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EXPLORATION OF THE TREND ANALYSIS OF RIF-RESISTANCE TUBERCULOSIS: A CASE OF MASVINGO PROVINCE, ZIMBABWE

BY

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A RESEARCH DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS IN PUBLIC HEALTH IN THE FACULTY OF THE COLLEGE OF HEALTH, AGRICULTURE AND NATURAL SCIENCES

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Abstract

Tuberculosis (TB) continues to be a critical global public health challenge, particularly in Masvingo province, Zimbabwe, where healthcare resources are limited. This study primarily focused on the trend analysis of the total number of TB samples, TB samples from HIV-positive individuals, TB-positive cases, and rifampicin-resistant (Rif-resistant) TB cases in Masvingo province, as observed across three distinct periods: the pre-COVID-19 period (2018–2019), the COVID-19 period (2020–2021), and the post-COVID-19 period (2022–2023). The researcher employed a mixed-methods approach, utilizing quantitative data from 10 laboratories in Masvingo Province equipped with GeneXpert machines (diagnostic tools used for diagnosis of TB), along with qualitative information from seven district TB coordinators and one provincial TB coordinator to supplement the results obtained from the quantitative analysis. The quantitative analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 20. A two-sample proportional test was employed to depict the trend analysis and contributing factors for the total number of TB samples, TB samples from HIV-positive individuals, TB-positive cases, and Rif-resistant TB cases. The results indicated that the proportion of TB samples collected during the pre-COVID-19 period (41.0%) was significantly higher than during the pandemic (31.0%), a difference that was statistically significant ($p = 0.000 < 0.05$). Qualitative analysis revealed that limited healthcare access during the pandemic, due to travel restrictions from government lockdowns, contributed to this decline. Notably, the proportion of TB samples from HIV-positive individuals increased during the COVID-19 period (35.0%) compared to the pre-pandemic period (33.9%), a difference that was statistically significant ($p = 0.015 < 0.05$). This suggests that the combined vulnerabilities of HIV and COVID-19 led to increased healthcare interactions, supported by qualitative insights indicating that people living with HIV were viewed as high-risk and had more contact with medical practitioners. Temporal variations in TB positivity rates were evident, with a higher proportion of positive cases recorded in the pre-COVID-19 era (39.5%) compared to the pandemic (29.37%), a difference that was statistically significant ($p = 0.000 < 0.05$). This decline may indicate a recovery of healthcare services or improved patient adherence to treatment due to heightened health awareness during the pandemic. A significant decline in rifampicin-resistant TB (RR-TB) cases was also observed between the COVID-19 period (39.22%) and the post-COVID-19 period (17.65%), a difference that was statistically significant ($p = 0.001 < 0.05$), suggesting a recovery of healthcare services or improved patient adherence to treatment as a result of increased health awareness during the pandemic. COVID-19 negatively affected the TB continuum of care regressing the gains that had been made towards the END TB Strategy. This is evidenced by the drop in the total number of samples collected due to a reduction in the presumption rate, the pick in TB samples from HIV-positive clients, and a pick in Rif-resistance TB.

Keywords- COVID-19, HIV-positive, Rif-Resistance, TB samples, TB

Declaration Page

This dissertation is my original work except where sources have been cited and acknowledged. The work has never been submitted, nor will it ever be forwarded to another university for the award of a degree.

Yvonne T. Mbaura  (07/04/2025)

Student's Full Name **Student’s Signature (Date)**

Prof Elton Mugomeri

Main Supervisor's Full Name **Main Supervisor’s Signature**

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Dedication Page

I dedicate this document to Almighty God and my family, whose unwavering support has been instrumental in my endeavours. I extend my heartfelt gratitude to Washington, Anand, Andile, Aakil, and Aiden for their encouragement and belief in me throughout this journey.

List of Acronyms and Abbreviations

AUREC	Africa University Research Ethics Committee.
BCG	Bacillus Calmette-Guerin
COPD	Chronic Obstructive Pulmonary Disease
COVID-19	Corona virus disease
DHIS2	District Health Information System
DR-TB	Drug- resistant tuberculosis
HIV	Human Immunodeficiency Virus
HPV	Human Papilloma Virus
ICU	Intensive Care Unit
LIMS	Laboratory Information Management System
MDR-TB	Multi-drug-resistant tuberculosis
MoHCC	Ministry of Health and Child Care
PMD	Provincial Medical Director
PPE	Personal Protective Equipment
RR-TB	Rifampicin- Resistant tuberculosis
SARS-COV-2	severe acute respiratory syndrome coronavirus 2
SPSS	Statistical Package for Social Sciences
TB	Tuberculosis
UHC	Universal Health Coverage
WHO	World Health Organisation
XDR-TB	Extensively drug-resistant tuberculosis

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Tuberculosis (TB) remains a pressing global public health challenge, especially in regions with under-resourced healthcare systems. Despite being one of the most studied infectious diseases, TB continues to present significant difficulties in diagnosis, treatment, and prevention. Historically, it has claimed more human lives than any other infectious disease, underscoring its persistent threat to global health (Tobin & Tristram, 2024). A major concern in TB control is the growing ability of *Mycobacterium tuberculosis* to develop resistance to widely used medications such as rifampicin. In response, the World Health Organization (WHO) recommends the use of multidrug therapy (MDT) to enhance treatment efficacy (Kant & Tyagi, 2021). However, poor adherence to treatment remains a critical contributor to both relapse and the emergence of drug-resistant TB strains.

The global burden of TB remains substantial. In 2019, an estimated 10 million people developed TB, continuing a slow downward trend over the years (WHO, 2020). However, the WHO (2023) reported that TB was still responsible for 1.3 million deaths in 2022, only a marginal decline from the 1.4 million deaths recorded annually in both 2020 and 2021. Alarmingly, 7.5 million new TB cases were diagnosed in 2022, representing the highest annual figure since global TB surveillance began in 1995. The regional distribution of new cases highlights Southeast Asia as the most affected (46%), followed by Africa (23%) and the Western Pacific (18%). Currently, approximately 10.6 million people are living with active TB, including 5.8 million men, 3.5 million women, and 1.3 million children. Moreover, an estimated one-quarter of the world's population carries a latent

TB infection, with 5% to 10% at risk of progressing to active disease. The burden is particularly severe in low-income countries where overcrowding, malnutrition, and poverty provide an enabling environment for TB transmission.

TB control efforts are further hindered by the disease's close relationship with HIV. According to WHO (2021b), people living with HIV (PLHIV) are approximately 19 times more likely to develop active TB than individuals without HIV. In 2022 alone, TB caused 167,000 deaths among PLHIV, reinforcing its position as the leading cause of death in this group (Tobin & Tristram, 2024). Although antiretroviral therapy (ART) enhances immune recovery, it does not fully restore protection against TB. In some cases, the reconstitution of TB-specific CD4+ T cells post-ART initiation can trigger TB-associated immune reconstitution inflammatory syndrome (TB-IRIS), complicating clinical management. PLHIV are especially vulnerable within the first year of infection, often experiencing more severe disease progression, particularly in settings with constrained resources (Tobin & Tristram, 2024).

