus pneumoniae* (pneumococcus) and *Neisseria meningitides* (meningococcus). The most frequent causative agents of neonatal meningitis are *Staphylococcus aureus*, *Escherichia coli*, and *Streptococcus agalactiae* (group B Streptococcus) (Barichello et.al, 2023).

Cryptococcal meningitis is transmitted from person-to person through respiratory droplets or throat secretions from an infected individual. Therefore, close contact with a carrier of the disease can facilitate the spread. Bacterial meningities is usually a systemic spread of

the infections from diverent sites within the body. Developing countries have significant incidence of bacterial meningitis compared to developed countries. In Europe, incidence of bacterial meningitis ranges from 0.3 to 3.0 cases per 100,000 people. In Africa, particularly in sub-Saharan Africa where the "meningitis belt" is located, the incidence rate ranges from 10 to 1,000 cases per 100,000 during epidemics (Barichello et al., 2023). Factors such as malnutrition, limited access to health care and overcrowded living condition make the population more vulnerable to infection (CDC, 2024). Studies have also shown that certain age groups are at higher risk of infection than others are. Bacterial meningitis is more common in infants below the age of one as well as individuals between the ages of 16 and 21. In addition, adults over the age of 65 have also shown high risk to developing bacterial meningitis (CDC, 2024). Depending on age, a different bacterium is usually the culprit. Group B Streptococcus is common in newborns under the age of two months, whereas *Streptococcus pneumonia* is the most common in all other age groups, with the exception of those aged 11 to 17, when *Neisseria meningitides* remains the most common cause (Runde et al., 2023). In addition, there is also a geographical variation in clinical outcomes. A study has shown that the mortality rate ranges from 6% in Germany, a developed country, to 54% in Malawi. According to the most recent WHO data published in 2020, meningitis deaths in Zimbabwe reached 1,325 or 1.22% of all deaths (WHO, 2023). However very little data exist on the etiology of the disease in Zimbabwe. Current information on meningitis is primarily focused on *Cryptococcus neoformans.* This concentration stems from the high morbidity and mortality associated with these opportunistic infections in individuals living with HIV, particularly in sub-Saharan Africa, where the burden of both HIV and these pathogens is substantial. With evidence of immunosuppression due to pathogens or malignancies, could the etiologies of meningities

be shifting? Furthermore, more sensitive diagnostic tests have emerged, what information can they give on the etiologies of meningitis.

Antimicrobial resistance is a growing public health challenge that complicates the management of bacterial infections, including meningitis. Resistance to commonly used antibiotics, such as penicillin and ceftriaxone, have been reported in various regions, leading to treatment failures and increased mortality rates. In Zimbabwe, preliminary studies indicate rising resistance rates among bacterial pathogens, but specific data on resistance patterns in the context of bacterial meningitis remain scarce. Understanding these patterns is vital for adapting treatment guidelines and ensuring effective patient care.

1.3 Problem statement

Bacterial meningitis is a critical and often life-threatening condition, particularly among adults, with significant morbidity and mortality rate (Runde et al., 2023). From 1928 to 2018, 2,628,283 cases of meningitis, including 151,808 deaths, were reported in 53 African countries, with a mean case-fatality rate of 5.77% (Mazamay et al, 2021). Despite advances in medical science, the etiology of bacterial meningitis in adults can vary widely, and the rise of antimicrobial resistance poses a growing challenge to effective treatment. At Parirenyatwa Group of Hospitals, a leading healthcare institution, there is a pressing need to understand the specific bacterial pathogens causing meningitis in adult patients and to identify current patterns of antimicrobial resistance.

There is a strong focus on cryptococcal meningitis in literature. While *Cryptococcus neoformans* dominate the literature, there is a notable lack of comprehensive data on other potential pathogens causing meningitis. The concentration on cryptococcal meningitis may overshadow the importance of understanding the full spectrum of meningitis etiologies.

Currently, there is limited available data on the precise bacterial etiology and resistance profiles in this patient population.

The recent installation of the BioFire system at Parirenyatwa Group of Hospitals has significantly transformed the approach to CSF microbial testing. This syndromic PCR-based platform allows for the simultaneous detection of multiple pathogens, reducing turnaround time (TAT) to under four hours—compared to the traditional culture-based methods that take 3 to 5 days. Additionally, BioFire offers greater sensitivity and specificity than conventional culture techniques, which have inherent limitations. Given these advancements, it is necessary to reassess the role of bacterial culture in CSF diagnostics, particularly since previous data on meningitis etiology have been dominated by Cryptococcus neoformans, potentially overshadowing the burden of bacterial meningitis.

This lack of detailed, localized data on bacterial meningitis underscores the need for a study to elucidate the predominant bacterial species causing meningitis and their resistance patterns. Such insights are crucial for guiding treatment protocols, improving patient management, and developing targeted interventions to combat antimicrobial resistance.

This study aims to address these gaps by investigating the aetiology of bacterial meningitis in adult patients at Parirenyatwa Group of Hospitals and analyzing the associated antimicrobial resistance patterns. The findings will provide essential information to enhance clinical decision-making, optimize treatment strategies, and ultimately improve patient outcomes..

1.4 Study Justification

There is a lack of comprehensive data on the causative agents of bacterial meningitis and their resistance patterns to commonly used antibiotics in Zimbabwe, and specifically at

Parirenyatwa Group of Hospitals, This gap in knowledge hinders the ability to implement effective treatment protocols and infection control measures.

Understanding the aetiology of bacterial meningitis in this specific population is essential for several reasons for targeted treatment. Identifying the predominant bacterial pathogens and their resistance profiles will enable healthcare providers to select the most effective empirical treatments, reducing the time to appropriate therapy and improving patient outcomes. In addition, knowledge of local antimicrobial resistance patterns is crucial for developing and updating guidelines for antibiotic use, which can help in combating the rise of resistant strains and preserving the efficacy of existing antibiotics.

The findings from this study can inform public health strategies and policies aimed at preventing bacterial meningitis, including vaccination programs and other preventive measures. Furthermore, data on the prevalence and resistance patterns of bacterial pathogens can guide hospital administration in resource allocation, ensuring that necessary diagnostic tools and effective antibiotics are available.

By addressing these critical aspects, this study aims to enhance the clinical management of bacterial meningitis at Parirenyatwa Group of Hospitals and contribute to the broader efforts in controlling this life-threatening infection.

1.5 Research objectives

1.5.1 Broad Objective

To assess the prevalence and resistance patterns against specific antibiotics against causative agents of bacterial meningitis in adult patients admitted at Parirenyatwa Group of Hospitals from January 2023 to August 2024

1.5.2 Specific Objectives

1. To assess the prevalence of bacterial meningitis among adult patients visiting Parirenyatwa Group of Hospitals from January 2023 to December 2024
2. To identify the etiology bacterial pathogens responsible for meningitis in adult patients at Parirenyatwa Group of Hospitals from January 2023 to December 2024
3. To evaluate the resistance profiles of these bacterial pathogens against commonly used antibiotics.

1.6 Research questions

1. What is the prevalence of bacterial meningitis among adult patients at Parirenyatwa Group of Hospitals
2. What are the predominant bacterial pathogens responsible for meningitis in adult patients at Parirenyatwa Group of Hospitals?
3. What are the resistance profiles of these bacterial pathogens against commonly used antibiotics?

1.7 Study Limitations

Geographical and Demographic Factors: The study will be focused on Parirenyatwa Group of Hospitals in Harare. Although this is a quaternary hospital in Zimbabwe, the study's findings may not be applicable to other regions or populations factors.

Antibiotic Usage Prior to Admission: Patients who have received antibiotics before hospital admission may have altered bacterial cultures, affecting the recovery rate.

1.8 Study delimitations

Population: The study focuses only on adult patients admitted to Parirenyatwa Group of Hospitals, excluding pediatric cases and patients from other hospitals.

Time Frame: The study is limited to 24 months (January 2023 to December 2024) to ensure manageable data collection and analysis.

Pathogens Studied: This study will primarily focus on bacterial pathogens. However, fungal and viral causes will also be included for comparison to understand their contribution to the disease.

Diagnostic Methods: The study uses specific diagnostic techniques available at the hospital, which may not include the latest or most advanced methods.

Lack of clinical outcomes: The study does not correlate the laboratory diagnosis of CSF microbial testing and its antimicrobial resistance patterns with clinical outcomes, such as treatment failures or mortality rates. Linking resistance data with patient outcomes could provide a more comprehensive picture of the impact of aetiology and antimicrobial resistance on the management of bacterial infections.

1.9 Summary

This study on the aetiology and antimicrobial resistance patterns of bacterial meningitis in adult patients at Parirenyatwa Group of Hospitals is significant as it addresses a critical public health issue in Zimbabwe. By identifying prevalent pathogens and their resistance profiles, the research aims to inform effective treatment strategies and guide antibiotic stewardship. Additionally, the findings will contribute to the understanding of local epidemiology, ultimately improving patient outcomes and informing public health

interventions. This study fills a crucial knowledge gap in the context of rising antimicrobial resistance

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter discussed in detail the existing literature reviews on the etiology and antimicrobial susceptibility patterns of bacteria associated or known for causing bacterial meningitis. The chapter reviews what bacterial meningitis is, causative agents and antimicrobial resistance patterns for common antibiotics used to treat bacterial meningitis. This chapter also highlights how a strong focus on Cryptococcal meningitis is linked to drug resistance meningitis.

