RESEARCH PAPER

Immune Suppression and Antimicrobial Resistance in Hospitalised HIV Patients: Evidence from Free State and Northern Cape Hospitals.

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Abstract

Background: Globally, studies has shown that microorganism infections are responsible for high rate of morbidity and mortality among immune-compromised patients. Such an increase is being observed in Sub-Saharan countries, particularly in Intensive-Care Units. Such an increase is be attributed by different factors such as age, immune status, pre-existing disease and diagnostic or therapeutic interventions. The deadly twin diseases namely HIV and TB made chronic patients more prone and susceptible to other opportunistic microorganisms.

Objectives: The study aimed to determine the prevalence microbial population in immunocompromised patients hospitalized in the different hospitals living with TB or/and HIV positive. Secondly to identify factors posing risks in the target study population, and to determine the antimicrobial prevalence rate in the different hospital wards.

Methods: This was ethically approved a retrospective, cross-sectional study using data collected over a period of five years with inclusion criteria being that patient should have TB or / and HIV at the time of hospitalization

Results: Forty-eight thousand five hundred ninety seven met the inclusion criteria in the study with majority from the Frances Baard District Municipality in Kimberley (NC) (58.4%), and Mangaung Metropolitan Municipality (FS) accounted for 37.9%. Most patients (58.4%) where treated at RM Sobukwe hospital, followed by 20.9% patients treated at the Universitas Academic hospital. The highest age (28-37) group accounted for 27.1%, and second most been 38-47 years at 26.4%, the least population (0.8%) aged (78-87) years. Fewer patients were admitted to hospitals age (58 years and above) and majority were female (49.9%) with 0.7% of the patients' gender was unknown.

Majority of patients (89.4%) tested negatively with 6.8% patients tested positively for TB across all six hospitals, while 1.6% and 1.8% patients' TB results were unknown or not tested, respectively. The highest number of patients testing positive for TB was recorded at the National Hospital (9.7%), Bongani Hospital (8.3%). RM Sobukwe Provincial hospital reported n=2,226 (7.8%) TB-positive cases, Mofumahadi Manapo Mopeli hospital (7.1%) TB-positive cases, Pelonomi hospital (6.3%) positive cases, and Universitas Academic hospital h (3.6%) TB-positive cases. Majority patients' group (70.9%) were not HIV-1/2 rapid screen tested, of those tested 1.2% were found to be HIV positive while 4.2% tested negative. The results showed that majority (70.9%) were not screened, while 4.3% were positive a significant 24.4% were negative. The results showed that only 0.6% of the patients encountered unclear HIV outcomes

The data show that fewer (7.9%) patients test showed undetectable HIV (<50 copies/mL) viral load, an indication of possible adhered to ART treatment. Almost a same number (6.9%) of patients exhibited a low HIV (50-10,000 copies/mL) viral load, and (6.8%) showed a similar trend of high HIV viral load >100,000 copies/mL. A significant 74.9% of patients were not tests HIV. The data showed that most patients (68.9%) had no CD4 ARV results, an indication of less monitored immune systems. Weak immune system (<350 cells/mm3) was found in (23.4%) patients, suggestion of less-adherence with ART treatment. 3.6% of the patients experienced mild immunosuppression (350–499 cells/mm3), while 4.2% had a robust immune system, indicating adherence to ART treatment

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The study also evaluated the prevalence testing method for all the specimens submitted to the laboratory for microbes and antimicrobial testing. Automated culture was the method mostly used in the laboratory, and it was reported to be at the rate of 42.8%, followed by culture urine (25.4%), culture pus (23.3%). Culture catheter tip was the least frequently used test method, displaying a rate of 8.5%. 48 597 specimens were reported to have been tested in the laboratory. In the study, the type of specimen collected from patients and sent to the laboratory for testing was also analysed. 48 597 specimens were collected. Blood culture (38.4%) was the most frequently collected specimen as the patients might have been suspected of having a bloodstream infection and urine was the second-most frequently collected specimen (16.5%), as the patients might have been suspected for having UTI. The study observed a prevalence of microorganisms in hospitals that are located in urban facilities, compared to facilities located in rural areas and the most prevalent bacterial speciesbeen

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Gram negative accounting for 40.1% namely (*Escherichia Coli* (16.9%), *Klebsiella pneumoniae* subsp pneumonia (9.4%); *Proteus mirabilis* (4%); *Acinetobacter baumannii* (3.7%); *Pseudomonas aeroginosa* (3.2%), *Enterobacter Cloacae* subsp. Cloacae (2.9%), and gram positive organisms accounted for 35.6% (*Staphylococcus aureus* (14.5%), Coagulase Negative *Staphylococcus* (11.9%), *Staphylococcus epidermidis* (5.2%), *Streptococcus pneumoniae* (4%). Gentamicin was found to have resistance in gram-positive bacteria *Enterococcus faecalis* at 31.8% and *Enterococcus faecium* at 69.8%. The study also showed that *Streptococcus pneumoniae* had high sensitivity (50.7%) to ceftriaxone antibiotic. The results showed that both groups gram-negative and gram-positive bacteria were resistant to trimethoprim-sulfamethoxazole antibiotic on 68.3% and 42.2%, respectively.

Discussion: The study proved that the ward type where patients were admitted to plays a huge risk factor in antibiotic treatment. Most patients who were admitted to medical wards showed a very high prevalence of antimicrobial resistance. Resistance was observed in all the antibiotics. The same trend was observed in both ICUs, in the A6 Intensive Care Unit and Multidisciplinary unit. Nitrofurantoin antibiotic displayed high sensitivity in most wards.

Conclusion: Even though minority of data was screened its worth reporting that of those tested a high HIV viral load and low CD4 count, which show non-compliance with ART. The majority of male patients had a detectable viral load and a low CD4 count, which is a risk factor for acquiring microbial infections. There was a high prevalence of antimicrobial resistance from different wards in the study and trimethoprim-sulfamethoxazole antibiotic showed high resistance to both gram-negative and gram-positive bacteria, 68.3% and 42.2%, respectively.

Keywords: Microbial infections, Multidrug-resistant organisms, Antimicrobial resistance

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Introduction

Microbial infections are the major cause of morbidity and mortality in an immune-compromised subset of patients (Singh et al., 2014). Opportunistic infections are associated with individuals in poor health and are caused by several different microorganisms (Yamashita *et al.*, 2013). Patients' long stay in hospital exposes them to these microbes through different pathways, which can be contaminated hospital equipment, bedding articles or aerosols (Xia et al., 2016). Furthermore, cross-contamination of microorganisms between patients can be spread through contact with hospital staff members. Microorganisms such as *Staphylococcus aureus, Enterobacteriaceae* species (*Escherichia, Salmonella, Citrobacter, Shigella), Acinetobacter baumannii, Klebsiella pneumoniae, Enterococci* and *Pseudomonas* spp are the most common pathogens associated with infections in hospitalized patients. The study by Xia et al., showed that sensitive microorganisms are better controlled and suppressed/killed by the antibiotics due to their sensitive to antibiotics while the resistant strains survive and spread easily within the hospital environment (Xia et al., 2016). The current available antibiotics are becoming less effective on microbes, and it is important to develop new strategies to manage them (Cerini et al., 2023). In developing countries, controlling antimicrobial resistance (AMR) is still challenging because of the lack of surveillance system, self-prescription of antimicrobial agents and poor injection control (Jemal et al., 2020). Furthermore, most of the admitted patients are treated with empirical prescribed antibiotics and this commonly leads to antimicrobial resistance (AMR) and the emergence of multidrug resistance (MDR) as well as death of patients (Temesgen et al., 2023).The rapid increase by microorganisms posed health challenges globally and South Africa's challenges of healthcare to be specific are associated with nosocomial infections caused by multidrug-resistant organisms. These include Methicillin-resistant *Staphylococcus aureus* (MRSA), Carbapenem-resistant *Acinetobacter baumannii (*CRAB) and Carbapenem-resistant *Enterobacterales* (CRE), which show resistance to most available antibiotics and lead to a high mortality rate. In the previous decades, Methicillin-resistant *Staphylococcus aureus* (MRSA) was prevalent among opportunistic and nosocomial infections and caused pneumonia, sepsis, colitis and urinary tract infection (UTI), among other illness (Yamashita et al., 2013). Rising antibiotic resistance rates among *Escherichia Coli* (with resistance to third generation Cephalosporins and Fluoroquinolones) is particularly problematic, as Cephalosporins are the mainstay of empiric therapy for both community acquired and hospital acquired infections in resource-limited settings (Jemal *et al.*, 2020). The rate of microbial infections differs from region to another, along with time variations (Nimer, 2022). Hospital setting and patient population also has a huge impact on the prevalence of infections caused by micro-organisms (Szabó et al., 2022). The prevalence of microbial infections has been observed to be increasing in hospitals caring for a large number of patients. An increasing antibiotic resistance has also been observed (Szabó et al., 2022). Tilahun et al. (2023) conducted a study to assess the bacteriology of community-acquired pneumonia at six healthcare facilities in Ethiopia. The study observed 64% bacterial growth in rural facilities and 40.8% bacterial growth in urban facilities and according to them, etiological differences are due to environmental contamination (Tilahun et al., 2023). Multidrug-resistant bacteria are usually encountered among immunocompromised patients (Bhat et al., 2021). There are many patient risk factors that influence the acquisition of microbial infections, such as age, immune status, pre-existing disease and diagnostic or therapeutic interventions (Nair

et al., 2018). Patients with chronic diseases such as cancer, diabetes mellitus, renal failure TB or HIV are vulnerable to infections, especially to opportunistic organisms (Nair et al., 2018). Modern diagnostic and therapeutic procedures such as biopsies, endoscopic examinations, catheterisation, ventilation and surgical procedures have also been reported to increase the risk of contracting microbial infections (Nair et al., 2018). Furthermore, other identified risk factors includes movement of admitted hospital patients between one unit to another. Nair et al., further supports that by indicting that such risk are also among burn patients and neonates and patients in intensive-care units (Nair et al., 2018).

Problem statement

South Africa is one of the developing countries with many people suffering from TB (87%) and HIV (7.9 million) (Matakanye et al*.,* 2021; Inbarani et al., 2022). Micro-organisms such as bacteria, fungi, viruses and parasites have been reported as opportunistic infections among immunocompromised people, which resulted in a huge challenge to patient care, with an increase in morbidities, mortalities and cost of healthcare (Nazeerah et al., 2022). Early diagnosis and treatments of microorganisms in immunocompromised patients are important to reducing morbidity and mortality rate. Little information is known about the prevalence of antimicrobial resistance rate in hospitalized patients in different wards at the different regional/provincial hospitals of the Free State and Northern Cape Province.