Efforts to curb TB transmission continue to face significant obstacles. The airborne nature of TB facilitates rapid spread, and its non-specific symptoms such as persistent cough and fatigue, often lead to delayed diagnosis. Treatment typically requires a prolonged regimen of multiple antibiotics, which presents adherence challenges even in countries with well-functioning health systems. In many low-income regions, diagnostic delays are exacerbated by shortages in trained personnel, diagnostic tools, and public health infrastructure. Conversely, in high-income countries where TB is rare, limited clinical exposure may lead to underdiagnosis or mismanagement.

The COVID-19 pandemic compounded these challenges by disrupting TB prevention and care services worldwide. According to Dean et al. (2022), fear of exposure and social isolation measures significantly hindered patient adherence to TB treatment by limiting access to health facilities and medications. This was further worsened by the redeployment of healthcare staff toward COVID-19 case management. Consequently, WHO (2022) reported a substantial decline in TB notifications from 7.1 million cases to 5.8 million during the pandemic. This decline did not necessarily reflect fewer infections but rather indicated underdiagnosis and underreporting, which in turn contributed to increased TB-related mortality.

As one of the deadliest pandemics in recent history, COVID-19 profoundly affected all aspects of society, including healthcare. It reversed progress made under the End TB Strategy by exacerbating the vulnerabilities of already strained health systems. Globally, attention shifted toward managing and preventing COVID-19, often at the expense of other health priorities such as TB. Quarantine measures, lockdowns, and the reassignment of health personnel disrupted TB services at all levels prevention, diagnosis, and treatment. For instance, in Zimbabwe, health facilities such as Wilkins Hospital in Harare and Rujeko Clinic in Masvingo were converted into COVID-19 isolation centers, diverting resources away from TB care.

McQuaid et al. (2021) illustrated the cascading impact of COVID-19 on TB services, visually depicting the various points in the TB care continuum that experienced either increases or decreases in patient numbers due to pandemic-related disruptions as shown in the figure below.

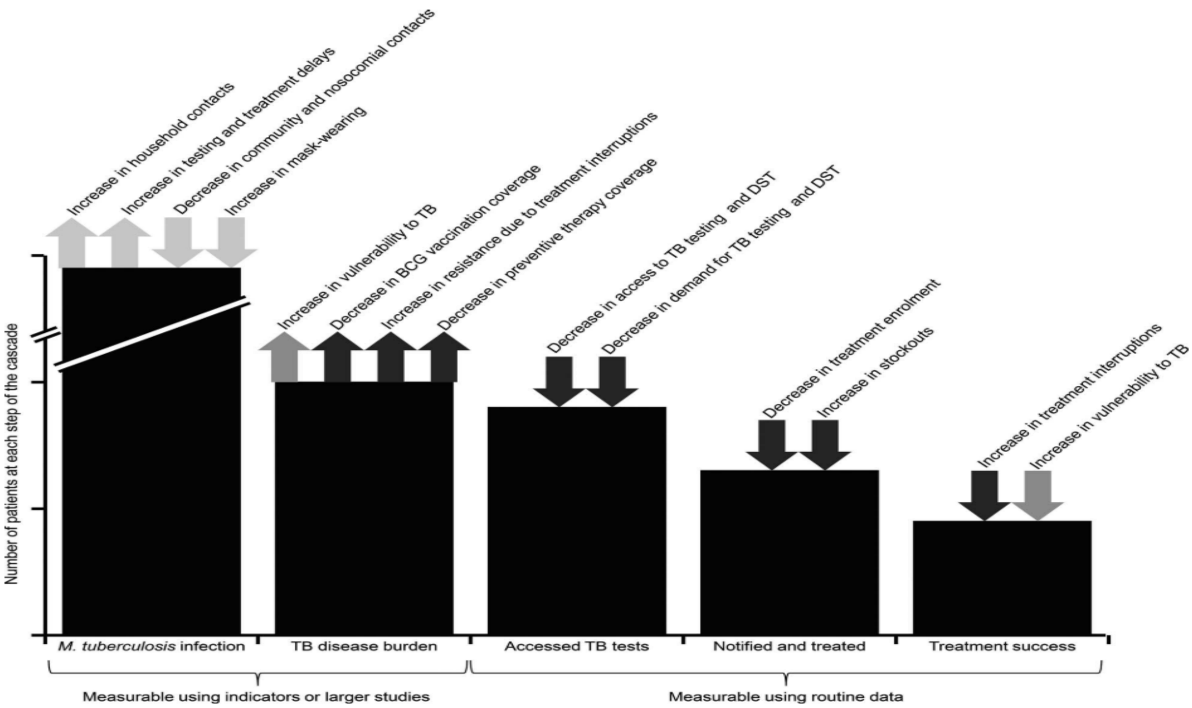

Figure 1: Impacts of COVID-19 on the TB care cascade

This disruption underscores the urgent need to assess how pandemic responses influenced patterns of rifampicin-resistant TB (RR-TB), particularly in vulnerable regions such as Masvingo Province.

Furthermore, the pandemic had a detrimental impact on the economy, leading to unemployment and worsening poverty. Since poverty and unemployment are some of the social determinants of health they contributed to deteriorating health inequalities, which increased the incidence of TB and the spread of drug resistance to TB worldwide. This created favourable conditions for drug resistance to emerge after the pandemic.

Publications on COVID-19 impacts on drug-resistant TB are for the pre-Covid and Covid-era only. Nothing has been published in the post-Covid era. This study therefore is going to compare the trends in TB drug-resistant patterns before Covid (2018-2019), during the Covid era (2020-2022), and post-Covid era (2023-2024) in Masvingo province. It’s a retrospective study looking at GeneXpert drug resistance data at all districts, mission and provincial laboratories.

1.2 Background of the study

Tuberculosis is one of the neglected and re-emerging infectious diseases of public health concern. It is one of the top ten causes of death globally with an incidence rate of 127/100 000 and a mortality rate of 22 deaths/100 000. According to the WHO 2022 Global TB Report Zimbabwe's TB incidence is 190/100 000 and the death rate is at 7%. Zimbabwe was removed from the top 30 high-burdened countries for TB but remains on the list of high-burdened countries for TB/HIV and MDR/RR-TB (multi-drug resistant/Rifampicin-resistant TB).

Early treatment discontinuation, inaccurate or inefficient use of anti-TB, for example, poor drug quality or substandard storage environments can result in drug resistance that is transmittable from one person to another. Other risk factors include low socioeconomic status (education, income, low nutrition, and smoking), HIV coinfection, and diabetes. Globally, there were 600,000 new cases of multi-drug-resistant TB, 16% occurred in the African continent in 2016 (WHO, 2017). According to a TB- drug resistant survey done in Zimbabwe in 2015, it was noted that the prevalence of MDR-TB remained unchanged since 1994 (1.9% among new patients, and 8.3% among retreatment patients) but the prevalence of Rifampicin Resistant TB (RR-TB) doubled that of MDR-TB.