2.2 Conceptual Framework

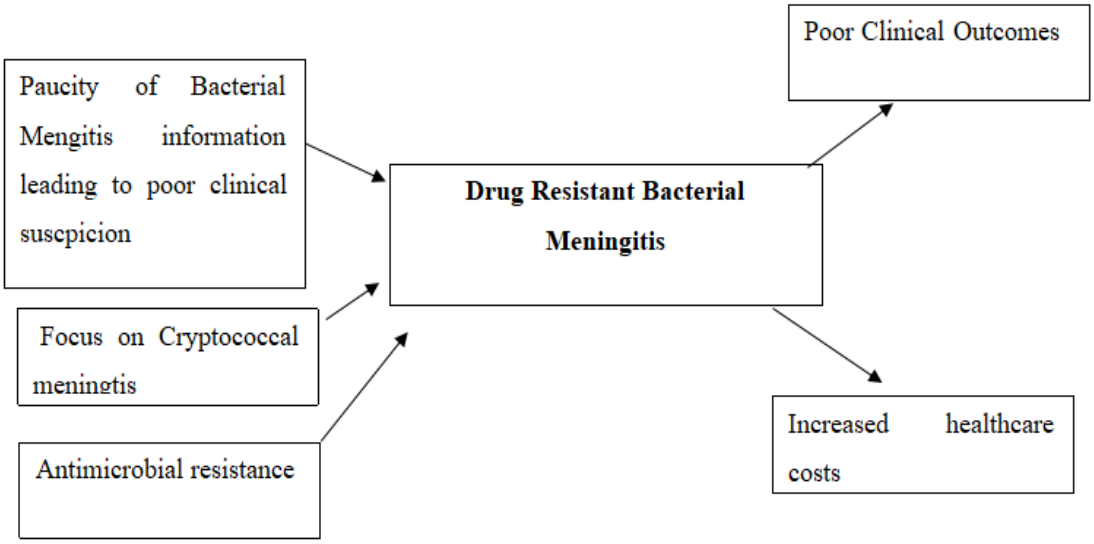

Figure 1: Conceptual framework

Drug resistant bacterial meningitis can lead to poor clinical outcomes such as high mortality. In addition, it can result in increased health care costs. Factors which contribute to drug resistant bacterial meningitis are the lack of data regarding bacterial meningitis, an over emphasis on cryptococcal meningitis and antimicrobial resistance.

2.3.1 Aetiology of Bacterial Meningitis in Adults

Bacterial meningitis (BM) occurs when the meninges become inflamed as a result of a bacterial infection. BM is classified into nosocomial infection or community acquired infection. A study conducted in 2019 showed that the incidence of BM globally was 2-51 million with an estimated death of 236 000 deaths (Wunrow et.al, 2023). Bacterial meningitis affects both developed and developing countries, the burden is disproportionately higher in resource-constrained regions. A study on the global epidemiology of invasive meningococcal disease (IMD) found that High incidence countries were mainly found in the African Meningitis Belt (AMB), which stretches from Senegal to Ethiopia. Moderate and low-incidence countries were present in Europe and Australia (Jafri et.al, 2013). Over the last decades, developed countries have managed to decrease incidence of BM through implementing of mass vaccination campaign and standardized epidemiological surveillance systems. On the contrary, BM continues to be epidemic to the ABM region. The incidence of the disease varies from 1.1 to 2 in the US and in Western Europe up to 12 in 100 000 per year in Africa (Hoffman & Weber, 2009).

The most common causative agents of BM in adults is *Streptococcus pneumoniae* (*S.pneumoniae*) and *Neisseria meningitides (N.meningitis*). A study established that *S.pneumoniae* and *N.meningitis* accounted for 25.1-41.2% and 9.1-36.2% of cases of BM respectively (Pallas Health ResearchandConsultancyBV, Rotterdam, 2018). *S.pneumoniae* commonly causes pneumonia or infection. On the other hand, *N.meningitis* causes a bacterial meningitis called meningococcal meningitis, a highly contagious infection. In addition to *S.pneumoniae* and *N.meningitis*, *Haemophilus influenza* has also been identified as a common cause of bacterial meningitis. Findings from another study about the global burden of meningitis found that *S. pneumoniae, N. meningitidis*, and *H. influenzae* were responsible for 55.7%, 57.2% and 46% of the meningitis cases and deaths

respectively. All three bacteria are respiratory pathogens that colonize the human respiratory tract (Tsang, 2021). Less common causes of BM are gram-negative bacteria are *Escherichia coli, Klebsiella, Enterobacter, Pseudomonas aeruginosa*. (Runde et al., 2023).

The most common causes of meningitis in the Meningitis belt is *S.pneumoniae* and *N.meningitis, H. influenzae.* Among *N.meningitis* the serogroup A is responsible for 80 to 85% of cases of bacterial meningitis in Africa. BM has a strong seasonal pattern in the meningitis belt. The epidemic occurs in during the dry season windy season (from January to April) (Geugan et al, 2021). a study conducted in Niger found the case-fatality ratio meningococcal meningitis was lower for serogroup A (5.5%) than for serogroups X (12%) and W135 (12.7%). With a CFR of 49.8%, pneumococcal meningitis, albeit representing only 20.7% of confirmed cases, accounted for 50% of the deaths (Boisier et al, 2007)

Common symptoms of bacterial meningitis include fever, headache, vomiting, altered mental status, neck rigidity, photophobia, and dizziness. In one study, the majority of patients had fever (80%), followed by altered mental status (70%), headache (48.3%), and neck rigidity (41.7%) (Maimoona , 2014).Specific pathogens may cause distinct clinical presentations, but overlap exists. For example, *N. meningitidis* often presents with fever, headache, and neck stiffness, while *L.monocytogenes* may cause fever, headache, and altered mental status (Motamedifar et al, 2015).

Outside the meningitis belt, *S.pneumoniae* is the most common etiological agent (Mazamay et al, 2021). Regarding meningitis in the developing world, and specifically in Africa, very little reliable data is available. This is due to a lack of robust health surveillance system which makes it difficult to track and report cases of BM. In addition underreporting also

contributes to the lack of reliable data. People in rural areas may not seek medical attention which leads to an underestimation of disease prevalence in a particular region (Mazamay et al, 2021). In order to implement targeted public health interventions, region-specific data on bacterial meningitis is crucial. Different regions may have varying predominant strains of causative agents of meningitis. Thus having an understanding of regional differences allows for targeted vaccination campaigns. In addition, accurate regional data can help with resource allocation as Health authorities can prioritize areas with higher incident rate for vaccination drives medical supplies. These points highlight the significance of studying Aetiology and Antimicrobial resistance patterns of Bacterial Meningitis in Adults Patients of patients at Parirenyatwa Group of Hospitals, as it will provide regional data.

2.3.2 Antimicrobial resistance patterns of Bacteria causing Meningitis

The primary bacteria responsible for bacterial meningitis include *Streptococcus pneumoniae, Neisseria meningitidis and Haemophilus influenzae*. Each of these pathogens has shown varying degrees of resistance to commonly used antibiotics

A 2021 study which focused on antimicrobial resistance patterns on CSF found that *S.pneoumoniae* isolates were sensitive to fluoroquinolones, linezolid or vancomycin. In addition the susceptibility to amoxicillin cefotaxime and ceftriaxone was 74.8%, 59.0%, and 50.0%, respectively (Peng et al , 2021) However it was found that 84% of the isolates were resistant to erythromycin, clindamycin, Sulfamethoxazole, and Tetracycline (Peng et al , 2021). The results of this study coincides with the findings of a similar study conducted in Pakistan. This study found that *S.pneumoniae* isolates were 100% susceptible to both levofloxacin and vancomycin. In addition, it was found that 64% of isolates were resistant to erythromycin (Ali & Taj, 2021). Peng et al , 2021 found that *S.pnemoniae* isolates were

susceptible to amoxicillin however Ali & Taj, 2021 found that 100% of the isolates were resistant to amoxicillin. A similar study by Assegu et al, 2020 also showed that *S.pnemoniae* was resistant to amoxicillin as 80% of the isolates were resistant to the drug. Multidrug resistance (MDR) is a growing concern in *S.pneumoniae*. A study in Brazil reported that 42.9% of pneumococcal meningitis isolates were MDR, defined as resistance to three or more antibiotic classes. Another study in the United States found that 27.5% of invasive pneumococcal disease isolates were MDR (Arreaza & de la Fuente, 2000).

H. influenzae has shown varying patterns of antimicrobial resistance, particularly concerning bacterial meningitis. Despite the introduction of the H. influenzae type b (Hib) vaccine, which has markedly reduced the incidence of invasive Hib disease, antibiotic resistance remains a critical challenge in managing infections caused by this bacterium. Resistance to ampicillin has been observed in isolates. Approximately 28-30% of isolates are resistant to ampicillin (Potts et al, 2016). Furthermore, the prevalence of beta-lactamase production, a key mechanism conferring resistance, has nearly doubled from 2003 to 2023, underscoring the growing challenge of treating infections caused by resistant strains (Abavisani, Keikha, & Karbaleae, 2024). In addition susceptibility to Ceftazidime, Ceftriaxone and Ciprofloxacin was found to be 90%, 86% and 95% (Ali & Taj, 2021). These results are similar to findings of Potts et al, 2016 in which isolates showed susceptibility to Ceftazidime, Ceftriaxone and Ciprofloxacin.