Aim

The study aimed to determine the antimicrobial resistance rate in different wards, and the extend at which TB and HIV risks are associated with other microorganisms.

Literature review

Microbial infections are an increasing problem across Sub-Saharan Africa, while bacterial contamination of indoor hospitals, particularly in Intensive-Care Units is a serious global health hazard with high morbidity and mortality rates (Archary et al., 2017; Temesgen et al., 2023). Infections caused by antimicrobial resistant pathogens are a major concern and are becoming more difficult and costly to manage and treat (Nair et al., 2018). Antimicrobial resistance is of concern in low and middle income setting where treatment options are limited due to cost and availability of drugs (Olaru et al., 2021). Antibiotic overuse and misuse due to incorrect diagnosis, as well as irrational and counterfeit antibiotic market combinations and irregular consumption due to wrong prescription or poor compliance, all contributes to the wide spread of drug resistance among microbial infections (Javeri et al., 2012). In addition, (Olaru et al., 2021), mentioned that the main drivers for antimicrobial resistance are inappropriate antimicrobial use, transmission of resistant pathogens in healthcare settings and rapid dissemination of resistant pathogenic strains due to international travel and trade. It has been reported that 15%-30% of microbial infections may be avoidable (Nair *et al.*, 2018).

The gold standard of microbial infections surveillance would be prospective onsite, continuous hospital-wide surveillance; however, this kind of approach requires numerous resources (Nair *et al.*, 2018). Point prevalence surveys are the most common type of surveillance done because they are less demanding when it comes to human and technical resources (Nair *et al.*, 2018). The true burden of microbial infections in South Africa is poorly studied, and it is assumed to be higher in the public sector compared with private sector (Nair *et al.*, 2018). There is a need for local resistance prevalence data to guide empirical prescription and to identify areas in which medical need for new agent is greater (Agmy *et al.*, 2013). To successfully prevent, identify and treat infections, sound knowledge of the ever-changing spectrum of infections is necessary and the understanding of research outcomes will aid in personalising treatment, improving prognosis and reducing the cost of health care (Bhat et al,. 2021). Prevalent of microbial infections and antimicrobial resistance pattern may vary from region to region, depending on the antibiotic pressure in that locality (Agmy et al., 2013). The microbiological flora as well as the sensitivity pattern to different antibiotics tend to change over time in a particular health care setup (Patel *et al.*, 2010)

Infection with Human immunodeficiency virus (HIV) is a public health problem that is associated with immunosuppression and an augmented predisposition to opportunistic infections (Chabala *et al.*, 2020). People living with HIV have more frequent hospital admissions, clinic visits and antimicrobial treatment programmes compared to individuals without HIV infections putting them at higher risks of the acquisition of infection with resistant bacteria (Olaru et al., 2021). Hospital admissions for acute bacterial infections are more frequent in HIV infected individuals and the frequent hospital admissions may lead to a higher number of antimicrobial prescriptions and a higher risk of acquisition of resistant pathogens during hospitalization (Olaru et al., 2021). Microbial infections are the important cause of morbidity and mortality in immunocompromised patients that are infected with HIV (Shahcheraghi *et al.*, 2016). The infections are consecutive to different subnormalities of host defence against infectious agents (Iyamba et al., 2014). Therefore, in this case, *Enterobacteriaceae* which are responsible for gastrointestinal and urinary tract infections may raise the incidence of HIV and the progression of HIV infection to Acquired immunodeficiency syndrome (AIDS) (Iyamba et al., 2014). Bacterial pathogens such as *Salmonella* species, *Clostridium difficile* and different strains of *E. coli* have also been identified as etiologic agents with the potential to cause severe illness in HIV-infected patients (Kebede et al., 2017). Symptoms, duration and potential severe manifestations of enteric bacterial infections are influenced by various factors including immunity status of the patient measured by CD4+ T-cell count and the use of Highly Active Antiretroviral Therapy (HAART)

and prophylaxis (Kebede et al., 2017). Several studies have proved that several bacterial infections still occurred in high rates even in the absence of severe CD4 cell depletion (Shahcheraghi et al., 2016). Highly Active Antiretroviral Therapy (HAART), a group of different classes of drugs that are used in the treatment of HIV and prophylactic management of opportunistic infections have significantly improved clinical outcomes and overall survival of HIV-infected individuals (Chabala *et al.*, 2020). In the study that was conducted by (Kebede et al., 2017), they also mentioned that the introduction of HAART and prophylactic management of opportunistic infections has brought a huge improvement in the health system.However, even in the era of a combination of antiretroviral therapy (cART), respiratory-tract infections are the major cause of morbidity and mortality among HIV-positive patients (Kamara et al., 2024), and when it comes to patients with HIV seropositivity, the infection rate differs from 3.9 to 20 infections per 100 people per year (Kamara et al., 2024). About 70% of illness in HIV-positive people are respiratory-tract infections (Lubega et al., 2023) and factors associated with these infections are low CD4 counts (<200 cells/mm³) and detectable viral loads (Lubega et al., 2023). The outcome of immune dysfunction, regulation and decrease of CD4 lymphocytes causes a high susceptibility of infections and risk of other complications like resistant pathogens (Lubega et al., 2023). In addition, Franceschini et al. (2020) also report that the majority of the patients in their study were on effective cART (65.3%). However, 34.7% of patients with Blood Stream Infection (BSI) had a virological failure; 25% and 13% of the patients showed HIV-RNA above 10 000 copies/mL and 100 000 copies/mL, respectively, while the median CD4 count at the moment of the episode was low (207 CD4 cells/mm³) (Franceschini et al., 2020). Franceschini et al. (2020) mention that 48% of patients died during the study, with a median survival duration of 28 days after the last episode of bacteraemia. Furthermore, the 30-day mortality rate after the last episode was 24.2%, while the 90-day mortality rate was 32.4%. The mortality rate of MDR microorganisms were 33.3% and 46.9% at 30 and 90-days after the last bacterial episode, respectively (Franceschini et al., 2020). The mortality for BSI due to MDR microorganisms was higher than observed in people without MDR at a rate of 44.7% versus 24.3%, respectively (Franceschini et al., 2020).Lower Respiratory Tract Infection (LRTI) is responsible for about 3 million deaths annually among all ages over the world and is the leading cause of mortality in low-income countries (Carrim et al., 2023). The most common bacterial agents in lower-respiratory-tract infection are *Pseudomonas, Acinetobacter, Klebsiella, Citrobacter, Escherichia coli* (Goel et al., 2009). In the study that was conducted by Okon et al. (2023) on sputum samples of HIV-positive patients, the rate of LRTI was higher among patients with CD4 cells of 201–300 cells/mm^3 (64.3%), while patients with CD4 cells above 301–400 cells/mm^3 (2:16.7%) had the lowest LRTI rate (Okon et al., 2023). Patients with a viral load above 1 000 copies/mL (45.1%) had the highest LRTI prevalence rate when compared with those who had a viral load below 1 000 copies/mL (1:10%) (Okon et al., 2023). The study further showed that gram-positive and gram-negative bacteria were mostly sensitive to Imipenem, 93.3% and 77.8%, respectively (Okon et al., 2023). In the study, they further stated that Trimethoprim-sulfamethoxazole (40%) and Ceftriaxone (51.7%) were the antibiotics to which gram-positive bacteria showed high resistance, furthermore, Gentamicin (44.4%), Azithromycin (33.3%) and Trimethoprim-sulfamethoxazole (33.3%) were also the antibiotics which gram-positive bacteria showed high resistance (Okon et al., 2023).Another study was conducted by Kamara et al. (2024), using sputum samples of HIV-positive patients with cough symptoms in Uganda to check for bacterial isolates. Bacterial growth was observed in 56/180 participants (31.1%) and the most prevalent organisms isolated in the study were *Staphylococcus aureus* (35.7%), followed by *Pseudomonas aeroginosa* (19.6%), *Streptococcus pneumoniae* (17.9%), *Klebsiella pneumoniae* (12.5%) and *Enterobacter* species (8.9%). Research has shown that *Staphylococcus aureus* was observed to be sensitive to Imipenem, Ceftriaxone and Chloramphenicol; however, it was resistant to Piperacillin-tazobactam (Kamara et al., 2024). Furthermore, *Pseudomonas aeroginosa* was sensitive to Imipenem, Ceftriaxone and Ciprofloxacin, while *Enterobacter* species were sensitive to Gentamicin and Cefepime, but resistant to Ampicillin. Lastly, *Klebsiella pneumoniae* was sensitive to Imipenem, but resistant to Azithromycin (Kamara et al., 2024). Factors that were associated with sputum culture positive among HIV-positive patients in the study were age, education, viral load and peripheral oxygen saturation. Therefore, an unsuppressed viral load ≥200 copies per millilitre of blood and low peripheral oxygen saturation of ≤94% at room air were independently linked with a sputum culture-positive cough, which means that a patient with an unsuppressed viral load was 2.315 times more likely to have a sputum culture-positive cough when compared to the patients whose viral load was fully suppressed (Kamara et al., 2024). A patient with low peripheral oxygen saturation was 2.448 times likely to have a sputum culture-positive cough when compared to the patients with normal peripheral oxygen saturation (Kamara et al., 2024).Critically ill patients in ICU have a higher chance to acquire bacterial infections in the bloodstream (Dewi et al., 2023). Bacteraemia is a bacterial infection in the bloodstream and can reflect the presence of blood infection in a patient (Dewi et al., 2023). Bacterial bloodstream infections form a significant public health problem and present an important cause of morbidity and mortality in HIV infected patients (Jemal et al., 2020). Both Gram-negative and Gram-positive bacterial agents play a vital role in causing high morbidity of bloodstream infections (Jemal et al., 2020). Bacteremia infection due to *Salmonella, Campylobacter* and *Shigella* has been mentioned to be more prevalent in patients with lower CD4+ T-cell count (Kebede et al., 2017). A study regarding the prevalence in pathogenic bacteria in patients with bacteraemia from 1996 to 2016

in hospitals found an increase in the prevalence of multidrug-resistant (MDR) bacteria from 6.2% in 1997 to 2000 to 15.8% in 2013 to 2016 (Dewi et al., 2023). The increase includes Extended Spectrum b-lactamase (ESBL)-producing bacteria, Carbapenem-resistant *Enterobacteriaceae*, *Psedomonas aeroginosa* and *Acinetobacter baumannii* (Dewi et al., 2023). Data on microbial profiles and antibiotic sensitivity can be used to determine the effectiveness of blood-infection control measures in hospitals (Dewi et al., 2023).