Drug resistance is among the key challenges in ending TB in this era and is becoming more challenging post the Covid 19 pandemic. (Timire, C. et al. 2019) During the pandemic, healthcare facilities focused on Covid 19 and overlooked other diseases like TB. This shift slowed the spread of COVID-19 but caused serious short- and long-term disruptions to the programmes for other major diseases. The short-term effects were the decline in TB diagnosis and notifications, and shortages of TB drugs due to the channelling of resources to the pandemic. One of the long-term effects being experienced now is the increase in tuberculosis multi-drug resistance. In Zimbabwe, the GeneXpert machine used for molecular testing of mycobacteria tuberculosis is being used for viral load testing, early infant diagnosis testing, COVID-19 testing and HPV testing. This multiplexing is affecting TB diagnosis, and during the pandemic, the machine was strictly being used for COVID-19 testing.

In a bid to respond to old and new challenges in the management of tuberculosis, world leaders developed the World Health Organization END TB Strategy 2016-2035. The strategy entails the global fight against TB as a development, social justice and human rights issue, while re-stressing the public health and clinical fundamentals of TB care and prevention. (WHO, 2016).

1.3 Statement of the problem

Tuberculosis (TB), particularly its drug-resistant forms such as rifampicin-resistant TB (RR-TB), continues to pose a critical threat to global public health, disproportionately affecting low- and middle-income countries like Zimbabwe. Despite progress under the global End TB Strategy, the COVID-19 pandemic severely disrupted healthcare systems worldwide, including TB control programs. Studies conducted in various countries have shown a sharp decline in TB case notifications, increased treatment interruptions, and a higher risk of drug resistance during the pandemic due to health system strain, fear of attending healthcare facilities, and lockdown-related barriers to care.

In Zimbabwe, the pandemic had a particularly severe impact. According to Worldometer (2024), the country recorded 266,359 COVID-19 cases and 5,740 deaths. In response, Zimbabwe implemented a strict public health order—Statutory Instrument 83 of 2020—aimed at curbing the spread of COVID-19 through lockdowns and movement restrictions. While these measures were vital for infection control, they inadvertently disrupted essential TB services, particularly for vulnerable populations such as those co-infected with HIV and those with drug-resistant TB.

Although evidence from other countries confirms the adverse effects of COVID-19 regulations on the TB continuum of care, including reduced TB detection, increased loss to follow-up, and missed opportunities for drug resistance testing, there is limited empirical data on how these effects manifested in Zimbabwe, particularly in specific provinces such as Masvingo. The absence of localized evidence hampers effective post-pandemic recovery planning and compromises targeted interventions for high-risk subpopulations.

This research is, therefore, crucial in assessing the trends and contributing factors influencing TB service indicators—such as total TB samples, TB cases among HIV-positive individuals, TB positivity rates, and RR-TB incidence—across three distinct periods: pre-COVID-19 (2018–2019), during COVID-19 (2020–2021), and post-COVID-19 (2022–2023). By focusing on Masvingo Province, the study will provide valuable, context-specific insights into how pandemic-related policies have shaped TB outcomes. These findings are expected to inform evidence-based public health strategies aimed at rebuilding resilient TB control programs and mitigating future disruptions.

1.4 Research aim and objectives

The primary aim of this study was to investigate the trend analysis and contributing factors for the total TB samples, TB samples from HIV-positive cases, TB-positive cases and Rif-resistance TB cases pre-COVID-19 period (2018-2019), during COVID-19 period (2020-2021) and post COVID-19 period (2022-2023) in Masvingo province.

Therefore, the researcher's objectives were as follows;

1) examination of the trend and contributing factors influencing total TB samples by facility and gender-age group for the cases pre-COVID-19 period, during COVID-19 period and post COVID-19 period.
2) examination of the trend and contributing factors for TB samples from HIV-positive cases by facility and gender-age group for the cases pre-COVID-19 period, during COVID-19 period and post COVID-19 period.
3) examination of the trend and contributing factors for TB-positive cases by facility and gender-age group for the cases pre-COVID-19 period, during COVID-19 period and post COVID-19 period.
4) examination of the trend and contributing factors for the Rif-resistance TB cases by facility and gender-age group for the cases during pre-COVID-19 period, during COVID-19 period and post COVID-19 period.

1.5 Research Questions

The research answered the following questions.

1) What are the contributing factors of the trend in the total TB samples in the pre-COVID-19, during and post COVID-19 periods?

2) What are the contributing factors of the trend in the TB samples from HIV-positive cases in the pre-COVID-19, during and post COVID-19 periods?
3) What are the contributing factors of the trend in the TB-positive cases from HIV-positive cases in the pre-COVID-19, during and post COVID-19 periods?
4) What are the contributing factors of the trend in the Rif-resistance TB cases in the pre-COVID-19, during and post COVID-19 periods?

1.6 Assumption/Hypothesis

a. Total TB samples

Null hypothesis (H0): There was no statistically significant difference in the total TB samples during pre-COVID-19 period, during COVID-19 period and post COVID-19 period.

Alternative hypothesis (H1): There was a statistically significant difference in the total TB samples during pre-COVID-19 period, during COVID-19 period and post COVID-19 period.

b. TB samples from HIV-positive cases

Null hypothesis (H0): There was no statistically significant difference in TB samples from HIV-positive cases during pre-COVID-19 period, during COVID-19 period and post COVID-19 period.

Alternative hypothesis (H1): There was a statistically significant difference in TB samples from HIV-positive cases during pre-COVID-19 period, during COVID-19 period and post COVID-19 period.

c. TB-positive cases

Null hypothesis (H0): There was no statistically significant difference in TB-positive cases

during pre-COVID-19 period, during COVID-19 period and post COVID-19 period.

Alternative hypothesis (H1): There was a statistically significant difference in TB-positive cases during pre-COVID-19 period, during COVID-19 period and post COVID-19 period.

d. Rif-resistance TB cases

Null hypothesis (H0): There was no statistically significant difference in Rif-resistance TB cases during pre-COVID-19 period, during COVID-19 period and post COVID-19 period.

Alternative hypothesis (H1): There was a statistically significant difference in Rif-resistance TB cases during pre-COVID-19 period, during COVID-19 period and post COVID-19 period.

1.7 Significance of the Study

1.7.1 Academia

This study will contribute to academic knowledge by filling a contextual gap in understanding the effects of COVID-19 regulations on rifampicin-resistant tuberculosis (RR-TB) in Zimbabwe, particularly in Masvingo Province. It offers empirical data and trend analysis across different pandemic phases, providing a foundation for further scholarly inquiry into infectious disease dynamics during public health emergencies. The findings will support curriculum development in public health, epidemiology, and infectious disease management.

1.7.2 Health Profession

For healthcare practitioners and policymakers, this research offers evidence-based insights into the consequences of health policy decisions during pandemics. By highlighting disruptions in the TB continuum of care, especially among high-risk groups like people living with HIV, it aids in developing more resilient TB programs and informs the integration of TB and emergency response systems.

1.7.3 Future Researchers

The study lays the groundwork for further investigations into the intersection of global pandemics and chronic infectious diseases. It provides a methodological and contextual baseline for future researchers aiming to explore TB control, drug resistance trends, and health system resilience in low-resource settings post-COVID-19.