Penicillin has traditionally been the first-line antibiotic for treating meningococcal meningitis. However, resistance to penicillin has been increasing globally. A systematic review and meta-analysis found that non-sensitivity to penicillin was higher at 27.2%, while resistance to other commonly used antibiotics like ceftriaxone, cefotaxime, ciprofloxacin and rifampin remained low, ranging from 1-3.4% (Mosayeb et al, 2022). Another study reported higher resistance to cefotaxime and ciprofloxacin at 45% (Tafera

& Mekonnen, 2020). Multidrug resistance (MDR) is also emerging in *N.meningitidis*. One study found that 60.4% of isolates exhibited MDR, with serogroup B being 100% MDR, followed by serogroup X at 80% and serogroup Y/W-135 at 72.7%. Only 16.9% of isolates had no resistance to any of the antibiotics tested. (Tafera & Mekonnen, 2020). Ongoing surveillance and prudent antibiotic stewardship are essential to preserve the effectiveness of antibiotics against this serious infection.

To combat the rising tide of antibiotic resistance, several strategies are essential. Implementing antibiotic stewardship programs is crucial to promote the judicious use of antibiotics and minimize unnecessary prescriptions. Additionally, public awareness campaigns can educate communities about the importance of appropriate antibiotic use and the dangers of self-medication. Ongoing surveillance of resistance patterns is vital to inform treatment guidelines and ensure the effective management of infection.

The patterns of antimicrobial resistance present significant challenges in the treatment of bacterial meningitis and other invasive infections. With rising resistance rates to key antibiotics, particularly ampicillin, healthcare providers must adapt their treatment strategies to ensure effective patient care. Continued research and surveillance are essential to understand the dynamics of resistance and develop effective interventions to mitigate its impact on public health.

2.3.3 Antimicrobial resistance patterns of bacterial meningitis pathogens in Zimbabwe

A study analyzing antimicrobial resistance in Harare from 2012 to 2017 found high resistance rates to common antibiotics, such as ampicillin and penicillin, with resistance levels ranging from 70% to 100% for certain pathogens. The study highlighted significant

increases in resistance to commonly used antibiotics, indicating a growing public health challenge in Zimbabwe (Mhondoro et al, 2019).

While the study primarily focused on various bacterial pathogens, it underscores the need for specific data on pathogens responsible for bacterial meningitis, such as *Neisseria meningitidis* and *Streptococcus pneumoniae*. Resistance rates to first-line antibiotics, particularly penicillin, have been noted to be higher in some regions, with non-sensitivity to penicillin reported at 27.2% globally (Mosayeb et al, 2022).Zimbabwe's drug resistance index indicates a high risk of antimicrobial-resistant pathogens, scoring 66% (Mambondiyani, 2024). This reflects significant challenges in managing infections, including bacterial meningitis, where effective treatment options may be limited due to resistance.

The data on antimicrobial resistance patterns in Zimbabwe reveal a critical need for ongoing surveillance and research focused on specific pathogens causing bacterial meningitis. Understanding these resistance patterns is essential for guiding effective treatment strategies and improving patient outcomes in the face of rising antimicrobial resistance.

2.3.4 Cryptococcal meningitis and its relation to drug resistance bacterial meningitis

Cryptococcal meningitis is a severe fungal infection of the membranes protecting the brain and spinal cord caused mostly by the fungus *Cryptococcus neoformans*. It is an opportunistic infection that primarily affects persons with weaker immune systems, particularly those with HIV/AIDS (Veltman, Bristow, & Klausner, 2014). In sub-Saharan Africa, the incidence of cryptococcal meningitis ranges from 0.85 to 1.1 cases per 100,000

population. However, in people living with HIV, the incidence is much higher, ranging from 3.2 to 7.9 cases per 100,000 population (Muzazu & Assefa, 2022).

Literature has placed a great focus on cryptococcal meningitis. A concentrated focus on treating Cryptococcal meningitis, a fungal infection, can inadvertently contribute to the rise of drug-resistant bacterial meningitis through several mechanisms. Patients suffering from Cryptococcal meningitis, particularly those with weakened immune systems are at a higher risk of developing secondary bacterial infections. To manage these infections, healthcare providers often resort to broad-spectrum antibiotics. The over prescription and inappropriate use of these antibiotics can contribute to the development of antimicrobial resistance among bacterial pathogens, including those responsible for bacterial meningitis (Abdelkader et al, 2017). When the focus is heavily tilted towards managing fungal infections, there may be insufficient emphasis on antimicrobial stewardship programs that promote the appropriate use of antibiotics. This neglect can worsen the problem of antibiotic resistance, as healthcare systems may not prioritize monitoring and controlling antibiotic use in the context of concurrent fungal infections.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodology was used by the researcher in conducting the study. This chapter will discuss study population, research design, and inclusion and exclusion criteria in detail

3.2 Research design

This research employed a retrospective cross sectional study design to investigate the aetiology and antimicrobial resistance patterns of bacterial meningitis in adult patients admitted to Parirenyatwa Group of Hospitals from January 2023 to August 2024. This design facilitated the collection of data on bacterial pathogens and their resistance profiles at a single point in time, offering insights into the current epidemiological trends and resistance patterns.

3.3 Study Population

All patients aged 18 and above, on the day of presentation to hospital, admitted with a clinical diagnosis of meningitis to adult medical wards at Parirenyatwa hospital, (Harare) and fulfilling the criteria described below. Cases were recruited consecutively over a 24-month period (1 January 2023 to 31 December 2024).

3.4 Inclusion Criteria

The study included samples from adult patients (aged 18 years and older on the day of admission). Both community-acquired and hospital-acquired cases were included. These patients were admitted to Parirenyatwa Group of Hospitals with a clinical diagnosis meningitis.

3.5 Exclusion Criteria

Patient's records with incomplete data will not be used.

3.6 Sample size

The sample size was calculated using the statistical formula for approximating a single proportion. Historical data suggests that BM makes up 20-30% of meningitis cases (WHO, 2023)

Assume a confidence level of 95% (Z = 1.96), an estimated prevalence of 20% (P = 0.20), and a margin of error of 5% (E = 0.05).

$$n = \frac{(1.96)^2 \cdot 0.20 \cdot (1-0.20)}{(0.05)^2}$$

$$n = \frac{3.8416 \cdot 0.20 \cdot 0.80}{0.0025}$$

$$n = \frac{0.6144}{0.0025}$$

$$n \approx 246$$

So, approximately 246 participants are needed to estimate the prevalence with a 95% confidence level and a ±5% margin of error.

3.7 Sampling Procedure

Convenience Sampling was employed to select all cases of bacterial meningitis diagnosed during the study period where complete data is available. This approach involves:

Reviewing patient records to identify cases meeting the diagnostic criteria.

Extracting relevant data on patient demographics, clinical presentation, microbiological findings, and antimicrobial resistance pattern

3.8 Pilot Study

The pilot study reviewed records of a sample of 20 patients who meet the inclusion criteria. This sample size allows for initial testing of data collection methods without being too extensive.

3.9 Study Setting

The study was set at Parirenyatwa Group of Hospitals which is a quaternary level hospital where highly specialized care is provided to patients with more complicated cases. Currently, Parirenyatwa hospital is the largest government hospital complex in Zimbabwe. The hospital serves the citizens of Harare as well as other patients from across the country who seek more complex form of treatment

3.10 Data analysis

Statistical Analysis

Descriptive statistics was used to calculate the prevalence of identified pathogens and their resistance patterns as well as to summarize demographic and clinical characteristics of the study population.

Chi-square Test was emplyed to assess associations between age, aetiology and resistance patterns.

Data Visualization

Graphs and Tables: Visual representations of the data, bar graphs for pathogen prevalence, pie charts for resistance rates, and tables summarizing demographic information and clinical findings. This will facilitate easier interpretation of the results.

The results were interpreted in the context of existing literature on bacterial meningitis and antimicrobial resistance

3.11 Ethical considerations

Patient information and samples collected was kept confidential.

Approval for this study was obtained from the Ethics Review Committee (ERC) of Africa University (AUREC). Also, consent to conduct the research will be acquiring from Parirenyatwa Group of Hospitals, Harare. During the extraction of this data, no names or identity markers that may like the data to an individual was collected to promote anonymity.

CHAPTER 4: RESULTS

4.1 INTRODUCTION

This chapter contains the results of the study, data presentation and analysis. The data is expressed in percentages or absolute values and presented in the form of tables, charts & graphs. A brief explanation of fundamental information is also provided were necessary. The overall mean age of the study population is 41 years. 51% of the participants were male (232/447) and 48% of the participants were female (215/447).The mean age for male participants is 42 years while for females is 39 years.

Table 1: Demographics distribution of study population.