Mycobacterium tuberculosis causes a chronic infection of the lungs called tuberculosis (TB). It is characterized by slight fever, weight loss, sweating at night and chronic cough producing blood-stained sputum (Seyi et al., 2019). Tuberculosis is a deadly disease, despite the novel advances in its diagnostic tools and drug therapy (Gashaw et al., 2021). Pulmonary tuberculosis is a main cause of lower respiratory-tract infection and may present as an acute or chronic disease (Dube et al., 2016). Factors that contribute to the high prevalence of tuberculosis in developing countries and difficulties in its control include co-infection with HIV, the emergence of multidrug-resistant tuberculosis, inadequate treatment, continuing poverty, malnutrition, overcrowding and increasing numbers of displaced persons (Seyi et al., 2019). Almost 10% of new TB cases globally are HIV positive. However, this number varies on a country basis and can be as high as 80% (Seyi et al., 2019). Tuberculosis has been a major co-morbidity in HIV-positive individuals since the beginning of the HIV epidemic (Seyi et al., 2019), and the emergence of HIV in South Africa has resulted in a huge rise in the incidence of tuberculosis (Cohen et al., 2010). Infection with HIV increases the risk of developing tuberculosis and speeds up its progress (Seyi et al., 2019). The risk of developing TB is 5% to 10% in HIV-negative persons and 50% in HIV-positive people. This results in difficulty for health systems to keep up with the increasing demands for health services for both diseases (Seyi et al., 2019).

A systematic review of previous studies recorded that hospital admissions in HIV-positive patients reported that community-acquired pneumonia and tuberculosis accounted for 57% of in-patient deaths globally (Owusu et al., 2024). In 2010, the number of people who died from TB were about 1.4 million, including 350 000 people with HIV (Seyi et al., 2019). Tuberculosis is mostly implicated in HIV-associated pneumonia; however, information on the role of other bacterial and viral pathogens is not much in many developing countries (Owusu et al., 2024) and the risk of mortality in hospitalized patients is believed to be higher due to limited diagnosis of microbial aetiologies of pneumonia (Owusu et al., 2024). An estimation by the World Health Organization (WHO) is that TB causes about 40% of AIDS deaths in Sub-Saharan Africa and Southeast Asia (Seyi et al., 2019). About 80% of TB cases in South Africa are HIV seropositive (Cohen et al., 2010). Pulmonary infection is the most common immunodeficiency-virus-affiliated illness with complications in the period of antiretroviral therapy (ART) (Owusu et al., 2024). Mixed pulmonary infections with two or more pathogens are common in HIV-positive patients. They often present diagnostic difficulties for doctors and result in potentially serious consequences for the patient if it is unrecognized (Seyi et al., 2019). ART has prompted a reduction of the rate of respiratory disorders, including tuberculosis (Mushunje et al., 2024).

There are not much published data on the role of other respiratory organisms in patients who are suspected to have TB; however, in Africa, a study conducted in Botswana reported microbiologically confirmed TB in 52%, *Mycoplasma pneumoniae* infection in 17% and *Pneumocystis jirovecii* infection in 3% of PTB adults suspects (Dube et al., 2016). Co-infection with two or more microorganisms is reported in 25% of patients (Dube et al., 2016). Dube et al. (2016) conducted a study to investigate the respiratory pathogen in nasopharynx (NP) of children who were hospitalized with suspected TB. In this study, 16% of the children were TB positive and 13% of the children were HIV infected, with a similar HIV prevalence by TB category (Dube et al., 2016). The most common bacteria detected in NP were *Moxaxella catarrhalis* (64%), *S. pneumoniae* (42%), *H. influenzae spp* (29%) and *Staphylococcus aureus* (22%) (Dube et al., 2016). However, *Mycoplasma pneumoniae* (9%), *Bordetella pertussis* (7%) and *Chlamydia pneumoniae* (4%) were detected as less prevalent in the study (Dube et al., 2016). The most-detected viral agents were the human metapneumovirus (hMPV) (19%), rhinovirus (15%), influenzae C virus (9%) adenovirus (7%) and Coronavirus O43 (5.6%) (Dube et al., 2016). Furthermore, seasonal patterns were observed when it comes to hMPV, rhinovirus, enterovirus and influenzae viruses with peak prevalence in late winter (August) and spring (November) (Dube et al., 2016).

The study conducted by Dube et al. (2016) further details that bacteria alone were detected on 40% of samples; viruses alone were detected in 5% of samples; and both bacteria and viruses were detected in 55% of the samples. Furthermore, in children that were diagnosed with TB, both bacterial and viral targets were detected at the rate of 71% (Dube et al., 2016). In the cohort study that was conducted by Ueckermann et al. (2022), pulmonary tuberculosis was diagnosed in 33% (41/117) of patients, while *P. jirovecii* was the associated pathogen in 21.4% (25/117) of patients. In the study, they reported that 22 sputum and BAL cultures revealed other bacteria as the aetiology for pneumonia, which included *Pseudomonas aeroginosa* 45% (9/20), *Streptococcus pneumoniae* 30% (6/20), *Klebsiella pneumoniae* 20% (4/20) and *Staphylococcus aureus* 5% (1/20) (Ueckermann et al., 2022). The study further showed that 52% (61/117) of patients required admission to ICU and the in-hospital mortality rate was 40.2% (47/117) (Ueckermann et al., 2022). Ueckermann et al. (2022) mention that in their study, the mean CD4 count of those with TB was lower than those without TB and some patients diagnosed with HIV during the presenting admission and late diagnosis of HIV have been shown to be a risk factor for admission to the ICU (Ueckermann et al., 2022). Patients on Highly Active Antiretroviral Therapy (HAART) in the study conducted

by Ueckermann et al. (2022) were more likely to survive than those who were not; 38.6% of survivors were on HAART compared to 31% of non-survivors. Patients with TB admitted to ICU had a high mortality rate of 33% to 67% and a South African study in patients with TB admitted to ICU showed that 53% of patients were co-infected with HIV with a mortality rate of 59% (Ueckermann et al., 2022).

The co-infection of *S. pneumoniae* and *M. tuberculosis* is regarded as a defining disease of the acquired immunodeficiency syndrome and their establishment in a person depends on whether certain conditions are favourable such as smoking, a crowded environment, use of drugs and use of steroids, as a low CD4 cell count in patients may be indicated by *Streptococcus pneumoniae* and *Mycobacterium tuberculosis* co-infection in HIV-positive patients (Seyi et al., 2019). *Streptococcus pneumoniae* and *Mycobacterium tuberculosis* are the two most common causes of co-infection in HIV-seropositive patients in Sub-Saharan Africa and highly contribute to the mortality and morbidity rates of HIV/AIDS globally, they further have similar clinical features and radiological appearances (Seyi et al., 2019). Seyi et al. (2019) conducted a study on the prevalence of *Streptococcus pneumoniae* and *Mycobacterium tuberculosis* co-infection in HIV-positive adult patients who were on Highly Active Antiretroviral Therapy (HAART) in Nigeria. They report a prevalence rate of 8.8% (*Streptococcus pneumoniae* mono-infection), 21.5% (*Mycobacterium tuberculosis* mono-infection) and 2.7% (*Streptococcus pneumoniae* and *Mycobacterium tuberculosis* co-infection) among 260 patients.

Antimicrobial susceptibility testing is important in prescribing an effective drug regime for TB patients, especially in areas where drug resistance is high (Gashaw et al., 2021). The global mortality rate of TB is reducing by 3% annually. However, the threat of its drug resistance is on the increase (Gashaw et al., 2021). The cumulative effects of treatment interruption like lack of awareness about the nature of the bacteria, shortage and lack of the WHO's recommended diagnostic tools, and a prolonged drug consumption period for treatment increases the risk (Gashaw et al., 2021). Prevalent flora and antimicrobial resistance patterns can sometimes vary from region to region, depending upon the antibiotic pressure in that locality (Agmy et al., 2013). There is a need for local resistance-prevalence data to guide empirical prescription and to identify areas in which a medical need for new agents is greater (Agmy et al., 2013).

Objectives

1. Determine microorganisms prevalence associated with immunocompromised patients who were hospitalized in the different hospitals having TB or are HIV positive.
2. Identify the risk factors that are associated with microbial infections in immunocompromised patients.
3. Determine the antimicrobial prevalence rate in different hospital wards.

Methodology

Study design and setting

This was a retrospective, cross-sectional study. In this study, the data were from 1 January 2018 to 31 December 2022. All patients who were admitted at the selected sites having underlying diseases such as TB and HIV from 1 January 2018 to 31 December 2022 were selected. The study measured the presence of exposure and disease at one point in time, including repeat patient admissions. Participants were selected regardless of microbial exposure and outcome/disease status. Data were requested from the National Health Laboratory Service Central Data Warehouse. The application to use these was submitted through the Academic Affairs and Research Management System (AARMS) and the data consisted of patients' laboratory results.

Study population

The study population consisted of patients who were admitted to hospitals from the age of 18 and above. Laboratory records of all the patients' samples that were sent in the laboratory to be examined were reviewed from the NHLS Central Data Warehouse (CDW) in order to get demographic and laboratory results data. The population, with a minimum of 1 200 samples, with 200 from each hospital was categorized into different age groups. All the patients' laboratory results were requested from CDW. Patients' data for this study were included if they met the inclusion criteria and did not meet the exclusion criteria.

The inclusion criteria of the data were that data generated should be of HIV-positive patients with no TB. Patients who are HIV negative with TB only. Patients who were diagnosed with both TB and HIV. All patients who had laboratory results of microorganisms and antimicrobial susceptibility.

The exclusion criteria were:

All patients below the age of 18 years. The results of patients that were admitted before 1 January 2018 and after 31 December 2022, and all antimicrobial susceptibility rests done on those samples.

The data from the following hospital/sites were included in the study. Bongani Regional Hospital (Welkom), Mofumahadi Manapo Mopeli Regional Hospital (Qwaqwa), National District Hospital (Bloemfontein), Pelonomi Regional Hospital (Bloemfontein), Universitas Academic Hospital (Bloemfontein), Robert Mangaliso Sobukwe Provincial Hospital (Kimberley).

Data analysis

Laboratory data were obtained from the NHLS CDW. The data were analysed through STATA version 13 statistical software for Windows and the results of total microbial profile and antimicrobial susceptibility for each hospital were presented in a table. A summary of the statistical data was made where normally distributed data were summarized using mean and standard deviation. Data that were not normally distributed were then described using medians and interquartile ranges. Categorical variables were summarized using

frequencies and proportions. Crosstabulation was used to describe the interaction between each independent variable by each category of dependent variable.