1.8 Delimitation of the Study

This study was geographically delimited to Masvingo Province in Zimbabwe, which was strategically selected due to its unique epidemiological and socio-economic characteristics that may influence TB transmission and drug resistance patterns. Masvingo shares a border with Beitbridge, a major transit town characterized by high cross-border movement between Zimbabwe and South Africa. Such mobility increases the risk of TB transmission and complicates continuity of care.

Additionally, districts such as Chiredzi and Mwenezi, known for large-scale sugarcane farming report a relatively high TB burden. Agricultural settings, particularly those involving migrant labor and dense worker settlements, are globally recognized as hotspots for TB transmission due to factors like overcrowding, poor living conditions, and limited access to health services.

Moreover, Masvingo District includes several mining areas such as Bere, Summerton, and Bushmead near Nemanwa, where exposure to dust, silica, and poor ventilation further elevate TB risk rates (Gwitira et al., 2021). These contextual factors make Masvingo Province an ideal case study for examining the effects of COVID-19 policies on rifampicin-resistant TB patterns.

1.9 Limitations of the Study

This study faced several limitations. Firstly, the retrospective nature of data collected relied on the accuracy and completeness of health records, which may be compromised due to disruptions during the COVID-19 pandemic. Secondly, the study was geographically confined to Masvingo Province, which may have limited the generalizability of the findings to other regions in Zimbabwe.

1.10 Summary

The chapter introduced the burden of TB and how its management and control was affected by the COVID-19 related disruptions. Highlights were given on the impact of COVID on both a global and local basis which then narrowed to Masvingo, which is the specific area this study is related to. The following chapter will provide literature review, examining the development of TB in the pre-COVID-19, during and post COVID-19 periods.

2 CHAPTER 2: REVIEW OF LITERATURE

2.1 Introduction

This chapter explored a review of the literature that is related to the research topic to establish any knowledge gaps on the impact of Covid 19 on TB drug resistance. The literature was reviewed per the framework given by Nakano and Muniz (2018) attached below (Nakano & Muniz, 2018)

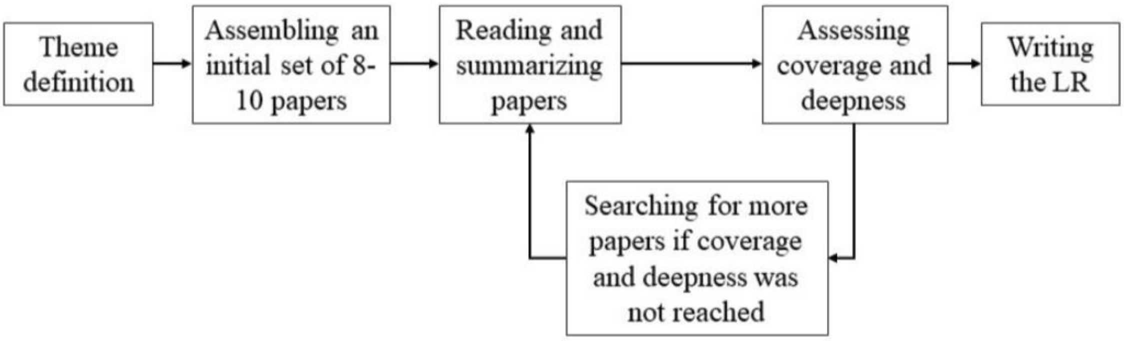

Figure 2: Steps for literature review

Related papers were identified using PubMed and Google Scholar database search.

2.2 Definitions

Tuberculosis (TB) is a preventable, treatable, highly transmissible communicable disease that is caused by a bacteria called Mycobacteria tuberculosis. It mainly affects the lungs and other body parts. Those infected are classified as either having active TB disease, which is characterized by the presence of clinical symptoms, or latent TB, which is an asymptomatic clinical state that is not infectious/transmissible. The clinical signs and symptoms of TB are cough which is greater than one week old, fever, night sweats, and weight loss, greater than 10%. Until COVID-19, TB was the leading cause of death from single infectious agent. It’s an infectious diseases of public health concern and was declared a global public health emergency by the World Health Organisation in 1993

(Takarinda et al., 2015). According to the World Health Organisation meeting held on the TB vaccine, it was reported that approximately 2 billion people are currently infected by Mycobacterium tuberculosis across the globe (Looney et al., 2023). The incidence rate of tuberculosis increased by 3.6% in 2021 compared to 2020. This showed a reversal trend of about 2% decrease per year in the past two decades. The most affected continents are Sub Saharan Africa and Asia. India, Nigeria, Republic of South Africa, Tanzania, Zambia and Zimbabwe collectively accounted for 82% of the global TB cases in 2021. Zimbabwe is ranked the 17^{th} highest TB burden country in the world. According to the WHO 2022 Global TB Report Zimbabwe's TB incidence is 190/100 000 and the death rate is at 7% (Bagcchi, 2023). Zimbabwe was removed from the top 30 high-burdened countries for TB but remains on the list of high-burdened countries for TB/HIV and Multi-Drug Resistant/Rifampicin-Resistant TB (MDR/RR-TB).

Undernourishment, HIV infection, alcohol use disorders, smoking, and diabetes are the most significant risk factors contributing to global incident of TB cases. Someone with a positive symptom screen and or an abnormal chest Xray is a presumptive TB case and must undergo investigations to find out if they have an active TB. This is done through sputum smear microscopy and molecular testing of Mycobacterium tuberculosis in sputum, stool or other body fluids. Molecular testing and drug susceptibility testing detect tuberculosis strains that are resistant to one or more anti-tuberculosis drugs. Drug resistant TB (DR-TB) includes mono-resistance, poly-resistance, multidrug-resistant TB (MDR-TB), pre-extensively drug resistance and extensively drug-resistant TB (XDR-TB), Rifampicin resistant TB (RR-TB), and the untreatable total drug-resistant TB (TDR-TB).

Monoresistance is resistant to one first line anti-TB drug only. The first line medicines are isoniazid, rifampicin, pyrazinamide, and ethambutol. Poly-resistance is resistant to more than one first line anti-TB drug, other than both isoniazid and rifampicin. Multi drug-resistant tuberculosis (MDR-TB) is resistant to at least both isoniazid and rifampicin. Pre-extensively drug-resistant (Pre-XDR-TB) is resistant to a combination of isoniazid and rifampicin, as well as to any of fluoroquinolones. XDR-TB is resistant to a combination of isoniazid, rifampicin, any one of fluoroquinolones and Group A second line drugs. Drug resistant medicines are grouped in Group A, B, and C. Group A include bedaquiline, levofloxacin or moxifloxacin, and linezolid. Group B includes clofazimine, and cycloserine or terizidone. Group C contains delamanid, carbapenems plus, clavulanic acid, amikacin, and prothionamide just to name a few. Rifampicin resistant TB (RR-TB) is resistant to rifampicin, with or without resistance to any other anti-TB drugs. The next section explores the causes of TB drug resistance. The untreatable total drug-resistant TB is resistant to all first line drugs and second line drug

2.3 Causes of TB drug resistance.

Ichsan et al. (2023) grouped causes of drug-resistant TB into:

I. Relapsed cases and matters related to TB treatment. These include treatment failure, non-adherence to treatment, contacts with drug-resistant TB patients, distance to programmatic management of drug -resistant TB sites, and pre-existing resistance.
II. Individual background like social economics status, marital status, ethnicity, education, occupation, and living area and conditions.
III. Habits like smoking, drug addiction and alcoholism.
IV. Comorbidities like diabetes, COPD, liver diseases, HIV and chronic chest diseases.