Age	**Male (%)**	**Female (%)**	**Total (%)**
18-29	40 (8.9%)	62 (13.8%)	102 (22.8%)
30-39	57 (12.7%)	51 (11.4%)	108 (24.1%)
40-49	71 (15.9%)	56 (12.5%)	127 (28.4%)
50-59	40 (8.9%)	22 (4.9%)	62 (13.8%)
60-69	18 (4.0%)	16 (3.6%)	34 (7.6%)
70-79	2 (0.4%)	6 (1.3%)	8 (1.8%)
80-89	4 (0.9%)	2 (0.4)	6 (1.3%)
Grand Total	232 (51.9%)	215 (48.1%)	447 (100.0%)

Figure 2

4.2 Prevalence of Bacterial Meningitis

4.2.1 Positive Bacterial Meningitis cases by gender

The study was conducted at Parirenyatwa Group of Hospitals in Harare using data from BioFire covering a two-year period from January 2023 to December 2024. The study population constituted 447 individuals presumptively positive for meningitis. Out of the 447 CSF that were tested for meningitis, 35 samples were positive for bacterial meningitis. 18(46%) samples of the positive CSF samples were from female patients and 16 (51.53%) were from male patients.

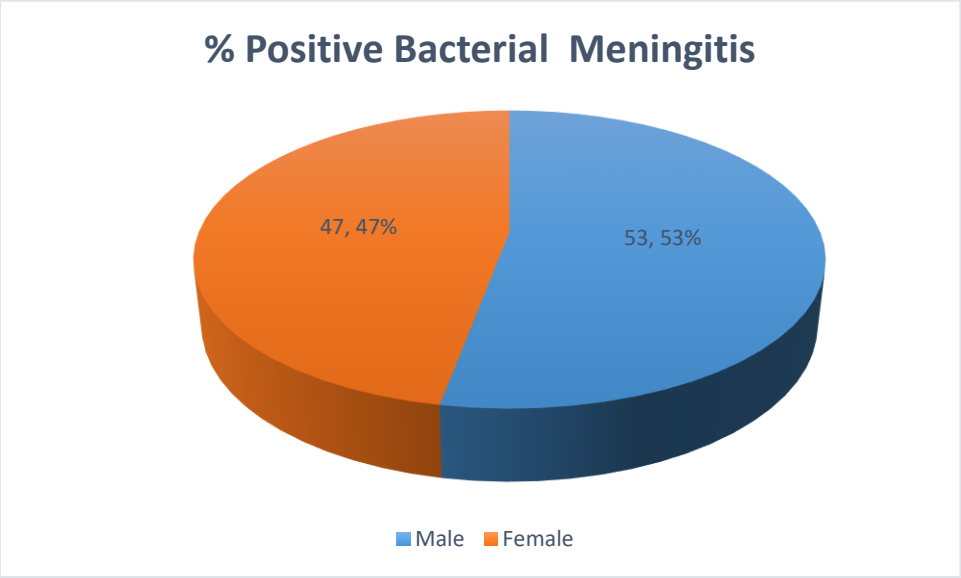

Figure 3 Frequency of positive bacterial meningitis cases by gender p-value = $P(Z \leq 0.686) = 0.2466$.

4.2.2 Positive Bacterial Meningitis cases by age group

From the 35 positive cases of bacterial meningitis detected over the two-year period 13 (37%) samples belonged to the 18-29 Years age group followed by 30-39 Years age group where 31% of the positive cases where detected. The least number of cases were detected in the 40-49 Years age group. Both 50-59 and 60-69 Years had the second lowest number of cases with a prevalence of 11%.

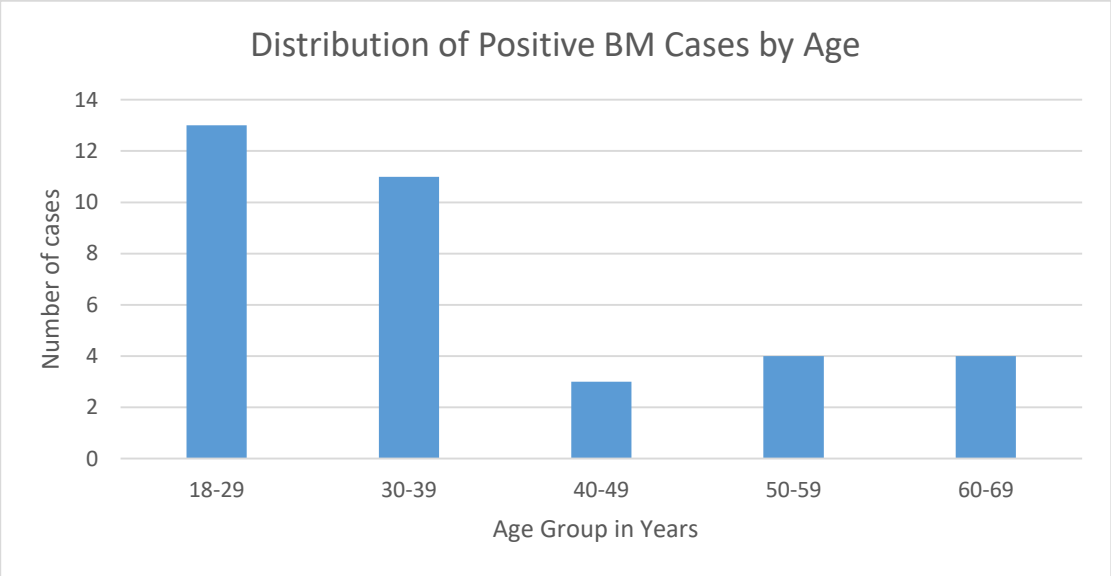

Figure 4 Number of positive bacterial meningitis cases across age groups ($P \approx 0.0153$)

4.2.3 Temporal Distribution of Bacterial Meningitis

A greater number of confirmed meningitis cases occurred during 2023. The highest number of confirmed meningitis cases occurred during March 2023. The monthly prevalence of confirmed meningitis was lower in 2024. It was notable that the seasonal distribution indicated that the number of positive CSF cultures decrease during autumn (April to June)

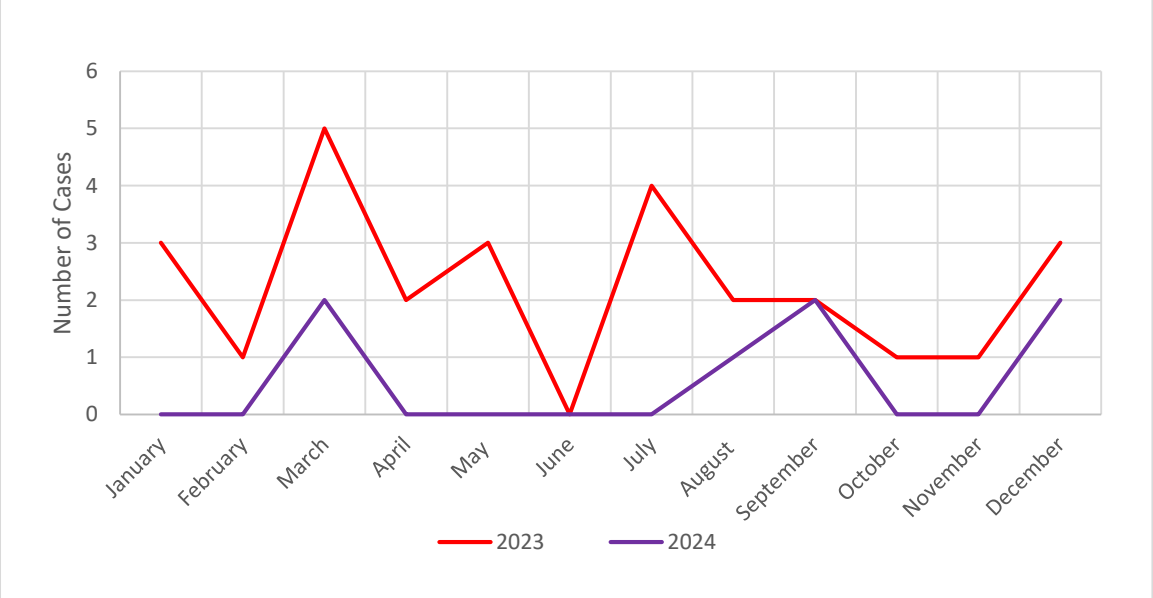

Figure 5 The distribution of confirmed meningitis cases at Parirenyatwa Group of Hospitals from January 2023 to December 2024

4.4 Aetiology of Bacterial Meningitis

The prevalence of BM in adult patients who submitted samples at Parirenyatwa Group of Hospitals in this from January 2023 to December 2024 report was 7.6% (35/447), the listed above bacterial pathogens were isolated and identified: *E. coli* 1 (2.9%), S. agalactae 1 (2.9%), *N.meningitidis*, 10(28.9%), *H.influenzae* 4 (11.4%), *S.pneumoniae* 19 (54.2%).