Ethical consideration

The study obtained ethical clearance from the Ethics committee of the Faculty of Health Sciences, University of Free State, UFS-HSD2024/1404/2801. Permission to use data from the CDW was requested from the National Health Laboratory Service, and the application was submitted through AARMS, Reference Number: PR2455098. Patient information and identities were not used and only information on organisms and mentioned data were utilised.

Results

Table 1: Sites frequency distribution per district name

Frequency distribution per district name		
DISTRICT NAME	**Frequency**	**Percentage%**
Frances Baard	28 395	58.4
Lejweleputswa	1 437	3
Mangaung Metro	18 440	37.9
Thabo Mofutsanyana	325	0.7
Total	48 597	100

Table 1 above shows a descriptive statistic indicating that the data collected for the study were from the Frances Baard District Municipality in Kimberley in the Northern Cape Province (58.4%). This is followed by the Mangaung Metropolitan Municipality in the Free State Province with 37.9%, Lejweleputswa District Municipality in the Free State Province with 3% and lastly, Thabo Mofutsanyana District Municipality in the Free State Province with 0.7%.

Table 1: Sites frequency distribution per hospital

Frequency distribution per Hospital		
FACILITY NAME	**Frequency**	**Percentage%**
Robert Mangaliso Sobukwe Provincial hospital	28 395	58.4
Bongani Regional Hospital	1 437	3
National District Hospital	1746	3.6
Mofumahadi Manapo Mopeli Regional Hospital	325	0.7
Pelonomi Regional Hospital	6 541	13.5
Universitas Academic hospital	10 153	20.9
Total	48 597	100

Table 2 shows the distribution per facilities sampled for this study. The majority of the patients (58.4%) were treated at the Robert Mangaliso Sobukwe provincial Hospital, followed by 20.9% of patients reported to have received treatment at the Universitas Academic hospital, and 13.5% patients who received treatment at the Pelonomi Regional Hospital.

Table 2: Patients frequency distribution per age categories

Frequency distribution per age categories		
AGE TESTED IN YEARS	**Frequency**	**Percentage%**
18–27	9 151	18.8
28–37	13 190	27.1
38–47	12 831	26.4
48–57	7 138	14.7
58–67	3 830	7.9
68–77	1 872	3.9
78–87	409	0.84
88+	103	0.21
Unspecified	73	0.15
Total	48 597	100

Table 3 shows the patients' age grouped into categories. The results show that 27.1% of the patients were aged 28–37 years, followed by 26.4% aged 38–47 years and 18.8% of patients aged 18–27 years. Aged 48 and above accounted for 27.7% collectively, including unspecified ages.

Table 3: Patients frequency distribution per gender

Frequency distribution per gender		
GENDER	**Frequency**	**Percentage%**
Male	24 018	49.4
Female	24 257	49.9
Unknown	322	0.7
Total	48 597	100

Table 4 shows that 49.4% of the patients in the study were males, while 49.4% of respondents were female. A very small percentage (0.7%) was not classified.

Table 4: TB test(s) frequency outcomes distribution

Frequency distribution per TB test outcomes		
GeneXpert Ultra results	**Frequency**	**Percentage%**
None	755	1.6
Negative TB	43 427	89.4
Positive TB	3 308	6.8
Unknown	851	1.8
Error	256	0.5
Total	48 597	100

Table 5 represents patients that were tested for tuberculosis using the GeneXpert Ultra assay, administered at intake. The majority of patients (89.4%) tested negatively for TB, 6.8% tested positively for TB, while 1.8% and 1.6% of patients were either unknown or were not tested, respectively. 0.5% of the patients received test results with errors.

Table 6: HIV-½ Rapid (Screen) results

Frequency of HIV-½ RAPID (SCREEN)		
HIV-½ rapid results	**Frequency**	**Percentage%**
None	45 969	94.6
Negative	2 048	4.2
Positive	580	1.2
Total	48 597	100

Table 6 above presents the HIV-½ rapid-test results of a subset of the dataset. The table shows that the majority of the patients (94.6%) were not tested for HIV using a rapid-test method, followed by 2% of patients who tested HIV negatively using the rapid-test method, and 1.2% tested HIV positively.

Table 7: HIV-½ AB/AG (Screen) results

Frequency of HIV-1/2 AB/AG (SCREEN)		
HIV-½ AB/AG results	**Frequency**	**Percentage%**
None	34 347	70.7
Negative	11 869	24.4
Positive	2 090	4.3
Equivocal	291	0.6
Total	48 597	100

Table 7 above presents the sampled patients' results for HIV-½ AB/AG tests. Most of the patients (70.7%) were not tested for HIV using the HIV-½ AB/AG test method, while 24.4% tested HIV negative using the HIV-1/2 AB/AG test method. A total of 4.3% tested HIV positive and 0.6% of patients' results were equivocal.

Table 8: HIV viral load results

Frequency of HIV VIRAL LOAD		
HIV viral load results	**Frequency**	**Percentage%**
None	36 406	74.9
Undetectable < 20–50	3 862	7.9
Low 50 – 10,000	3 347	6.9
Medium 10,001 – 100,000	1 683	3.5
High > 100,000	3 299	6.8
Total	48 597	100

Table 8 above presents the patients' viral-load results of the provided dataset. Most of the patients' (74.9%) HIV viral load were not tested, 7.9% had an undetectable viral load, 6.9% had a low HIV viral load, and the remaining 6.8% had a high HIV viral load.

Table 9: CD4 ARV results

Frequency of CD4 ARV		
CD4 ARV results	**Frequency**	**Percentage%**
None	33 444	68.8
Advanced/severe immunosuppression – <350 cells/mm³	11 346	23.4
Mild immunosuppression – 350–499 cells/mm³	1 766	3.6
No significant immunosuppression – ≥500 cells/mm³	2 041	4.2
Total	48 597	100

Table 9 above shows that the majority (68.8%) of the patients' CD4 counts were not tested at intake, 23.4% of patients were reported to have severe immunosuppression with CD4 counts of below 350 cells/mm³, while 4.2% of patients had healthy levels of CD4, with a CD4 count of ≥500 cells/mm³. Only 3.6% of the patients were reported to have mild immunosuppression, with CD4 counts ranging between 350–499 cells/mm³.

Table 10: Frequency of Test Method Name

Frequency of Test Method Name		
Test method name	**Frequency**	**Percentage%**
Culture Urine	12 355	25.4
Automated Culture	20 808	42.8
Culture Catheter Tip	4 124	8.5
Culture Pus	11 310	23.3
Total	48 597	100

Table 10 above shows the type of test method that was used to test the specimens collected from patients. Automated cultures were the test method mostly used in the laboratory. It was reported at the rate of 42.8% cases, culture urine and culture pus were used in 25.4% and 23.3% of cases, respectively. Lastly, culture catheter tip was the least frequently used test method, only used in 8.5% of cases.

Table 11: Specimen type collected

Frequency of specimen type		
Specimen type	**Frequency**	**Percentage%**
Abscess (Deep) Aspirate	1	<0.1
Abscess (Superficial) Aspirate	1 887	3.9
Abscess (Superficial) Swab	84	0.2
Arterial Catheter Tip	1 530	3.1
BL, BLC, BLE, PUSW	2	<0.1
Blood Culture	18 668	38.4
Breast Aspiration	2	<0.1
Burn Swab	22	0.5
Catheter Urine	1 416	2.9
CAVP	12	<0.1

Corneal Scraping	6	<0.1
Dialysis Fluid	2	<0.1
Endotracheal Tube	1	<0.1
Fluid / Aspirate	1 323	2.7
Haemodialysis Catheter Tip	101	0.2
Intravenous Catheter Tip	877	1.8
Midstream Urine	2 950	6.1
Peritoneal Dialysis Fluid	380	0.8
Sputum	3	<0.1
Swab (Superficial)	7 580	15.6
Tenckhoff Catheter Tip	1 338	2.8
Tracheal Aspirate	1	<0.1
Urinary Catheter Tip	1	<0.1
Urine	8 036	16.5
Ventricular Catheter Tip, Cerebral	2	<0.1
Ventriculoperitoneal Shunt	110	0.2
Wound Swab	1 598	3.3
Wound Aspirate	83	0.2
Unknown	581	1.2
Total	48 597	100

Table 11 shows the profile of specimen types that were collected from the sample population. The table shows that blood cultures accounted for 38.4% of all specimens collected. Abscess (Deep) Aspirate, Endotracheal Tube, Tracheal Aspirate, and Urinary Catheter Tip specimens were reported to be the least collected specimens, accounting for less than 1% each.

Table 12: Prevalence microorganisms

Frequency of the top 10 microorganisms name		
Microorganism's name	**Frequency**	**Percentage%**
Escherichia Coli	4 451	16.9
Staphylococcus aureus	3 836	14.5
Coagulase Negative *Staphylococcus*	3 146	11.9
Klebsiella pneumoniae Subsp. p*neumoniae*	2 481	9.4
Staphylococcus epidermidis	1 372	5.2
Streptococcus pneumoniae	1 064	4
Proteus mirabilis	1 062	4
Acinetobacter baumannii	985	3.7
Pseudomonas aeroginosa	833	3.2

Enterobacter Cloacae Subsp. *Cloacae*	758	2.9

Table 12 above presents the 10 most prevalent microorganisms in the sample population. *Escherichia Coli* was reported in 16.9% cases, while *Staphylococcus aureus* and Coagulase-negative *Staphylococcus* accounted for 14.5% and 11.9% of the cases, respectively.

Table 13: Hospital wards

Frequency of the top six wards		
Ward name	**Frequency**	**Percentage%**
A6 INTENSIVE CARE UNIT	1 587	10.1
EMERGENCY UNIT	3 593	22.9
M1 MEDICAL WARD	2 479	15.8
MEDICAL RECOVERY	3 246	20.7
MEDICAL WARD U5A	2 678	17
MULTIDISCIPLINARY UNIT	2 135	13.6
Total	15 718	100

Table 13 is a summary displaying the top six wards, which accounted for 15 718 of responses and shows the distribution of patients across different hospital wards within a subset of the total population. It also shows an overview of how patients were allocated in different ward units, highlighting the relative size and contribution of each ward to the overall patient population. Lastly, an understanding to this distribution is important for interpreting the patterns of antimicrobial sensitivity or resistance and other clinical characteristics in subsequent analyses. The table shows that the top six wards in this study consist of the following frequency rate: Emergency unit (22.9%), M1 Medical Ward (15.8%), Medical recovery unit (20.7%), Medical Ward U5A (17%), and the Multidisciplinary Unit 13.6%, as well as the A6 Intensive-Care Unit (ICU) with 10.1%.