The picture below summaries all the above listed causes of drug-resistant TB.

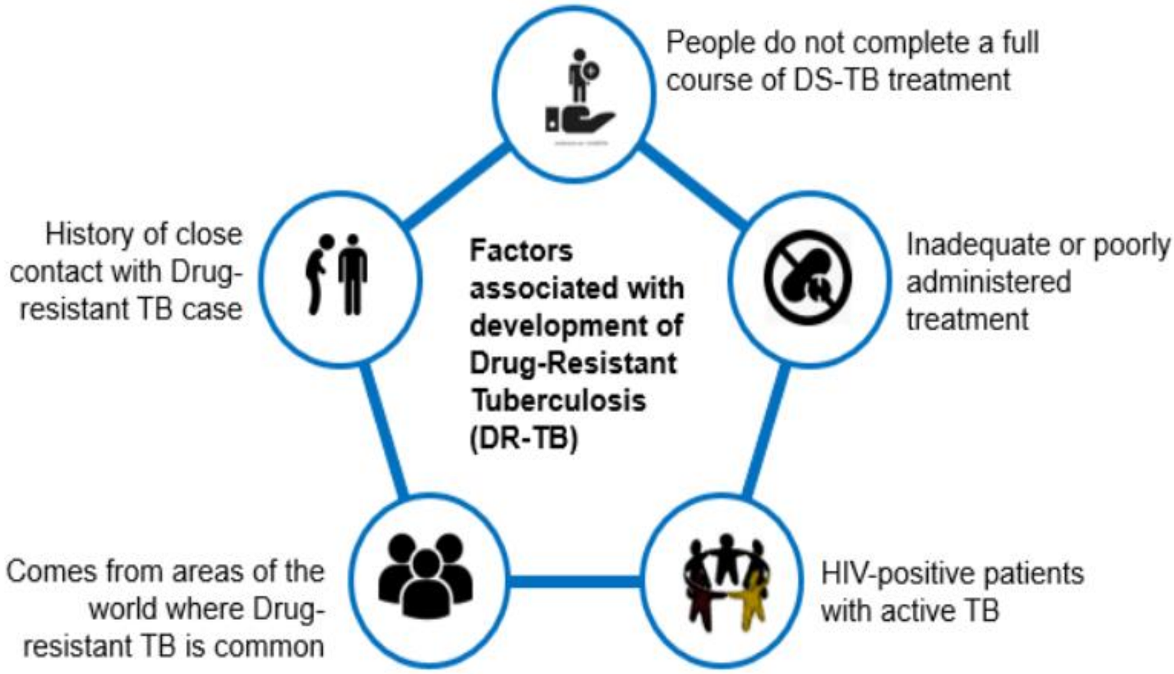

Figure 3: Causes of drug-resistant TB

Risk groups for drug-resistant TB include children and adults with history of TB treatment, people who are exposed to known or presumed drug-resistant TB cases, and people who are exposed in institutions that have high DR-TB prevalence like prisons.

(Ichsan et al., 2023)study showed that prior history of TB treatment is the leading cause of drug-resistant TB. Strains that are resistant to drugs are generated when insufficient therapy is received. When poor therapy persists, mutations will eventually result in drug-resistant TB. Ayazet al., (2012), Hoza et al. (2015), and Shivekar et al. (2020) shared the same sentiments on the leading cause of drug-resistant. Ayaz et al. showed that patients with a treatment failure have twice higher risk for drug resistance TB than those who haven't experienced any treatment failure. Hoza et al. (2015) reported that in Tanzania prevalence of MDR-TB was twice (22.2%) that of new cases (11.4%). This was even higher in Parkistan were the prevalence of MDR-TB in previously treated patients was seven-times higher than in new cases (Shivekar et al., 2020). All these findings expose the challenges in home-based supervision of patient adherence to treatment since this is being done by non-medical cadres.

With regards to TB drug-resistant and HIV positivity, Yoshiyama T. et al., (2001) study in northern Thailand showed that HIV positivity is an important risk factor associated with primary drug-resistance TB (OR 2.2, 95%CI 1.3-3.9). In a study that was done in Europe, Faustini et al., (2006) had similar findings showing that HIV infection favours the transmission of drug-resistant strains of TB (OR 3.52; 95%CI 2.48-5.01). On the other hand, Quy, H. T. et al, (2006) and Ngagosya, R. et al. (2012) findings showed lack of association between TB drug-resistance and HIV positivity and were also supported by Hoza et al. (2015).

Socioeconomic status is one of the determinants of health that is a significant factor influencing the prevalence and transmission of drug-resistant TB in both developed and low to middle income countries. The socioeconomic factors that are associated with drug resistant TB include living conditions (overcrowding, poor ventilation, lack of access to clean water and sanitation), nutrition, healthcare access, poverty, and education. Poor living conditions facilitate the transmission of TB bacteria, they also contribute to poor health and weakened immune systems that predispose individuals to TB. Lack of education affects individuals' health literacy such that the population will not be aware of TB prevention and treatment. This will lead to risky behaviours and non-adherence to treatment. In a study conducted by Chen, J. (2006) in China, he discovered that TB drug resistance is associated with low economic status (OR 5.623, 95% CL 3.462-9.386), incomplete DOTS (OR 8.8875, 95%CI 6.136-15.442), and poor compliance (OR 6.467, 95% CI 3.942-10.622). In a similar study done by Gennaro, F. et al. (2017), low income (unadjusted OR 1.67, 95%CI 1.2-2.41), and alcohol abuse (unadjusted OR 1.88, 95%CI 1.18-3.00) were associated with drug-resistant TB. Furthermore, Rajendran, M. et al (2020) did a systematic review of the contributing risk factors towards the prevalence of drug-resistant TB and found out that men are more at risk of drug-resistant TB than women because they predominantly drink alcohol, smoke and abuse drugs as compared to their counterparts. Also, younger people are vulnerable to drug resistant TB because they are more involved in social activities like drinking alcohol, and smoking cigarette than the elderly.

There is need to address the above listed social determinants of health to create a more equitable and supportive environment for TB patients to reduce the risk of drug-resistant TB and to improve on the treatment outcomes and quality of life.

2.4 The COVID-19 era and its impact on drug-resistant TB.

2.4.1 The COVID-19 era

In Wuhan province, China, they emerged a severe acute respiratory syndrome Coronavurus-2 (SARS CoV-2) which causes COVID-19 disease in December 2019. The virus likely originated in bats and was transmitted to humans through an intermediate animal host. Following the alarming spread and severity of the disease outbreak, WHO declared it a pandemic in March 2020. The public health systems were severely challenged by the emergence of the disease because:

I. Hospitals in outbreak epicentres became overwhelmed, with shortages of ICU beds, ventilators, and healthcare workers.

II. Global coordination in responds to the disease suffered from lack of international leaderships and fractured coordination regarding travel restrictions, resource allocation, and information sharing.