Table 2 Yearly distribution of meningitis pathogens of adult patients admitted at Parirenyatwa Group of Hospitals

AGENT	**2023(%)**	**2024(%)**	**TOTAL (%)**
Gram positive			20(57.1%)
S.pneumoniae	16(45.7%)	3(8.6%)	19(54.2%)
S.agalactae	1(2.9%)	0(0.0%)	1(2.9%)
Gram negative			15(42.8%)
E.coli	1(2.9%)	0(0.0%)	1(2.9%)
N.meningitidis	6(17.1%)	4(11.4%)	10(28.9%)
H.influenzae	3(8.6%)	1(2.9%)	4(11.4%)
TOTAL(%)	27(77.1%)	8(22.9%)	35 (100.0%)

4.4.1 Aetiology of Bacterial Meningitis by Gender

Table 3 Observed Cases of Bacterial Pathogens by Gender with Corresponding P-Values

This table summarizes the observed cases of bacterial pathogens in male and female patients, along with the p-values indicating the significance of gender differences in infection rates for each pathogen.

Pathogen	**Male**	**Female**	**P-Value**
S.pneumoniae	11	8	0.743
N.meningitidis	3	7	0.123
H.influenzae	3	1	0.486
E.coli	1	0	N/A
S.agalactae	1	0	N/A

The table presents findings on the prevalence of different pathogens in male and female subjects, along with the associated p-values. *S.pneumoniae* was observed in 11 males and 8 females, with a p-value of 0.743, indicating no significant gender difference. *N.meningitidis* was present in 3 males and 7 females, with a p-value of 0.123, suggesting a potential trend but not statistically significant. *H.influenzae* was found in 3 males and 1

female, with a p-value of 0.486, showing no significant difference. *E.coli* and *S.agalactae* were each found in one male and no females, with no p-values reported for these pathogens. Overall, the data does not show significant gender differences in the prevalence of these pathogens.

4.4.2 Aetiology of Bacterial Meningitis by Age

The obtained from Fisher's Exact Test indicates that there is not a statistically significant association between the distribution of major bacterial meningitis pathogens and age in this study. The result suggests that age does not significantly influence which pathogens are present in cases of bacterial meningitis within the study population, meaning that any observed differences in pathogen distribution across age groups may be due to random chance rather than a true effect.

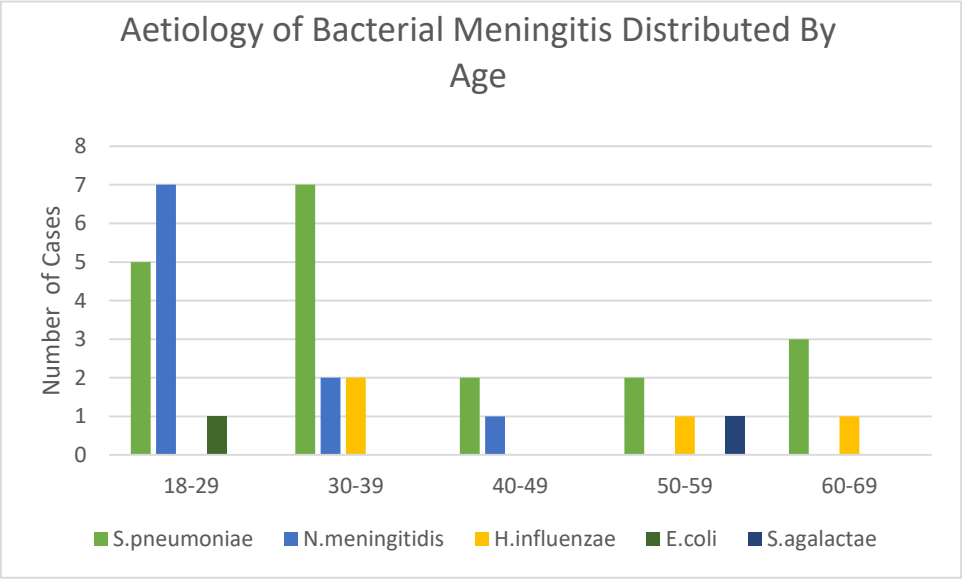

Figure 6 Distribution of major BM pathogens by age of adult patients admitted at Parirenyatwa Group of Hospitals p-value 0.1679

4.5 Antimicrobial resistance patterns of Bacterial Meningitis

In this study a retrospective antibiotic profile analysis of isolates was performed. Based on the provided data on antibiotic susceptibility, the tested bacteria exhibit high susceptibility to Penicillin (94%), Ampicillin (91%), Gentamicin (88%), and Ceftriaxone (88%). However, Meropenem shows a comparatively lower susceptibility rate of 75%, indicating potential resistance issues with this antibiotic.

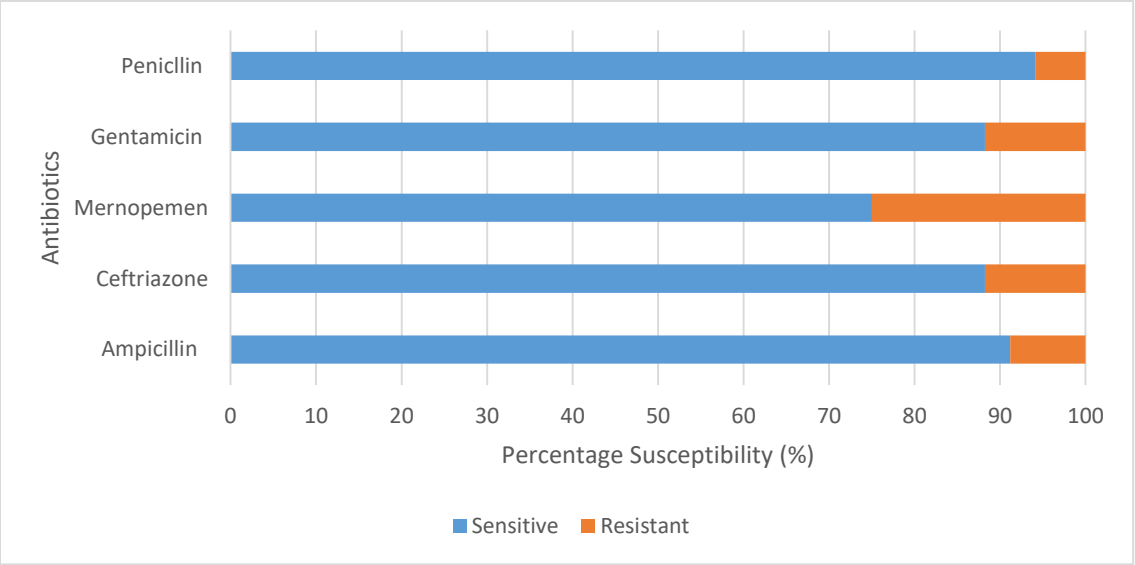

Figure 7: Antibiotic Susceptibility and Resistance Profiles of Bacterial Isolates

4.6 Bacterial Meningitis vs. Cryptococcus Neoformans

Over the two-year period, out of 447 suspected meningitis cases, 97 were positive for Cryptococcus neoformans and 35 were positive for bacterial meningitis

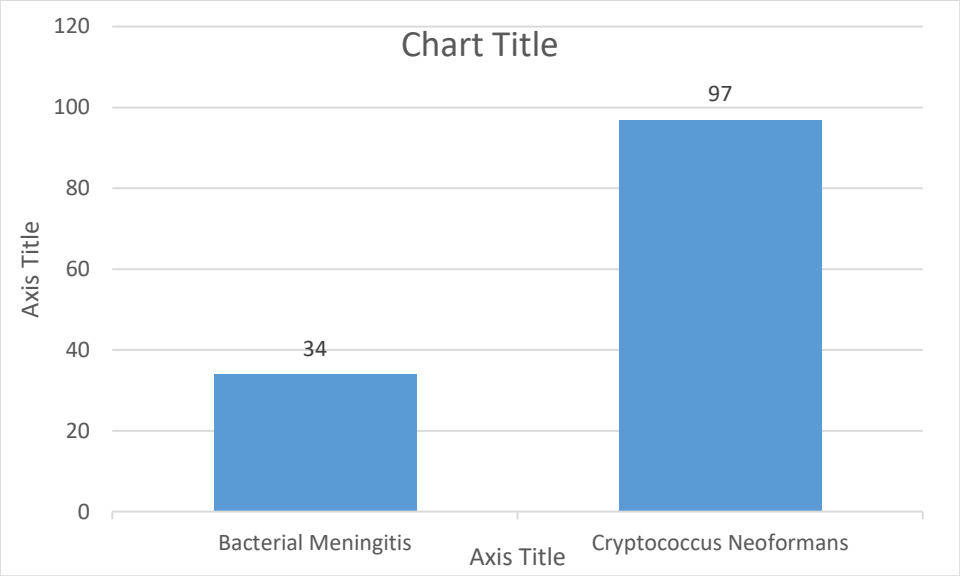

Figure 8 Comparison between number of positive Bacterial Meningitis cases and number of *Cryptococcus neoformans* cases at Parirenyatwa Group of Hospitals from 2023-2024. p-value = $P(Z \leq -5.87) \approx 0$

CHAPTER 5: Summary of findings, Conclusions and Recommendations

5.1 Introduction

This chapter provides a brief discussion of the study, summary of the research findings, conclusion and recommendations. Comparison and contrasting will be made with particular attention to literature from past studies related to the current study.

5.2 Discussion

The main objective of this study was to identify the major bacterial aetiology of BM and to identify the antimicrobial resistance pattern.