Table 14: Crosstabulation of Ward Name Against Gender

Crosstabulation of Ward Name Against Gender								
			GENDER			**Total**	**Phi**	**P-value**
			Male	*Female*	*Unknown*			
WARD NAME	A6 INTENSIVE CARE UNIT	N	843	722	22	1 587	**0.126**	**0**
		%	53.1%	45.5%	1.4%	100%		
	EMERGENCY UNIT	N	1 745	1 839	9	3 593		
		%	48.6%	51.2%	0.3%	100%		
	M1 MEDICAL WARD	N	1 041	1 431	7	2 479		
		%	42%	57.7%	0.3%	100%		
	MEDICAL RECOVERY	N	1 734	1 485	27	3 246		
		%	53.4%	45.7%	0.8%	100%		
	MEDICAL WARD U5A	N	1 133	1 545	0	2 678		
		%	42.3%	57.7%	0%	100%		
	MULTIDISCIPLINARY UNIT	N	1 181	954	0	2 135		
		%	55.3%	44.7%	0%	100%		

Table 14 shows that in the A6 Intensive-Care Unit, most of the patients are male, accounting for 53.1%, in contrast to the 45.5% of females and only 1.4% of the patients whose gender are unknown. In the Emergency Unit, most patients are females with 51.2% of the population, while males account for 48.6% of admissions into the Emergency unit, and 0.3% of population are classified under unknown. In the Medical Recovery ward, most of the patients are male (53.4%) and 45.7% are female.

Medical ward U5A is recorded to have more females as part of the sampled patients (57.7%), in comparison to males (42.3%).

The Multidisciplinary unit displays to have more males in the sample population, accounting for 55.3%, with 44.7% of women in the very same department; therefore, the phi coefficient of 0.126 shows a weak, but positive correlation between gender and ward name. However, the p-value of 0.000 shows a statistically significant association; therefore, it can be concluded that gender does influence the ward name in this study.

Table 15: Crosstabulation of Ward Name Against Age Category

Crosstabulation of Ward Name Against Age Category													
			AGE TESTED YEARS								Total	Phi	P-value
			18-27	*28-37*	*38-47*	*48-57*	*58-67*	*68-77*	*78-87*	*88+*			
WARD NAME	**A6 INTENSIVE CARE UNIT**	**N**	224	344	423	321	187	66	12	10	1587	**0.259**	**0**
		%	14.1 %	21.7 %	26.7 %	20.2 %	11.8 %	4.2 %	0.8 %	0.6 %	100%		
	EMERGENCY UNIT	**N**	853	834	891	471	355	135	46	8	3 593		
		%	23.7 %	23.2 %	24.8 %	13.1 %	9.9 %	3.8 %	1.3 %	0.2 %	100%		
	M1 MEDICAL WARD	**N**	418	976	688	255	92	45	1	4	2 479		
		%	16.9 %	39.4 %	27.8 %	10.3 %	3.7 %	1.8 %	0%	0.2 %	100%		
	MEDICAL RECOVERY	**N**	657	713	1043	523	184	84	36	6	3 246		
		%	20.2 %	22%	32.1 %	16.1 %	5.7 %	2.6 %	1.1 %	0.2 %	100%		
	MEDICAL WARD U5A	**N**	335	796	1032	357	115	38	5	0	2 678		
		%	12.5 %	29.7 %	38.5 %	13.3 %	4.3 %	1.4 %	0.2 %	0%	100%		
	MULTIDISCIPLINARY UNIT	**N**	402	627	380	311	283	116	14	2	2 135		
		%	18.8 %	29.4 %	17.8 %	14.6 %	13.3 %	5.4 %	0.7 %	0.1 %	100%		

Table 15 above is a crosstabulation of ward name against age category. In the A6 Intensive-Care Unit the most prevalent age group identified is 38–47 at a rate of 26.7%, compared to the 0.6% of the sample in the 88+ age group. In the Emergency Unit a similar trend is observed, with 24.8%, but compared to the A6 Intensive Care Unit, compared to the 0.2% of the patients in the 88+ age group. In the M1 Medical Ward, the largest group is observed between the ages of 28–37 years (39.4%), followed by 38–47 years (27.8%), with no patient aged 78–87 years and only 0.2% aged 88+ years. In the Medical Recovery ward, most patients are aged 38–47 years (32.1%) and 28–37 years (22%), with 1.1% patients aged 78–87 years and 0.2% aged 88+ years.

In Medical Ward U5A, the highest population observed is 38–47 years (38.5%) followed by 28–37 years (29.7%), with 0.2% aged 78–87 years and no sampled patients above the age of 88 years. In the Multidisciplinary Unit, most patients are aged 28–37 years (29.4%), followed by 18–27 years (18.8%) and 38–47 years (17.8%), with only 0.7% aged 78–87 years and 0.1% aged 88+ years. The Phi coefficient displays that there is a weak, but statistically significant association between wards and age group (Phi = 0.259). In addition, the p-value of 0.000 is < 0.001, indicating that the association is statistically significant. Therefore, it can be safely concluded that age does influence the ward name.

Crosstabulation of ward name with the top antimicrobials that showed the highest sensitivity or resistance pattern.

Table 16: Crosstabulation of Ward name against Amikacin

Crosstabulation of Ward Name against Amikacin										
			AMIKACIN					Total	Phi	P-value
			None	*Resistant*	*Inter-mediate*	*Sensitive*	*Dose-Dependent Sensitive*			
WARD NAME	**A6 INTENSIVE CARE UNIT**	**N**	729	656	0	26	176	1 587	**0.289**	0
		%	45.9%	41.3%	0%	1.6%	11.1%	100%		
	EMERGENCY UNIT	**N**	1788	1 532	0	133	140	3 593		
		%	49.8%	42.6%	0%	3.7%	3.9%	100%		
	M1 MEDICAL WARD	**N**	1469	839	0	48	123	2 479		
		%	59.3%	33.8%	0%	1.9%	5%	100%		

	MEDICAL RECOVERY	**N**	1570	1 389	0	89	198	3 246		
		%	48.4%	42.8%	0%	2.7%	6.1%	100%		
	MEDICAL WARD U5A	**N**	2077	467	1	53	80	2 678		
		%	77.6%	17.4%	0%	2%	3%	100%		
	MULTI-DISCIPLINARY UNIT	**N**	842	934	0	13	346	2 135		
		%	39.4%	43.7%	0%	0.6%	16.2%	100%		

Table 16 above displays the Crosstabulation of Ward Name against antibiotic Amikacin. The ward A6 Intensive-Care Unit (45.9%), Emergency Unit (49.8%), M1 Medical Ward (59.3%), Medical Recovery (48.4%), and Medical Ward U5A (77.6%) demonstrate to have their highest percentage values coming from the "none" category. This indicates that these sampled participants were not treated with this antibiotic, as there were no antibiotic susceptibility records of the samples from laboratory results.

The Emergency Unit displays the highest frequency of cases of resistance with 1 532 cases, followed by Medical Recovery accounting for 1 389 cases. However, the Emergency Unit reports to have 133 cases of sensitivity against Amikacin. The Phi coefficient shows that there is a weak, but statistically significant relationship between ward and the antibiotic Amikacin, Phi = 0.289. In addition, the p-value of 0.000 is <0.001, indicates that the association is statistically significant. Therefore, it can safely be concluded that Amikacin does influence the ward name

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***T*able 17: Crosstabulation of Ward Name against Amoxicillin Clavulanic Acid**

Crosstabulation of Ward Name against Amoxicillin Clavulanic Acid									
			AMOXICILLIN CLAVULANIC ACID				**Total**	**Phi**	**P-value**
			None	*Resistant*	*Sensitive*	*Dose Dependent Sensitive*			
WARD NAME	**A6 INTENSIVE CARE UNIT**	**N**	1 020	267	39	261	1 587	**0.255**	**0**
		%	64.3%	16.8%	2.5%	16.4%	100%		
	EMERGENCY UNIT	**N**	1 882	908	284	519	3 593		
		%	52.4%	25.3%	7.9%	14.4%	100%		
	M1 MEDICAL WARD	**N**	1 572	545	29	333	2 479		
		%	63.4%	22%	1.2%	13.4%	100%		
	MEDICAL RECOVERY	**N**	1 702	846	170	528	3 246		
		%	52.4%	26.1%	5.2%	16.3%	100%		
	MEDICAL WARD U5A	**N**	2 221	251	31	175	2 678		
		%	82.9%	9.4%	1.2%	6.5%	100%		
	MULTIDISCIPLINARY UNIT	**N**	1 381	310	62	382	2 135		
		%	64.7%	14.5%	2.9%	17.9%	100%		

Table 17 above presents the Crosstabulation of Ward Name against Amoxicillin Clavulanic Acid. The wards A6 Intensive Care Unit (64.3%), M1 Medical Ward (63.4%), Medical Ward U5A (82.9%) and the Multidisciplinary Unit (64.7%) indicate to have their highest percentage values in the "none" category. This indicates that the majority of patients in these wards were not treated with Amoxicillin Clavulanic Acid antibiotic.

The Emergency Unit accounts for the highest percentage of resistance with 908 (25.3%) cases, followed by Medical Recovery with 846 (26.1%) cases. Conversely, the Emergency Unit also reports the highest percentage of Amoxicillin Clavulanic Acid antibiotic sensitivity with 284 (7.9%) cases, followed by Medical Recovery reporting 170 (5.2%) cases. The Phi coefficient of 0.255 shows a weak but statistically significant relationship between ward and Amoxicillin Clavulanic Acid use. Additionally, the p-value of 0.000 is <0.001 indicates that this relationship is statistically significant; therefore, a conclusion can be made that the ward is associated with differences in the administration and resistance patterns of antibiotic Amoxicillin Clavulanic Acid.

Table 18: Crosstabulation Of Ward Name Against Cefuroxime Oral

Crosstabulation Of Ward Name Against Cefuroxime Oral										
			CEFUROXIME ORAL					Total	Phi	P-value
			None	*Resistant*	*Intermediate*	*Sensitive*	*Dose Dependent Sensitive*			
WARDNAME	A6 INTENSIVE CARE UNIT	N	986	281	1	23	296	1 587	0.199	0
		%	62.1%	17.7%	0.1%	1.4%	18.7%	100%		
	EMERGENCY UNIT	N	1 940	948	0	57	648	3 593		
		%	54%	26.4%	0%	1.6%	18%	100%		
	M1 MEDICAL WARD	N	1 611	499	0	4	365	2 479		
		%	65%	20.1%	0%	0.2%	14.7%	100%		
	MEDICAL RECOVERY	N	1 831	775	0	25	615	3 246		
		%	56.4%	23.9%	0%	0.8%	18.9%	100%		
	MEDICAL WARD U5A	N	2 127	233	0	26	292	2 678		
		%	79.4%	8.7%	0%	1%	10.9%	100%		
	MULTIDISCIPLINARY UNIT	N	1 304	351	0	28	452	2 135		
		%	61.1%	16.4%	0%	1.3%	21.2%	100%		

Table 18 above shows the Crosstabulation of Ward Name against oral Cefuroxime antibiotic. In the A6 Intensive Care Unit, 62.1% of cases are "none", indicating that no antibiotic susceptibility results were received from the laboratory. Therefore, these patients were not treated with this antibiotic. 17.7% cases are resistant, 0.1% intermediate, 1.4% are sensitive, and 18.7% dose-dependent sensitive. In the Emergency Unit, 54% cases are "none", 26.4% resistant, 0% intermediate, 1.6% patients' samples show sensitivity to this antibiotic, and 18% are dose-dependent sensitive.