III. There was inconsistent messaging on masks, risks, and vaccines which caused confusion and mistrust among populations.

IV. Insufficient testing capacity delayed detection allowing further spread.

V. Lack of effective contact tracing.

The pandemic produced wide-ranging health, social, and economic consequences. Firstly, under the health sector, over 775 million cases had been recorded globally and of these 1% succumbed to the disease as of 23 June 2024 (WHO, 2024). Loss of loved ones resulted mental health challenges. Secondly, under the social sector, there was widespread job loss, business closures, lockdowns, school shutdowns, travel restrictions, and mask mandate. Lastly, the economy was hardly hit with trillions of dollars lost due to reduced consumer spending, business closures, and manufacturing and supply chain disruptions. The following sections are going to look at the impacts of the COVID-19 era on drug-resistant TB in detail.

2.4.2 Negative impacts of COVID-19 on drug-resistant TB

2.4.2.1 TB funding

2030 Agenda for Sustainable Development has a motto of leaving no one behind through universal health coverage (UHC). This means that there is equity in healthcare services whereby all people no matter who they are or where they live can receive quality health services. During the COVID-19 pandemic, many health systems experienced a health shock, and some European countries were prepared to handle the pandemic whilst the African systems were negatively affected. Low public spending in health systems by the African government has affected health healthcare users and this was worse in the COVID-19 era. During the pandemic, the available budget that was available for supporting TB services were diverted to fight the pandemic. Nearly fifty percent of high

TB burden countries reported to have reallocated their TB funds to COVID-19 care or mitigation. This resulted in the significant reduction of TB funding (Chakaya et al., 2021). The funds were used to procure personal protective equipment (PPE), including gowns, face shields, masks, and gloves. It was also used to set up triage tents, and intensive care units for COVID-19 patients.

The funding dropped because the COVID-19 restrictive measures impacted the global economy resulting in shifts and fluctuations in international trade, finance, and investments. In the United Kingdom, lockdowns caused decrease of exports and imports whilst in some other developing economies like Kenya, there was a drop in imports and an increase in exports. As a result, some other countries delayed implementation of lockdowns while others lift their lockdowns without meeting the key strategic objectives outlined by the World Health Organization fearing possible financial crisis. For example, Zimbabwe lifted lockdown due to decimation of the informal sector which it largely depends on. Onyeaka et al., (2021).

Klinton et al., (2021) found out that COVID-19 lockdowns also disrupted Non-Governmental Organisation (NGO) outreach activities and field work due to the travel restrictions that were made. The organisations had to shift their budgets and tasks to help the ministries of health to fight the pandemic. By so doing this affected their programs post COVID-19 as they had to meet their objectives with limited funds. Ridde et al., (2023) study in West Africa showed that during the COVID-19 era there were challenges in salaries and bonuses for contract workers and volunteers. This demotivated the staff and resulted in strikes which created human resources shortages thereby affecting healthcare delivery.

2.4.2.2 Socioeconomic challenges

Drug-resistance TB risk factors include habits (smoking alcoholism, and drug addiction), individual background (living area, low socioeconomic status, education, occupation, body weight, and marital status), comorbidities (diabetes, HIV, and liver disease), and TB-treatment related outcomes (treatment failure, non-adherence to treatment, contact with TB or drug-resistant TB patient). The global lockdown had an impact on food security resulting in malnutrition which is a predisposing factor to TB and drug-resistant TB. This was common in Sub-Sharan Africa where there was reduction in labour and disruption in flow of food and other goods due to closure of borders. However, this was not a concern in the developed world.

In terms of education, schools were closed to stop the spread of COVID-19. (Onyeaka et al., 2021) reported that 143 countries enforced school closure, and it affected 1,184,126,508 of learners globally. CohenJon & Kupferschmidt Kai, (2020) argues that closure of schools was not necessary since COVID-19 rarely affected children. Some countries like Netherlands sent most students home but schools remained open for children with parents working in the vital sectors. Online education was embraced by many institutions worldwide but developing countries with poor internet connectivity faced challenges in moving to online learning. This means that the education system was disrupted and as such there are greater chances of failure of national exams and risk of poverty. Poverty as highlighted above is also a risk factor of TB and drug-resistant TB.

According to Onyeka et al, (2021) there was a surge in the number of mental health issues during the COVID-19 era. These included anxiety, depression, distress, sleep disorders, and post-traumatic stress disorders. The rise in these cases was a result of fear of infection, sadness, frustration, loneliness, and closure of small to middle enterprises. All these mental health issue exposed people to alcoholism, drug abuse and domestic violence and abuse. The World Health Organization estimated that 35% of women worldwide experienced some sort of abuse during COVID-19 era.

COVID-19 era predisposed people to almost all the risk factors of TB and drug resistance TB. There is need for public health specialists to be innovate and formulate strategies that mitigate the pandemics negative impacts.

2.4.2.3 TB care cascade challenges

COVID-19 era had an impact on all the ten TB health system pillars, which are governance, financing, workforce, health promotion, health literacy, drugs and technology, research, service delivery, equity, and health and development. Some impacts were direct whilst others were indirect, but both causes short term and long-term consequences on the TB program.

2.4.3 Impact of COVID-19 on household transmission of TB and drug-resistant TB

COVID-19 lockdowns prevented the spread of the virus but facilitated household transmission of TB and drug-resistant TB. One of the risk factors that increases the transmission of TB and drug-resistant TB is the prolonged contact at household level (Alene et al., 2020). Cilloni et al., (2020) demonstrated that a 3-month lockdown due to COVID-19 would cause an additional 1.65 million TB cases and 438000 TB deaths. The impact of increased household transmission is likely to be observed in the post Covid era like what happened after the HIV pandemic were there was an increase in the number of new TB and drug-resistant cases.

2.4.4 Impact of COVID-19 on TB/ drug-resistant TB diagnostic services and treatment.

COVID-19 testing was done on existing molecular testing platforms in the healthcare facilities, both conventional machines (Hologic Panther and Biomereux) and on point of care testing platforms like GeneXpert machine. These machines were the ones being used to test for TB and drug resistance. Multiplexing of these machines affected TB diagnosis in the Covid era since focus was on testing COVID-19 samples as they were urgent samples. McQuaid et al., (2021) reported that TB testing and drug-resistant TB testing decreased in China, Nigeria, South Africa, Kenya, Malawi, and Zimbabwe during the pandemic.

There were delays in the diagnosis and treatment of TB and drug-resistant TB cases during the COVID-19 era due to:

I. Stigma and fear of COVID-19 infection at healthcare facilities. This discouraged patients from visiting healthcare facilities for TB services.
II. Lockdown – this required patient to stay at home and healthcare workers were required to quarantine therefore they were not able to offer routine TB services.
III. Poor quality of care and errors since healthcare workers were experiencing anxiety and stress.
IV. Political leadership and the health service focused on the pandemic and neglected the TB programmes. There were shortages of anti-TB drugs, shortages of ventilators, and shortages of hospital beds. The disruption in treatment caused by stockouts increased risk of treatment interruption and decrease adherence to anti-Tbs which can cause drug-resistant TB.
V. Diversion of human and financial resources away from the routine TB services.