5.2.1 Prevalence of Bacterial Meningitis

Out of total 447 CSF samples submitted at Parirenyatwa hospital from January 2023 to December 2024, 35 yielded positive for bacterial meningitis using PCR-based diagnostics technique, Biofire reflecting prevalence of 7.8%. A similar study conducted in Ethiopia which using the same PCR-based diagnostics found a prevalence of 18.4% among CSF samples (Bårnes et al., 2018). In a study conducted at Turku University Hospital in Finland analyzed data from 148 adults with bacterial meningitis treated between 2011 and 2018. The study found that the prevalence of bacterial meningitis among adults was 33.8% (Sakke , 2023). A similar hospital-based study in Southern Taiwan investigated the epidemiology of adult bacterial meningitis over a 6.5-year period. The study reported a prevalence rate of 23% among adults (Chang et al., 2008). The prevalence at Parirenyatwa Hospital is lower than in that seen in the Ethiopian study probably because Zimbabwe is outside the traditional African meningitis belt, which spans from Senegal to Ethiopia. The meningitis belt experiences higher prevalence due to environmental factors such as dry seasons, dust storms, and close population density that facilitate the spread of *Neisseria meningitidis*. The study in Zimbabwe included all CSF samples submitted for testing,

which may include many cases with low clinical suspicion of bacterial meningitis. In contrast, the Finnish study focused specifically on adults with confirmed bacterial meningitis, leading to higher prevalence rates. The lower prevalence at Parirenyatwa Hospital likely reflects a combination of regional epidemiological differences, effective vaccination programs, diagnostic practices, population health status, and temporal factors. Further research comparing these variables directly would provide insights that are more conclusive.

The 18-29 Years age group accounted for 37% of the positive bacterial meningitis cases. Despite having only 23% of the participants, they had the highest incidence of the disease. 30-39 Years group accounted for 31% of the positive cases and comprised 24% of the participants. They had a significant incidence of bacterial meningitis relative to their proportion in the study. Surprisingly, 40-49 Years age group had the lowest incidence of bacterial meningitis at 9%, despite having the largest number of participants at 28%. The 50-59 Years and the 60-69 Years age groups both had an incidence of 11%. Both these group had few number of participants.

The higher incidence of bacterial meningitis compared to their participation rates observed in 18-29 and 30-39 age groups could indicate a higher susceptibility or exposure to bacterial meningitis pathogens. Younger adults, particularly those in the 18-39 age range, often engage in more social activities, such as attending large gatherings such as concerts, living in dormitories, or participating in group settings like military barracks. These environments facilitate enhances the risk of exposure to pathogens like *Neisseria meningitidis* and *Streptococcus pneumoniae* (CDC, 2024). In addition, Smoking and exposure to second-hand smoke can increase the risk of carrying bacteria that cause meningitis, such as pneumococci and meningococci (Cruickshank & Jefferies, 2014). The results are consistent with a study conducted in England showed a notable incidence in the

15-44 age range, where 21.5% of bacterial meningitis cases were reported (Sathyavani et.al, 2023). However, our study shows a discrepancy within this broader age range, with the 40-49 age group having a lower incidence.

The 40-49 age group, despite having the largest number of participants, had the lowest incidence. This might suggest better health practices, vaccination coverage, or lower exposure to pathogens in this age group. This results contrast with other studies where the 45-64 age group had a higher proportion of cases (24%) (Sathyavani et.al, 2023). In the a Dutch study, pneumococcal meningitis cases predominantly occurred in older adults (45-64) and the elderly(>65) as they had incidence rate of 15.1% and 14.1% respectively (Diederik et.al, 2021). Thus, most studies tend to suggest that older adults are generally at higher risk compared to younger adults.

The results highlight the need for targeted interventions and awareness campaigns, particularly in the 18-39 age groups, to reduce the incidence of bacterial meningitis. Further research is needed to understand the factors contributing to the lower incidence in the 40-49 age group and how these can be applied to other age groups. In conclusion, these findings suggest a complex relationship between age and the incidence of bacterial meningitis, with younger adults being more susceptible to infection despite having fewer participants in the study. Understanding these dynamics can help in developing more effective public health strategies.

Results from the study found that out of 35 positive cases, 51.53% were male and 46.47% were female. The P-Value of 0.2466 suggests that the observed differences or associations between gender and bacterial meningitis incidence in the study could be due to chance rather than a real effect. Therefore, the study did not provide sufficient evidence to conclude that such a relationship exists at a statistically significant level. Similarly, in a

study conducted by Dharmarajan et.al, 2016, Males constituted 47.2% of the cases, while females made up 52.8% suggesting that there was no significant male predominance in the overall prevalence of community-acquired meningitis. While gender does not significantly affect the overall prevalence of community-acquired meningitis in this study, there are notable differences in clinical presentation, etiology, and prognostic factors between males and females. Males were more likely to have a positive Gram stain (10.3% vs. 3.7%, $p=0.003$) and more often tested positive for C. neoformans (27.0% vs. 8.7%, $p<0.001$) than females. Furthermore, males often presented with fever and abnormal microbiology results, while females more frequently presented with nuchal rigidity. These differences highlight the importance of considering gender in the management and prognosis of meningitis. A similar study was conducted in Finland involving 148 patients. This study found that 48.6% of the cases were male, and it noted that the clinical characteristics and outcomes could vary based on gender, although specific gender-related outcomes were not detailed in this study (Niemelä et.al, 2023). Dias et.al, 2022 explored how biological sex and gender influence bacterial meningitis. This study found that women generally exhibited stronger immune responses, with higher serum inflammatory markers compared to men. In addition, Male sex was identified as an independent predictor of poor prognosis in bacterial meningitis cases based on clinical outcomes, including mortality, neurological complications, and long-term disability. Therefore, although most studies highlight that there is no statistical significance of prevalence of bacterial meningitis between male and female they do however reveal that gender affects the clinical presentation, and outcomes of bacterial meningitis. Understanding these sex and gender differences is crucial for developing targeted therapeutic strategies and improving patient outcomes in bacterial meningitis.

The results from the study indicates a higher number of confirmed meningitis cases in 2023 compared to 2024, with the peak occurring in March 2023. March falls within the dry season in Zimbabwe, which is often associated with higher transmission rates of bacterial meningitis.The monthly prevalence of confirmed meningitis decreased in 2024, and the seasonal distribution showed a decline in positive cerebrospinal fluid (CSF) cultures during autumn (April to June). This pattern aligns with typical seasonal trends observed in the African meningitis belt, where meningitis incidence often peaks during the hot, dry months (December to April) and decreases with the onset of the rainy season (May to June).

In the African meningitis belt, meningitis cases usually peak during dry seasons (December to March) due to factors such as dust and low humidity (Mustapha & Harrison, 2018). Dry conditions are believed to damage the pharyngeal mucosa which makes it easier for meningococci to colonize and invade the epithelium. This increases the likelihood of infection (WHO, 2023). In addition, dry season is usually characterized by high levels of dusty. These dust particles irritate the throat thereby increasing susceptibility to infection. In West Africa, Harmattan winds which are usually observed during dry season pick up dust from arid regions and bring cold air which contributes to the spread of meningitis by worsening respiratory conditions and potentially increasing susceptibility to meningococcal infections (Juliette et al., 2016).These factors combined create an environment that is conducive to the spread of meningococcal disease during the dry season.

The peak observed in March aligns with the end of dry season but the general pattern does not follow that seen in the belt. Another peak is observed from July to August which falls within rainy season that typically runs from May to November. While Zimbabwe experiences a similar dry season, its climate is not as pronouncedly Sahelian or Sudano-Guinean as in the belt, which might explain differences in the timing of the peak. In

addition, Zimbabwe does not fall within the African Meningitis Belt. Its geographical location and climate may contribute to variations in the seasonal distribution of meningitis cases compared to countries within the belt.

There is limited knowledge on typical peak months for meningitis cases in Zimbabwe over a broader period. Without more comprehensive data, it is challenging to definitively state the peak months for meningitis cases in Zimbabwe beyond the specific study period. Understanding these patterns is crucial for developing effective public health strategies to reduce the incidence of meningitis and improve health outcomes in Zimbabwe and similar contexts. Further research could explore the temporal distribution over a broader period to determine the pattern of Bacterial Meningitis in Zimbabwe so as to guide public health strategies.