In Medical Ward U5A, 79.4% patients are recorded under "none", 8.7% patients' samples show resistance to this antibiotic, 0% intermediate, 1% patients are sensitive to this antibiotic, and 10.9% dose-dependent sensitive. In the Multidisciplinary Unit, 61.1% are "none", 16.4% patients are resistant, 0% intermediate, 1.3% patients are sensitive, and 21.2% dose-dependent sensitive.

The Phi coefficient of 0.199 demonstrates a weak, but statistically significant relationship between ward and oral Cefuroxime results, with a p-value of 0.000 (<0.001) confirming statistical significance

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Table 19: Crosstabulation of Ward Name against Ciprofloxacin

Crosstabulation Of Ward Name Against Ciprofloxacin									
			CIPROFLOXACIN				Total	Phi	P-value
			None	*Resistant*	*Sensitive*	*Dose-Dependent Sensitive*			
WARDNAME	A6 INTENSIVE CARE UNIT	N	186	640	32	729	1 587	0.408	0
		%	11.7%	40.3%	2%	45.9%	100%		
	EMERGENCY UNIT	N	480	2 255	75	783	3 593		
		%	13.4%	62.8%	2.1%	21.8%	100%		
	M1 MEDICAL WARD	N	176	1 147	55	1 101	2 479		
		%	7.1%	46.3%	2.2%	44.4%	100%		
	MEDICAL RECOVERY	N	446	1 983	38	779	3 246		
		%	13.7%	61.1%	1.2%	24%	100%		
	MEDICAL WARD U5A	N	1 322	867	30	459	2 678		
		%	49.4%	32.4%	1.1%	17.1%	100%		
	MULTI-DISCIPLINARY UNIT	N	464	1 021	19	631	2 135		
		%	21.7%	47.8%	0.9%	29.6%	100%		

Table 19 indicates the Crosstabulation of Ward Name against Ciprofloxacin antibiotic. In the A6 Intensive Care Unit, 11.7% of cases are recorded as "none", with 40.3% patients resistant to this antibiotic, 2% patients show sensitivity to this antibiotic, and 45.9% are dose-dependent sensitive. In the Emergency Unit, 13.4% are "none", 62.8% patients are resistant, 2.1% patients show sensitivity to this antibiotic, and 21.8% are dose-dependent sensitive. In the M1 Medical Ward, 7.1% are "none", 46.3% patients show resistance, 2.2% patients are sensitive, and 44.4% are dose-dependent sensitive.
In Medical Recovery, 13.7% are "none", 61.1% show resistance, 1.2% display to be sensitive, and 24% are dose-dependent sensitive.
In Medical Ward U5A, 49.4% no patients' antibiotic results are "none", 32.4% patients are resistant, 1.1% are sensitive, and 17.1% are dose-dependent sensitive. In the Multidisciplinary Unit, 21.7% are "none", 47.8% patients show resistance, 0.9% are sensitive, and 29.6% are dose-dependent sensitive.

Therefore, the Phi coefficient of 0.408 indicates a moderate and statistically significant association between ward and Ciprofloxacin outcomes, with a p-value of 0.000 (<0.001) confirming statistical significance.

Table 20: Crosstabulation of Ward Name against Imipenem

Crosstabulation Of Ward Name Against Imipenem										
			IMIPENEM					**Total**	**Phi**	**P-value**
			None	*Re-sistant*	*Inter-mediate*	*Sen-sitive*	*Dose-Dependent Sensitive*			
WARD_NAME	**A6 INTENSIVE CARE UNIT**	**N**	641	420	0	54	472	1 587	0.367	0
		%	40.4%	26.5%	0%	3.4%	29.7%	100%		
	EMERGENCY UNIT	**N**	1 720	1 573	0	130	170	3 593		
		%	47.9%	43.8%	0%	3.6%	4.7%	100%		
	M1 MEDICAL WARD	**N**	1 424	825	0	20	210	2 479		
		%	57.4%	33.3%	0%	0.8%	8.5%	100%		
	MEDICAL RECOVERY	**N**	1 518	1 422	0	107	199	3 246		
		%	46.8%	43.8%	0%	3.3%	6.1%	100%		
	MEDICAL WARD U5A	**N**	2 064	534	0	10	70	2 678		
		%	77.1%	19.9%	0%	0.4%	2.6%	100%		
	MULTIDISCIPLINARY UNIT	**N**	815	850	2	45	423	2 135		
		%	38.2%	39.8%	0.1%	2.1%	19.8%	100%		

Table 20 shows how Imipenem sensitivity varies by ward. In the A6 Intensive Care Unit, 40.4% of isolates are "none", 26.5% are recorded to be resistant, 0% intermediate, 3.4% are found to be sensitive to the drug, and 29.7% dose-dependent sensitive. In the Emergency Unit, 47.9% are categorised as "none", 43.8% patients show resistance, 0% intermediate, 3.6% are sensitive, and 4.7% dose-dependent sensitive. In the M1 Medical Ward, 57.4% are "none", 33.3% show resistance to the drug, 0% intermediate, 0.8% are sensitive, and 8.5% dose-dependent sensitive. In Medical Recovery, 46.8% are recorded as "none", 43.8% are resistant, 0% intermediate, 3.3% patients are sensitive to the drug, and 6.1% dose-dependent sensitive. In Medical Ward U5A, 77.1% are "none", 19.9% show resistance, 0% intermediate, 0.4% are sensitive, and 2.6% dose-dependent sensitive.
In the Multidisciplinary Unit, 38.2% are "none" 39.8% patients show resistance, 0.1% intermediate, 2.1% are sensitive to the drug, and 19.8% dose-dependent sensitive. Therefore, the Phi coefficient of 0.367 indicates a moderate association between ward and Imipenem susceptibility, and the p-value of 0.000 (<0.001) shows this association is statistically significant.

Table 21: Crosstabulation of Ward Name against Moxifloxacin

Crosstabulation Of Ward Name Against Moxifloxacin									
			MOXIFLOXACIN				Total	Phi	P-value
			None	*Resistant*	*Sensitive*	*Dose-Dependent Sensitive*			
WARD_NAME	**A6 INTENSIVE CARE UNIT**	**N**	1 191	164	69	163	1 587	0.329	0
		%	75%	10.3%	4.3%	10.3%	100%		
	EMERGENCY UNIT	**N**	2 416	922	34	221	3 593		
		%	67.2%	25.7%	0.9%	6.2%	100%		
	M1 MEDICAL WARD	**N**	1 445	338	345	351	2 479		
		%	58.3%	13.6%	13.9%	14.2%	100%		
	MEDICAL RECOVERY	**N**	2 200	778	54	214	3 246		
		%	67.8%	24%	1.7%	6.6%	100%		
	MEDICAL WARD U5A	**N**	1 966	537	94	81	2 678		
		%	73.4%	20.1%	3.5%	3%	100%		
	MULTIDISCIPLINARY UNIT	**N**	1 910	119	31	75	2 135		
		%	89.5%	5.6%	1.5%	3.5%	100%		

Table 21 presents the distribution of Moxifloxacin antibiotic susceptibility across wards.

In the A6 Intensive Care Unit, 75% of isolates have results for this antibiotic "none", 10.3% are resistant, 4.3% isolates are sensitive to this drug, and 10.3% dose-dependent sensitive. In the Emergency Unit, 67.2% are recorded as "none", 25.7% are resistant, 0.9% are sensitive to this drug, and 6.2% dose-dependent sensitive. In the M1 Medical Ward, 58.3% are "none", 13.6% patients show resistance to the antibiotic, 13.9% are sensitive, and 14.2% dose-dependent sensitive.

In Medical Recovery, 67.8% are "none", 24% are resistant, 1.7% are sensitive, and 6.6% dose-dependent sensitive. In Medical Ward U5A, 73.4% are "none", 20.1% show resistance to the drug, 3.5% isolates are sensitive, and 3% dose-dependent sensitive. In the Multidisciplinary Unit, 89.5% are "none", 5.6% are resistant, 1.5% are sensitive, and 3.5% dose-dependent sensitive.

Therefore, the Phi coefficient of 0.329 shows a moderate association between ward and Moxifloxacin antibiotic susceptibility, and the p-value of 0.000 (<0.001) confirms this relationship is statistically significant.

Table 22: Crosstabulation of Ward Name against Rifampicin

Crosstabulation of Ward Name Against Rifampicin									
			RIFAMPICIN				Total	Phi	P-value
			None	*Resistant*	*Sen-sitive*	*Dos-e Depen-dent Sensitive*			
WARDNAME	**A6 INTENSIVE CARE UNIT**	**N**	1 179	176	29	203	1 587	0.345	0
		%	74.3%	11.1%	1.8%	12.8%	100%		
	EMERGENCY UNIT	**N**	2 371	727	247	248	3 593		
		%	66%	20.2%	6.9%	6.9%	100%		
	M1 MEDICAL WARD	**N**	1 391	360	125	603	2 479		
		%	56.1%	14.5%	5%	24.3%	100%		
	MEDICAL RECOVERY	**N**	2 205	756	103	182	3 246		
		%	67.9%	23.3%	3.2%	5.6%	100%		
	MEDICAL WARD U5A	**N**	1 223	969	6	480	2 678		
		%	45.7%	36.2%	0.2%	17.9%	100%		
	MULTI-DISCIPLINARY UNIT	**N**	1 789	190	1	155	2 135		
		%	83.8%	8.9%	0%	7.3%	100%		

Table 22 shows the distribution of Rifampicin antibiotic susceptibility across hospital wards. In the A6 Intensive Care Unit, 74.3% of isolates' antibiotic results show "none", 11.1% are resistant, 1.8% isolates are sensitive, and 12.8% dose-dependent sensitive.

The Emergency Unit has 66% patients isolates with no results "none," 20.2% are resistant, 6.9% are sensitive to this drug, and 6.9% dose-dependent sensitive.