All these resulted in misdiagnosis, delays in diagnosis and delays in treatment. WHO (2019) reported that 3 million TB cases were un-detected in 2018, and this is likely to increase with the impact of COVID-19.

2.4.5 Impact of COVID-19 on the prevention and control of TB

COVID-19 pandemic reversed the gains made towards the global strategy of ending TB by 2035. Several conferences for TB research and information sharing, amongst them the annual conferences and workshops were cancelled during the COVID-19 era. For example, the World Tuberculosis Day which is used for public awareness and for TB fund raising was not commemorated during the pandemic. Offer rates of BCG vaccination, which is given to children, and the TB preventive therapy, which is given to high-risk groups was negatively affected by the lockdown.(Alene et al., 2020). COVID-19 impacts on testing and diagnostic services discussed on section 2.2.3.2.3.2 above are the same that affected TB prevention and control programmes.

2.4.6 Positive impacts of COVID-19 on drug-resistant TB

To some extend the pandemic brought about some positives which offer hope for progress in combating ancient diseases like TB. The positives include increased collaboration on global response and knowledge sharing, strengthened health systems, increased focus on respiratory health and improved infection control practices.

To a greater extend, COVID-19 era negatively affected drug-resistant TB. Most of the effects were due to the lockdown implemented to stop the spread of the virus. The picture below summarises the negative impact of the pandemic as discussed above.

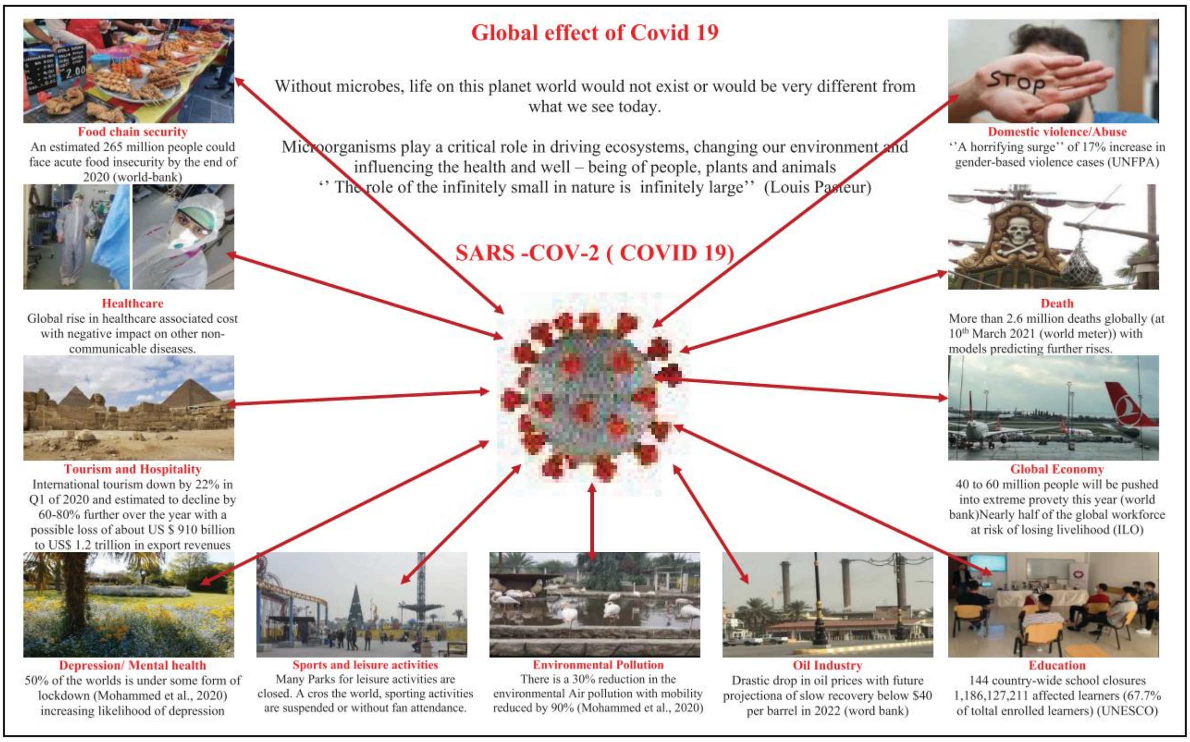

Figure 4: Negative impacts of COVID-19 era

2.5 Identified gaps

From all the publications that were reviewed, none looked at the trends of drug-resistant TB post the COVID-19 era in the Zimbabwe context. To assess the impact of Covid 19 era on TB drug resistance in Zimbabwe, this study is designed to identify if there was an increase or decrease in TB drug resistance cases after the pandemic in Masvingo province.

2.6 Theoretical Framework/Conceptual Framework

2.6.1 Theory of Planned Behavior (TPB)

- Relevance: TPB can examine how attitudes, subjective norms, and perceived behavioural control regarding healthcare access and adherence to TB treatment during the pandemic contributed to changes in antimicrobial resistance.

2.6.2 Disruption and Innovation Theory

- Relevance: This theory focuses on how crises can disrupt existing systems and lead to innovative responses. It could be used to evaluate how healthcare innovations (or lack thereof) during the pandemic affected TB treatment and resistance.