5.2.2 Aetiology of Bacterial Meningitis

In the study, *S.pneumoniae* emerged to be the most frequently occurring pathogen; at 54.2% frequency followed by *N.meningitidis* 28.9%, *H.influenzae* 11.4%, *S.agalactae* 2.9% and *E.coli* 2.9%. Globally, bacterial meningitis is primarily caused by three pathogens: *S. pneumoniae*, *N. meningitidis*, and *H. influenzae*. These pathogens account for the majority of cases in both high-income and low-income countries (WHO, 2024). Many studies of the aetiology of bacterial meningitis have illustrated a predominance of *S. pneumonia*. A study conducted in Congo by *Fonkoua & Cunin, 2001* detected *Streptococcus pneumoniae*, *Haemophilus influenzae* and *Neisseria meningitidis* as the main aetiological agents of bacterial meningitis with a prevalence of 56.2%,18.5% and 13.4% respectively. A similar study conducted in 2018 in Zimbabwe found that *S. pneumoniae* accounted for 40.0% of BM cases followed by *S. agalactiae* 17.5%., *S.aureus* 10.0% while the least common organism detected was *S.pyogens* 2.5% (Dzinamarira,

2018). The predominance of *S. pneumoniae* across studies underscores its critical role as a leading cause of bacterial meningitis globally. It is noteworthy that *N.meningitidis* , *H.influenzae* and *S.agalactae* are not easily culturable. This calls for protocols that support the identification of these in CSF. Latex Agglutination Tests can rapidly detect bacterial antigens in CSF for pathogens like *N. meningitidis* and *H. influenzae*. They are particularly useful when cultures fail. Techniques like BioFire FilmArray allow simultaneous detection of multiple pathogens, including fastidious organisms, directly from CSF. As of 2025, in Zimbabwe, BioFire is only available at Parirenyatwa Hospital. By implementing these protocols, Zimbabwe's healthcare system can improve the identification of fastidious pathogens in CSF, leading to more accurate diagnoses and better patient outcomes

The findings from the results showed that highest number of *Neisseria meningitides* cases were identified in the 18-29 Years age group (70%) followed by 30-39 age group (20%) . With regards to *Streptococcus pneumonia* the highest number of cases for this pathogen was found in the 30-39 age group (36%) this was followed by the 18-29 Years age group (29%). Notably *H.influenzae* was detected in all age groups except 18-29 and 40-49 Years age groups.

Trends seen in *Neisseria meningitides* are consistent with other studies indicating that adolescents and young adults are at higher risk of meningococcal disease due to increased social interaction and exposure in crowded settings like colleges and dormitories (CDC, 2024). Notably, no cases of *N. meningitidis* were detected in the 50 and above age groups. This aligns with observations that meningococcal disease is less common in older adults, who are more frequently affected by pneumococcal meningitis.

The results observed in *Streptococcus pneumonia* suggests that pneumococcal meningitis becomes more prevalent as individuals age into their thirties, possibly due to increased

exposure or waning immunity. S. *pneumoniae* is a common cause of bacterial meningitis in adults, particularly in older age groups, but these findings highlight its significance in younger to middle-aged adults as well. This contradicts current data from the WHO which show that *S. pneumoniae* is more common in older adults than in younger adults due to lowered immunity and increased susceptibility (WHO, 2023). *H. influenzae* was detected in all age groups except the 18-29 and 40-49 age groups. This pattern suggests that *H. influenzae* infections may be less common in young adults and middle-aged individuals, possibly due to vaccination efforts or other factors reducing its prevalence in these age groups

In conclusion, these findings emphasize the importance of age-specific strategies for preventing bacterial meningitis, including targeted vaccination and awareness efforts. The distribution of pathogens like *N. meningitidis* and *S. pneumoniae* across different age groups highlights the need for tailored public health interventions to address these varying risks effectively.

Moreover, studies have found that pathogens exhibit gender biased due to sociocultural and biological factors. Smoking and alcohol consumtions are well-documented risk factors casued by *Streptococcus pneumoniae*. Observational studies indicate that smokers have an increased risk of developing Invasive Pneumococcal Disease (IPD), with relative risks ranging from 2.2 to 4.1 (Cruickshank & Jefferies, 2014). In addition, studies have reported that individuals with a history of alcohol abuse had a higher incidence of IPD, with relative risks ranging from 2.9 to 11.4 in different studies (Cruickshank & Jefferies, 2014). These behaviors are more prevalent among men, which contributes to the observed male bias in pneumococcal infections. One study reported that 65% of patients with invasive pneumococcal disease (IPD), which includes bacterial meningitis were male, highlighting a clear gender disparity in infection rates (Guru et.al, 2014). Our study found that more

males were infected with *Streptococcus pneumoniae* as compared to females however the difference was not statistically significant (p=0.7). While the data suggest a male bias in the incidence of S. pneumoniae infections (11 males vs. 8 females), the small sample size limits the strength of any conclusions. Concerning *Neisseria meningitidis* & *Haemophilus influenzae* studies have shown no clear gender biased for these pathogen as similar rates have been observed in males and female (Dias et.al, 2022).

Currently no data exists on clinical presentation of patients with suspected meningitis at the Clinical Laboratory at Parirenyatwa Group of Hospitals. Findings from other studies underscore the necessity for clinical presentation to be included onto laboratory request forms to improve treatment and management strategies of patients with Bacterial Meningitis at Parirenyatwa Hospital.

5.2.3 Antimicrobial Resistance Pattern

The antibiotic susceptibility and resistance patterns observed in this bacterial meningitis study highlight critical trends in treatment efficacy and emerging resistance. From the results, penicillin showed the highest succeptibilty (94%). This contrast with other research studies. In a study 2017 study, 44.7% of gram-positive isolates were resistant to penicillin. (Mona et al., 2017). A similar trend was observed in a study conducted by Assegu et al F. D., 2020 found that both *S. pneumoniae* and *N. meningitidis* exhibited 100% resistance to penicillin. Ampicillin demonstrates a high efficacy (91% succeptibilty), falling slightly behind Penicillin. Other studies reported 51.5% resistance in gram-negative isolates (Assegu et al F. D., 2020). A similar pattern was observed in a 2020 study where 50-60% resistance was observed in *H. influenzae* and *E. coli* (Awulachew et al, 2020)

Meropenem displayed the lowest susceptibility of 75% conflicting with studies. Assegu et al D. , 2020 found 8.57% resistance in Gram-positive isolates, recommending it as the first-

line therapy. Meropenem's unexpectedly low performance may indicate emerging resistance in specific bacterial strains. Meropenem's susceptibility rate of 75% raises significant concerns, particularly because it is one of the antibiotics reserved as a last line of defense against multidrug-resistant bacterial infections. Meropenem, a carbapenem antibiotic, is reserved for severe infections caused by multidrug-resistant Gram-negative bacteria like Acinetobacter and Klebsiella. Its reduced effectiveness leaves limited alternatives

With regards to ceftriaxone 88% susceptibility rate indicates that ceftriaxone remains a reliable choice for treating bacterial meningitis, though resistance is emerging in some regions. A Swiss study reported 100% susceptibility of *S. pneumoniae* isolates to ceftriaxone, supporting its use as a cornerstone in meningitis therapy (Raemy et al, 2023)

While penicillin and ampicillin remain recommended, the observed resistance patterns emphasize the need for continuous local surveillance, and for regional adaptation of empirical treatment protocols. These discrepancies underscore the critical importance of context-specific antibiotic stewardship programs and the limitations of generalizing resistance patterns across populations. The study reinforces WHO recommendations for regular antimicrobial resistance monitoring in meningitis management (WHO, 2024).

5.2.5 Bacterial Meningitis vs. Cryptococcus Neoformans

The comparison of bacterial meningitis (35 cases) and Cryptococcus neoformans (CN) (97 cases) at Parirenyatwa Group of Hospitals from 2023–2024, with a $P(Z \leq -5.87) \approx 0$, reflects a significant difference in the number of cases. However, this disparity does not diminish the importance of bacterial meningitis testing. Concerning disease severity, bacterial meningitis is considered highly severe and can lead to severe neurological damage or even

death if not treated promptly. In contrast, cryptococcal meningitis typically progresses more slowly, with symptoms developing over days to weeks. The inflammatory response se in CN is generally milder than in bacterial meningitis (Tenforde et al., 2020). Despite the lower number of cases, bacterial meningitis has a high mortality rate. If not treated timely, the mortality rate of bacterial meningitis can exceed 50%. Even with appropriate treatment, mortality rates can range from 10% to 30%, depending on the causative organism and the patient's underlying health (Runde et al., 2023). CM has a higher mortality rate (up to 78% in HIV-positive individuals) but develops more gradually than bacterial meningitis (Tenforde et al., 2020). This allows for slightly more time for diagnosis and treatment compared to bacterial meningitis, where delays of even a few hours can be fatal. Both conditions require robust diagnostic protocols to ensure appropriate treatment. Therefore, early diagnosis of BM is crucial for improving treatment.

Bacterial meningitis presents with nonspecific symptoms such as fever, headache, and neck stiffness, which overlap with other types of meningitis, including CN.Testing cerebrospinal fluid (CSF) is critical to differentiate bacterial meningitis from fungal or viral causes. Misdiagnosis or delayed diagnosis can lead to inappropriate treatment, worsening patient outcome. In addition, BM has a high potential for outbreaks. Outbreaks caused by *Neisseria meningitidis* or *Streptococcus pneumoniae* can occur in crowded settings (i.e college dormitories, military barracks) (WHO, 2023). Thus, regular testing of bacterial meningitis is crucial for early detection and the prevention of outbreaks.

Another factor which supports bacterial testing is the emergence of antibiotic-resistant strains of bacteria that cause meningitis such as *Neisseria meningitidis*. These bacteria have developed resistance to commonly used antibiotics like penicillin and ciprofloxacin (CDC, 2024). This highlights the necessity of ongoing testing and monitoring of BM. Identifying the specific bacteria responsible for an infection allows for targeted antibiotic therapy,

which is crucial in the era of increasing antibiotic resistance. In addition, timely testing of BM can promote antibiotic stewardess by preventing the unnecessary usage of antibiotics. For example, a positive bacterial diagnosis ensures targeted antibiotic therapy, while a negative result may allow discontinuation of antibiotics, reducing costs and minimizing resistance risks.