M1 Medical Ward shows 56.1% under "none", 14.5% are resistant, 5% isolates are sensitive, and 24.3% dose-dependent sensitive. Medical Recovery reports 67.9% "none," 23.3% isolates show resistance, 3.2% are sensitive, and 5.6% dose-dependent sensitive. Medical Ward U5A has 45.7% under "none", 36.2% display resistance, 0.2% are sensitive, and 17.9% dose-dependent sensitive. The Multidisciplinary Unit displays 83.8% under "none", 8.9% show resistance to the drug, no sensitivity (0%) is recorded for this drug, and 7.3% are dose-dependent sensitive.

The Phi coefficient of 0.345 suggests a moderate relationship between wards and Rifampicin antimicrobial susceptibility, and the p-value of 0.000 indicates that this association is statistically significant.

Table 23: Crosstabulation of Ward Name against Teicoplanin

Crosstabulation Of Ward Name Against Teicoplanin									
			TEICOPLANIN				**Total**	**Phi**	**P-value**
			None	*Resis-tant*	*Sen-sitive*	*Dose-Depen-dent Sensitive*			
WARD NAME	**A6 INTENSIVE CARE UNIT**	**N**	1 138	391	24	34	1 587	0.204	0
		%	71.7%	24.6%	1.5 %	2.1%	100%		
	EMERGENCY UNIT	**N**	2 389	1 143	51	10	3 593		
		%	66.5%	31.8%	1.4 %	0.3%	100%		
	M1 MEDICAL WARD	**N**	1 340	1 069	53	17	2 479		
		%	54.1%	43.1%	2.1 %	0.7%	100%		
	MEDICAL RECOVERY	**N**	2 247	940	31	28	3 246		
		%	69.2%	29%	1%	0.9%	100%		
	MEDICAL WARD U5A	**N**	1 973	612	75	18	2 678		
		%	73.7%	22.9%	2.8 %	0.7%	100%		
	MULTI-DISCIPLINARY UNIT	**N**	1 794	330	4	7	2 135		
		%	84%	15.5%	0.2 %	0.3%	100%		

Table 23 presents teicoplanin antimicrobial susceptibility across hospital wards. In the A6 Intensive Care Unit, 71.7% of the isolates do not have laboratory results of this antibiotic, 24.6% isolates are resistant, 1.5% are sensitive, and 2.1% dose-dependent sensitive.

The Emergency Unit has 66.5% isolates with no results for this antibiotic "none", 31.8% are resistant, 1.4% show sensitivity, and 0.3% dose-dependent sensitive.

M1 Medical Ward 54.1% does not have results "none", 43.1% are resistant, 2.1% are sensitive, and 0.7% dose-dependent sensitive.

Medical Recovery has 69.2% under "none", 29% isolates are resistant, 1% are sensitive, and 0.9% dose-dependent sensitive. Medical Ward U5A reports 73.7% under "none", 22.9% isolates are resistant, 2.8% are sensitive, and 0.7% dose-dependent sensitive. The Multidisciplinary Unit has 84% "none", 15.5% show resistance, 0.2% are sensitive, and 0.3% dose-dependent sensitive.

Therefore, the Phi coefficient of 0.204 indicates a weak to moderate relationship between ward and Teicoplanin antibiotic susceptibility, However, the p-value of 0.000 shows that this association is statistically significant.

Table 24: Crosstabulation of Ward Name against Tigecycline

Crosstabulation Of Ward Name Against Tigecycline									
			TIGECYCLINE				Total	Phi	P-value
			None	*Resistant*	*Sensitive*	*Dose-Dependent Sensitive*			
WARD NAME	A6 INTENSIVE CARE UNIT	N	310	1 002	54	221	1 587	0.341	0
		%	19.5%	63.1%	3.4%	13.9%	100%		
	EMERGENCY UNIT	N	870	2 389	20	314	3 593		
		%	24.2%	66.5%	0.6%	8.7%	100%		
	M1 MEDICAL WARD	N	455	1 871	34	119	2 479		
		%	18.4%	75.5%	1.4%	4.8%	100%		
	MEDICAL RECOVERY	N	809	2 156	21	260	3 246		
		%	24.9%	66.4%	0.6%	8%	100%		
	MEDICAL WARD U5A	N	1 599	965	18	96	2 678		
		%	59.7%	36%	0.7%	3.6%	100%		
	MULTI-DISCIPLINARY UNIT	N	912	1 026	55	142	2 135		
		%	42.7%	48.1%	2.6%	6.7%	100%		

Table 24 presents Tigecycline susceptibility across hospital wards. In the A6 Intensive Care Unit, 19.5% of isolates do not have results for this antibiotic, 63.1% isolates are resistant, 3.4% are sensitive, and 13.9% dose-dependent sensitive.

The Emergency Unit shows 24.2% patients do have results for this antibiotic, 66.5% are resistant, 0.6% patients show sensitivity, and 8.7% dose-dependent sensitive. M1 Medical Ward has 18.4% isolates with no results, 75.5% are resistant, 1.4% are sensitive, and 4.8% dose-dependent sensitive.

Medical Recovery reports that 24.9% patients do not have results for this antibiotic, 66.4% are resistant, 0.6% are sensitive, and 8% dose-dependent sensitive. In Medical Ward U5A, 59.7% are recorded as "none", 36% isolates are resistant, 0.7% are sensitive, and 3.6% dose-dependent sensitive. The Multidisciplinary Unit has 42.7% who do not have results for this antibiotic, 48.1% are resistant, 2.6% are sensitive, and 6.7% dose-dependent sensitive.

The Phi coefficient of 0.341 demonstrates a moderate association between ward and Tigecycline antibiotic susceptibility, and the p-value of 0.000 confirms this association is statistically significant.

Table 25: Crosstabulation of Ward Name against Nitrofurantoin

Crosstabulation of Ward Name Against Nitrofurantoin									
			NITROFURANTOIN				Total	Phi	P-value
			None	*Resistant*	*Sen-sitive*	*Dose-Depen-dent Sensitive*			
WARD NAME	A6 INTENSIVE CARE UNIT	N	1033	178	135	241	1 587	0.203	0
		%	65.1%	11.2%	8.5%	15.2%	100%		
	EMERGENCY UNIT	N	2083	825	309	376	3 593		
		%	58%	23%	8.6%	10.5%	100%		
	M1 MEDICAL WARD	N	1651	243	369	216	2 479		
		%	66.6%	9.8%	14.9 %	8.7%	100%		
	MEDICAL RECOVERY	N	1 987	643	268	348	3 246		
		%	61.2%	19.8%	8.3%	10.7%	100%		
	MEDICAL WARD U5A	N	2 054	229	136	259	2 678		
		%	76.7%	8.6%	5.1%	9.7%	100%		
	MULTI-DISCIPLINARY UNIT	N	1 430	262	155	288	2 135		
		%	67%	12.3%	7.3%	13.5%	100%		

Table 25 presents the distribution of Nitrofurantoin antimicrobial susceptibility across different wards.

In the A6 Intensive Care Unit, the most of the isolates (65.1%) fall into the "none" category due to not having a laboratory report for this antibiotic, while 11.2% are resistant, 8.5% are sensitive, and 15.2% dose-dependent sensitive. The Emergency Unit shows 58% under "none", 23% are resistant, 8.6% are reported to be sensitive, and 10.5% dose-dependent sensitive. M1 Medical Ward has 66.6% under "none", 9.8% are resistant, 14.9% isolates are reported to be sensitive, and 8.7% dose-dependent sensitive.

In Medical Recovery, 61.2% are recorded under "none", 19.8% a resistant, 8.3% are found to be sensitive, and 10.7% dose-dependent sensitive. Medical Ward U5A shows the highest proportion in the "none" category at 76.7%, with 8.6% isolates reported to be resistant, 5.1% isolates are sensitive, and 9.7% dose-dependent sensitive. The Multidisciplinary Unit has 67% isolates not having laboratory results "none", 12.3% are reported as resistant, 7.3% are sensitive, and 13.5% dose-dependent sensitive.

The Phi coefficient of 0.203 demonstrates a weak association between ward and Nitrofurantoin antibiotic susceptibility, and the p-value of 0.000 (<0.001) demonstrates that this relationship is statistically significant.

Discussion

Descriptive statistics

Descriptive statistics of the study was done based on district name, facility name, gender of the patients and age group of the patients. This retrospective, cross-sectional study consisted of 48 597 participants and most of the participants in the study were from the Frances Baard District Municipality in Kimberley in the Northern Cape Province (58.4%), followed by the Mangaung Metropolitan Municipality in the Free State Province (37.9%). The majority of the patients in the study (58.4%) were treated at the Robert Mangaliso Sobukwe Provincial Hospital (Northern Cape Province), followed by 20.9% patients treated at the Universitas Academic hospital (Free State Province). The Mofumahadi Manapo Mopeli Regional Hospital had the least patients (0.7%). The highest age group percentage in the study was 27.1%, which fell between 28 and 37 years, followed by 26.4% between the ages of 38 and 47 years, with the lowest population (0.84%) was found between 78 and 87 years. The study showed that fewer patients were admitted to hospital from the age of 58 years and above. This could mean that most of the patients in these age groups are aware of their medical conditions and they comply with their treatment, which results in them having fewer hospital admissions. Another contributing factor can be the participants' lifestyle. Most participants in the study were recorded to be female 49.9%. There was a slight difference among male (49.4%). The study also recorded that 0.7% of the patients' gender was unknown.

1. Additional Descriptives

In the study, data of patients who tested for Tuberculosis using the GeneXpert ultra assay were analysed. The study showed that 89.4% of patients tested negatively for TB across all six hospitals. 6.8% patients tested positively for TB, while 1.6% and 1.8% patients' TB results were unknown or not tested, respectively. The majority of the participants in the patients in the study were not tested for HIV using the HIV-1/2 rapid screen test and of those who were tested, only 1.2% were reported to be HIV positive and 4.2% were negative. A total number of 70.7% of the patients did not have HIV-1/2 AB/AG screen results, while 24.4% tested negative and 4.3% tested positive.The data show that only 0.6% of the patients had equivocal HIV results, which means that the HIV sample had to be repeated using a different machine for confirmation. The study showed that 7.9% (n=3 862/48 597) patients' HIV viral load were undetectable, which means that the patients were compliant with Antiretroviral Therapy (ART) treatment. However, this rate is very low when compared to the rate of patients on effective ART (65.3%) in the study that was conducted by Franceschini et al. (2020). The results in our study supports the claims made by (Kebede et al., 2017), that HAART and prophylactic management of opportunistic infections has brought a huge improvement in the health system. The undetectable HIV viral load was <20-50 copies/mL, 6.9% patients had a low HIV viral load of 50-10 000 copies/mL and a population of n=3 299 (6.8%) was found to have a high HIV viral load >100 000 copies/mL. The study showed that 74.9% patients were not tested for HIV viral load. A total of 68.8% of patients in this study did not have CD4 ARV results, so their immune systems were not monitored. 23.4% of the patients displayed a low immune system (<350 cells/$mm^{3)}$, which means that they were not complying with ART treatment. 3.6% of the patients had mild immunosuppression (350–499 cells/mm^3) and 4.2% of the patients had a strong immune system, which means that they are complying with to ART treatment. These findings support the claims by Lubega et al. (2023) that low CD4 counts and detectable viral loads are risk factors for patients in microbial infections.