BM affects both immunocompetent and immunocompromised individuals, though the latter may have a worse prognosis whereas CN primarily affects immunocompromised individuals, such as those with HIV/AIDS, where it is a major cause of morbidity and mortality. Thus since BM affects a broader patient population with varying immune status, testing is essential.

In conclusion, while the number of bacterial meningitis cases may be lower compared to Cryptococcus neoformans, the potential severity, rapid progression, and public health implications of bacterial meningitis make testing and early detection indispensable.

5.3 Conclusion

N. meningitides and *S. pneumonia* are the main causative agents of bacterial meningitis of adult patients at Parirenyatwa Group of Hospitals. *S. pneumonia* is the predominant pathogen accountable for bacterial meningitis. Overall prevalence of bacterial meningitis is low. The highest number of cases were detected in the dry season.There is no clear association between gender and prevalence of bacterial meningitis however, the study did observe that there is an association between age. Younger adults were between the ages of 18-30 were more affected by meningitis compared to adults aged 40 and above. Antimicrobial resistance rate among common bacterial meningitis were generally lower that those observed in other studies. This may be attributed to geographical differences.

5.4 Recommendations

Based on these findings, the following recommendations were made

I. There is need to review the protocol of CSF culture in the laboratory. Current culture methods do not detect *N.meningitidis*, *H.influenzae* and *S.agalactae* which were causative agents detected in the study. Novel detection methods (i.e PCR) must be introduced to be able to detect these pathogens in CSF samples.

II. Health awareness campaigns are recommended to educate the general public particularly in the 18-39 age groups, who showed the highest incidence of BM. Campaings should educate public about early warning signs of BM and should be advised to seek early medical attention promptly.

5.5 Results dissemination

A soft copy of results will be submitted to Africa university while another copy is sent to Parirenyatwa Group of Hospitals to be used in identifying strengths, weaknesses and arrears that need to be improved gender biased in pathogens that cause bacterial meningitis, as suggested by other studies.

5.6 Suggestions for further study

The researcher suggest that futures studies should target larger population to gather more data on the bacterial meningitis. There is need to observe the prevalence over a broader time period to be able to identify a clear temporal pattern.

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APPENDICES

APPENDIX I:BUDGET

Travel Cost for data collection: $50

Ethics Approval Fee: $20

Data Collection tools (notebook, paper, pen): $10

APPENDIX II: Timeline of dissertation

JANUARY Week 1-3	Begin data collection at Parirenyatwa, attaining records patients admitted from January 2023 to August 2024
Week 4	Complete data collection and begin data descriptive and statistical analysis.Submit progress report to supervisor and address any feedback.
February Week 1-2	Complete data collection and begin data descriptive and statistical analysis.Submit progress report to supervisor and address any feedback.
Week 3	Finalize data analysis and interpretation, Including addressing potential confounding factors
Week 4	Draft discussion and conclusion sections of the report, connecting findings to existing literature and policy implications
DECEMBER	Complete the discussion and conclusion

Week 1	
Week 2-3	Revise and finalize research report based feedback from supervisor
Week 4	Submit research report University Supervisor

APPENDIX III: Data collection tool

Field	Response Type
Patient ID	
Date of Admission	
Age	
Gender	(Male/Female/Other)
Organisms Identified	
Antibiotic Names	
Susceptibility	(Sensitive/Intermediate/Resistant)

APPENDIX IV: AUREC SUPERVISOR LETTER

AFRICA UNIVERSITY
(A United Methodist-Related Institution)
"Investing in Africa's Future"

DEPARTMENT OF BIOMEDICAL AND LABORATORY SCIENCES
COLLEGE OF HEALTH, AGRICULTURE AND NATURAL RESOURCES

12 December 2024

The Clinical Director

Parirenyatwa Group of Hospitals

Dear Sir/ Madam

RE: APPLICATION FOR SUBMISSION OF PROJECT PROPOSAL FOR TATENDA IVY HOVE

This letter serves to confirm that I am supervising the above-mentioned student in her final year dissertation. She has satisfied the requirements of the college in developing her research proposal and it is ready for ethical review.

Your facilitation for the review of the proposal is greatly appreciated.

Thank you

Mr Z Chiwodza

Research Supervisor

zchiwodza@africau.edu

APPENDIX V: REQUEST FOR PERMISSION LETTER

Request for permission to conduct research at Parirenyatwa Group of Hospitals

The Clinical Director

Mazowe St, Harare

Dear Ma'am/Sir.

RE PERMISSION TO CONDUCT A MICROBIOLOGY RESEARCH AT YOUR CLINICAL LABORATORY

I am a medical laboratory science student (HBMLS) with Africa University, and have been on attachment at the laboratory department at your hospital. I am writing to formally request permission to conduct my dissertation research titled "Aetiology and Antimicrobial Resistance Patterns of Bacterial Meningitis in Adult Patients" at Parirenyatwa Hospital's laboratory facilities. This study aims to investigate the underlying causes and resistance patterns of bacterial meningitis, which is a significant public health concern. As part of my academic program in Medical Laboratory Science at Africa University, this research is essential for understanding the epidemiology of bacterial meningitis in our region and I believe it will contribute valuable insights to the medical community. I believe that conducting this research at Parirenyatwa Hospital, given its status as a leading healthcare institution and teaching hospital, will provide access to a diverse patient population and high-quality laboratory resources.

I assure you that all ethical considerations will be adhered to, including obtaining informed consent from participants and ensuring confidentiality throughout the study. I am committed to collaborating with your team to ensure that the research aligns with the hospital's standards and contributes positively to patient care. I would appreciate the opportunity to discuss this proposal further and explore how we can facilitate this research at Parirenyatwa Hospital. Thank you for considering my request. I look forward to your positive response

Sincerely,

Tatenda Hove

APPENDIX VI: SITE APPROVAL LETTER

All communications should be addressed to
"THE CHIEF MEDICAL OFFICER"
Telephone: 701520-701554/7
Fax: 706627
Website:www.parihosp.org

PARIRENYATWA GROUP OF HOSPITALS
P.O Box CY 198
Causeway
Zimbabwe

08 January 2025

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH STUDY AT PARIRENYATWA GROUP OF HOSPITALS – TATENDA I HOVE

The above matter refers.

The Parirenyatwa Group of Hospitals hereby grants you permission to conduct research on:-

Aetioiogy and antimicrobial resistance paternts of bacterial meningitis in adult patients admitted at Parirenyatwa Group of Hospitals

The permission is granted subject to the following conditions: -

1. The researcher will provide all sundries necessary for sample collections. ☐
2. The researcher sponsors all payments for the tests involved. ☐
3. The hospital incurs no cost in the course of the research. ☐
4. All relevant departments are notified in advance and the Head of section/ward signs acknowledgement of such notification. ☐
5. The conduct of the research does not interfere or interrupt the daily service provision by the hospital. ☐
6. Formal written feedback on research outcomes must be given to the Director of Clinical Services. ☐
7. Permission for publication of research must be obtained from the Director of Clinical Services. ☐

DR M. CHILANGA
ACTING CLINICAL DIRECTOR

08 JAN 2025
P. O. BOX 198, CAUSEWAY
HARARE, ZIMBABWE

APPENDIX VII: AUREC APPROVAL LETTER

"Investing in Africa's future"

AFRICA UNIVERSITY RESEARCH ETHICS COMMITTEE (AUREC)

P.O. Box 1320 Mutare, Zimbabwe, Off Nyanga Road, Old Mutare-Tel (+263-20) 60075/60026/61611 Fax: (+263 20) 61785 Website: www.africau.edu

Ref: AU 3566/25 20 January, 2025

TATENDA IVY HOVE
C/O Africa University
Box 1320
MUTARE

RE: AETIOLOGY AND ANTIMICROBIAL RESISTANCE PATTERNS OF BACTERIAL MENINGITIS IN ADULTS PATIENTS ADMITTED AT PARIRENYATWA GROUP OF HOSPITALS

Thank you for the above-titled proposal you submitted to the Africa University Research Ethics Committee for review. Please be advised that AUREC has reviewed and approved your application to conduct the above research.

The approval is based on the following. a) Research proposal

- **APPROVAL NUMBER** AUREC 3566/25
  This number should be used on all correspondences, consent forms, and appropriate document

- **AUREC MEETING DATE** NA
- **APPROVAL DATE** January 20, 2025
- **EXPIRATION DATE** January 20, 2026
- **TYPE OF MEETING**: Expedited

After the expiration date, this research may only continue upon renewal. A progress report on a standard AUREC form should be submitted a month before the expiration date for renewal purposes.

- **SERIOUS ADVERSE EVENTS** All serious problems concerning subject safety must be reported to AUREC within 3 working days on the standard AUREC form.
- **MODIFICATIONS** Prior AUREC approval is required before implementing any changes in the proposal (including changes in the consent documents)
- **TERMINATION OF STUDY** Upon termination of the study a report has to be submitted to AUREC.

Yours Faithfully

MARY CHINZOU
FOR CHAIRPERSON
AFRICA UNIVERSITY RESEARCH ETHICS COMMITTEE