The study also evaluated the prevalence testing method for all the specimens submitted to the laboratory for microbes and antimicrobial testing. Automated culture was the method frequently used in the laboratory and it was reported to be at the rate of 42.8%, followed by culture urine (25.4%), culture pus (23.3%). Culture catheter tip was the least frequently used test method, displaying a rate of 8.5%. 48 597 specimens were reported to have been tested in the laboratory. In the study, the type of specimen collected from patients and sent to the laboratory for testing was also analysed. A total of 48 597 specimens were collected. Blood culture (38.4%) was the most frequently collected specimen as the patients might have been suspected of having a bloodstream infection. This supports the claims from (Dewi et al., 2023) that critically ill patients in ICU have high chances of getting bacterial infections in the bloodstream. Urine was the second-most frequently

collected specimen (16.5%), as the patients might have been suspected for having UTI. Swab (superficial) was reported in 15.6% cases, abscess (superficial swab) reported in 3.9% cases, Arterial Catheter Tip was reported in 3.1% cases, wound swab reported in 3.3% cases, catheter urine reported in 2.9% cases, and fluid/aspirate reported in 2.7% cases. The top 10 prevalent microorganisms from the sample isolates were *Escherichia Coli* (16.9%), *staphylococcus aureus* (14.5%), Coagulase Negative *staphylococcus* (11.9%), *Klebsiella pneumoniae* subsp pneumonia (9.4%), *Staphylococcus epidermidis* (5.2%), *Streptococcus pneumoniae* (4%), *Proteus mirabilis* (4%), *Acinetobacter baumannii* (3.7%), *Pseudomonas aeroginosa* (3.2%), *Enterobacter Cloacae* subsp. Cloacae (2.9%).The findings in this study correspond with the study of Kamara (et al.,2024), as they also report that *Staphylococcus aureus* was 35.7%, *Pseudomonas aeroginosa* 19.6%, *Streptococcus pneumoniae* 17.9% and *Enterobacter* species at 8.9%. Similar findings were observed from the study of Dewi et al. (2023), as they also report an increase in the prevalence of *Pseudomonas aeroginosa* and *Acinetobacter baumannii* microorganisms. The study observed a prevalence of microorganisms in hospitals that are located in urban facilities, compared to facilities located in rural areas. This could be caused by patients being transferred from rural/district hospitals to urban/regional/ provincial/academic hospitals so that they can have access to advanced treatment. In contrast, with the study conducted by Tilahun et al. (2023), who report that more microorganisms are observed in rural facilities (64%) compared to urban facilities (40.8%).

2. Prevalence of the top 10 antimicrobial sensitivity or resistance in different ward

In the A6 Intensive Care Unit, the antibiotic cefuroxime oral was reported to be resistant in n=281 (17,1%) cases, while n=23 (1.4%) cases displayed to be sensitive to this antibiotic. Ciprofloxacin was found to be resistant in n=640 (40.3%) cases, in contrast to n=32 (2%) sensitive cases. Imipenem antibiotic displayed n=420 (26.5%) level of resistance, while n=54 (3.4%) isolates were sensitive to the antibiotic. Moxifloxacin displayed a n=164 (10.3%) resistance rate and n=69 (4.3%) were reported to have been sensitive to this antibiotic. Rifampicin showed resistance of n=176 (11.1%) cases and sensitivity was reported in n=29 (1.8%) cases. Teicoplanin was found to display resistance in n=391 (24.6%) cases and sensitivity was found in n=24 (1.5%) isolates. Tigecycline antibiotic was reported to be resistant in n=1 002 (63.1%) cases and sensitive in n=54 (3.4%) cases, lastly in this ward, Nitrofurantoin was resistant in n=178 (11.2%) cases and sensitive in n=135 (8.5%) cases.In the Emergency Unit, the antibiotic Amikacin displayed resistance in n=1 532 (42.6%) cases while sensitivity cases were found in n=133 (3.7%) isolates. Amoxicillin Clavulanic Acid showed a resistance rate in n=908 (25.3%) cases and sensitivity was noted in n=284 (7.9%) cases. The resistance rate in Cefuroxime oral antibiotic was n=948 (26.4%), while sensitivity was observed in n=57 (1.6%) cases. Ciprofloxacin antibiotic in this ward displayed resistance in n=2 255 (62.8%) cases, while sensitivity was observed in n=75 (2.1%). Imipenem was reported to be resistant in n=1573 (43.8%) cases, while sensitivity was observed in n=130 (3.6%) cases. Rifampicin was observed to be resistant in n=727 (20.2%) isolates and sensitivity was observed in n=247 (6.9%) isolates. Teicoplanin antibiotic in this ward showed resistance in n=1 143 (31.8%) and sensitivity was observed in n=51 (1.4%) isolates. Lastly, Nitrofurantoin antibiotic in this ward showed resistant in n=825 (23%) cases and sensitivity was reported in n=309 (8.6%) cases.In M1 Medical ward, the antibiotic Ciprofloxacin showed resistance in n=1 147 (46.3%) cases and sensitivity was observed in n=55 (2.2%) cases. Moxifloxacin antibiotic displayed almost the same percentage when it comes to resistance and sensitivity (13.6% and 13.9%), respectively. Rifampicin antibiotic in this ward showed resistance in n=360 (14.5%) isolates and sensitivity was reported in n=125 (5%) isolates. Teicoplanin showed resistance in n=1069 (43.1%) cases and was sensitive in n=53 (2.1%) cases. Tigecycline showed high resistance in n=1871 (75. 5%) isolates, compared to n=34 (1.4%) sensitive cases. Nitrofurantoin antibiotic showed resistance in n=243 (9.8%) cases and sensitivity was observed in n=369 (14.9%) cases.In the Medical Recovery ward, Amikacin was reported to be resistant in n=1389 (42.8%) isolates. Amoxicillin Clavulanic Acid was resistant in n=846 (26.1%) cases, while sensitive in n=170 (5.2%) cases. Ciprofloxacin was reported to be resistant in n=1 983 (61.1%) and sensitive in n=38 (1.2%) cases. Imipenem antibiotic was resistant in n=1 422 (43.8%) isolates and sensitive to n=107 (3.3%) isolates. Moxifloxacin was resistant in 778 (24%) isolates from this ward and sensitive in n=54 (1.7%) isolates. Rifampicin antibiotic was resistant in n=756 (23.3%) and sensitive in n=103 (3.2%) isolates. Teicoplanin in this ward was found to be resistant in n=940 (29%) cases and sensitive in n=31 (2.1%) cases. Nitrofurantoin in this ward was resistant in n=643 (19.8%) cases and sensitive in n=268 (8.3%) cases.

In Medical ward U5A, the antibiotic Cefuroxime oral was observed to be resistant in n=233 (8.7%) cases and sensitive in n=26 (1%) cases. Ciprofloxacin was reported resistant in n=867 (32.4%) isolates, while sensitive in n=30 (1.1%) isolates. Moxifloxacin antibiotic in this ward was resistant in n=537 (20.1%) cases and sensitive in n=94 (3.5%) cases. Teicoplanin antibiotic was reported resistant in n=612 (22.9%) cases and sensitive in n=75 (2.8%) cases. Lastly, it was reported Nitrofurantoin antibiotic showed resistance in n=229 (8.6%) cases and sensitive in n=136 (5.1%) cases.In the Multidisciplinary Unit, the antibiotic Cefuroxime oral was reported to be resistant in n=351 (16.4%) cases and observed to be sensitive in n=28 (1.3%) cases. Imipenem was found to be resistant in n=850 (39.8%) isolates and sensitive in n=45 (2.1%) isolates. Moxifloxacin was resistant in n=119 (5.6%) cases and sensitive in n=31 (1.5%) cases. Tigecycline antibiotic showed resistance in n=1 026 (48.1%) cases and sensitive in n=55 (2.6%) cases. Lastly, Nitrofurantoin antibiotic in this ward showed resistance

in n=262 (12.3%) isolates and sensitive in n=155 (7.3%) isolates.The study proved that the ward type where patients were admitted to plays a huge risk factor in antibiotic treatment. Most patients who were admitted to Medical wards showed a very high prevalence of antimicrobial resistance. Resistance was observed in all the antibiotics. The same trend was observed in both ICUs, in the A6 Intensive Care Unit and Multidisciplinary unit. Most patients showed a high prevalence of resistance to most antibiotics. These findings support the claims made by (Temesgen et al., 2023) that bacterial contamination of indoor hospitals, particularly in Intensive Care Units is a serious health hazard in the world with high morbidity rates. The findings in the study support the claims made by Temesgen et al. (2023), as they mention that treatment of patients with empirical antibiotics often leads to antimicrobial resistance. Bhat et al. (2021), claim that immunocompromised patients often suffer from antibiotics resistance. The same was observed in the study with HIV- and TB-positive patients. The study also showed that the Nitrofurantoin antibiotic displayed high sensitivity in most wards. The study showed that antibiotic Imipenem was sensitive to microorganisms in most wards. This is similar to the findings of Okon et al. (2023), as they report a high sensitivity rate for this antibiotics in most microorganisms.

Conclusion

The study showed that the majority of patients had a high HIV viral load and low CD4 count, which show non-compliance with ART, which is a risk factor for acquiring microbial infections. There was a high prevalence of antimicrobial resistance from different wards in the study.

Recommendations

It is not recommended for clinicians to use an antibiotic that shows intermediate sensitivity, as that drug is not guaranteed to work in the patient. This increases the statistics of MDR in patients. The use of empirical antibiotics in patients should be discontinued, as it also contributes to the increase of MDR. The government must initiate programmes to encourage patients regarding compliance with ART. The government must conduct regular studies to check the microbial profile prevalences and prevalence of antimicrobial resistance rate in hospitalized patients in different wards, as this will aid in implementing new systems.

Study limitation

The limitation in this study is that from the laboratory results provided, the researchers did not know which antibiotic was actually administered to the patients by clinicians and how the patients responded to that particular antibiotic, as the researchers did not have access to the patients' medical file in the wards.

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