2.6.3 Conceptual framework

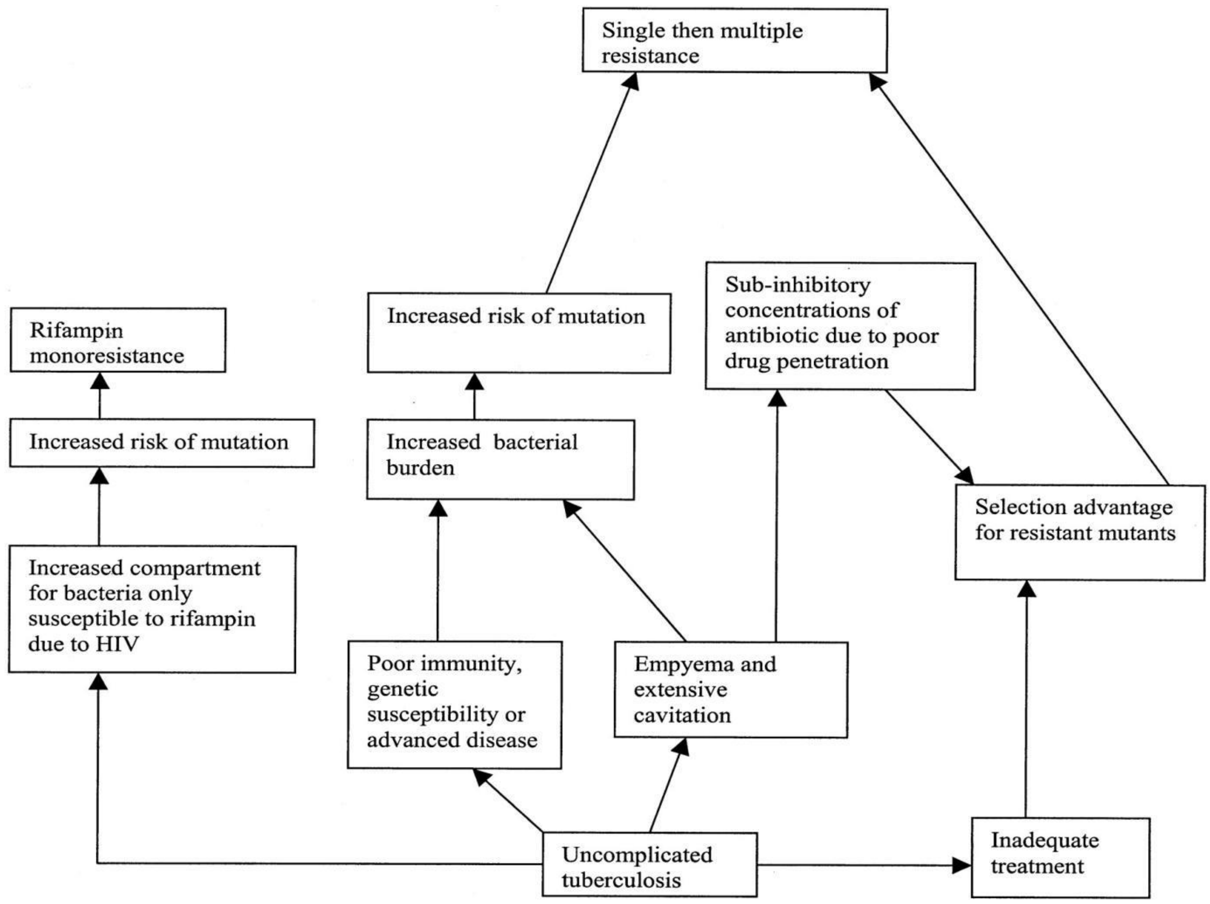

Figure 5: Conceptual Framework

2.7 Relevance of the Theoretical Framework of the study

Gillespie, (2002) showed evolution of drug-resistant TB in the framework above. The framework is relevant to the study since it shows all the risk factors of drug-resistant TB and how it emerges.

2.8 Empirical Literature Review

The outbreak of the COVID-19 pandemic significantly disrupted healthcare services globally, with particularly severe effects observed in low- to middle-income countries, where health systems were already under strain (McQuaid et al., 2020). This disruption triggered a reversal in TB trends and significantly impacted the volume of TB samples collected, the number of TB-positive cases recorded globally, and health outcomes among people living with HIV and those with Rifampicin-resistant TB. This review explores these trends across the pre-pandemic, pandemic, and post-pandemic periods, highlighting both the observed patterns and contributing factors.

2.8.1 Trend analysis and factors influencing total TB samples and TB-positive cases

Pre-COVID-19 Period

Prior to the onset of the COVID-19 pandemic, global efforts to control TB were yielding gradual improvements. In 2018, the number of people diagnosed and treated for TB reached 7 million, up from 6.4 million in 2017, indicating growing access to healthcare services (WHO, 2019). Correspondingly, TB-related deaths declined from 1.6 million in 2017 to 1.5 million in 2018, suggesting enhanced healthcare delivery and early case detection.

Despite these gains, there remained an estimated gap of 3 million undiagnosed or untreated cases, highlighting weaknesses in surveillance systems, particularly in high-burden and underserved populations (WHO, 2019). Furthermore, in 2019, TB was still among the top 10 causes of death globally, with 10 million cases recorded, disproportionately affecting men (56%), followed by women (32%) and children (12%) (WHO, 2020). These demographic disparities suggest differences in exposure, access to care, and health-seeking behaviour across population groups, with adult males particularly underutilizing TB services (Ortblad et al., 2021).

The steady reduction in TB incidence before COVID-19 was also supported by increased domestic and donor funding, although in 2020, only US$ 6.5 billion of the US$ 13 billion needed was mobilized, pointing to a persistent financing gap that limited the scale of interventions (WHO, 2020). Most of the available funding came from domestic sources in BRICS countries, while low-income, high-burden countries remained heavily dependent on international donors.

During the COVID-19 Pandemic

The COVID-19 pandemic created a major setback for TB control efforts worldwide. In 2021, for the first time in many years, the number of individuals falling ill with TB increased, reaching 10.6 million, a 4.5% rise from 2020 (WHO, 2022). This resurgence was driven primarily by disruptions to TB services, including reduced access to clinics, diagnostic delays, and reprioritization of resources toward COVID-19 (Stephenson, 2022).

This regression is widely attributed to interrupted diagnosis and treatment services, which led to nearly half of all estimated TB cases going undetected or untreated (Stephenson, 2022). Furthermore, the pandemic caused funding reductions and drops in BCG vaccination coverage among children, potentially increasing future vulnerability (Migliori et al., 2021). The co-infection of TB and COVID-19 also posed clinical challenges, with studies indicating that TB patients were more likely to experience severe COVID-19 outcomes (Visca et al., 2021).

However, WHO (2022) noted that the treatment success rate remained stable at 86% in 2020, comparable to 2019, suggesting that quality of care was maintained for those who managed to access treatment. This finding underscores the resilience of health systems in some contexts despite the extraordinary strain.

Post-COVID-19 Period

In the post-pandemic period, particularly from 2022 to 2023, a gradual stabilization in TB trends was observed. In 2023, an estimated 10.8 million people fell ill with TB, a modest increase from 10.7 million in 2022 and 10.4 million in 2021 (WHO, 2024). However, most of this rise was attributable to population growth rather than increased transmission, suggesting that TB incidence is beginning to stabilize. More also, TB-related deaths declined in 2023 to 1.25 million, down from 1.32 million in 2022, and below the pre-pandemic estimate of 1.34 million in 2019 (WHO, 2024). These improvements are partly due to the reinstatement of diagnostic and treatment services, and a global shift toward restoring essential health programs (Gunsaru, Henrion and McQuaid, 2024). However, WHO (2024) noted that 87% of global TB cases were concentrated in just 30 high-burden countries, with India, Indonesia, China, the Philippines, and Pakistan accounting for more than half of all cases, highlighting persistent geographic disparities in TB burden.

Although the global incidence rate in 2023 was only slightly higher than the previous year (134 cases per 100,000 population), the pace of recovery remains slow. Contributing factors include underinvestment, lingering COVID-related economic shocks, and delays in scaling up community-based TB testing.

2.8.2 Examination of the trend and contributing factors for TB samples from HIV-positive cases.

Pre-COVID-19 Period

Prior to the pandemic, TB remained a leading cause of death among PLHIV. In 2019, **approximately 8.2% of global TB cases (equivalent to 820 thousand individuals)** occurred in people living with HIV, resulting in an estimated **208,000 deaths** (WHO, 2020). Despite the heavy disease burden, these figures marked a significant decline compared to earlier years, like **2000**, when **2.4 million** deaths were reported among co-infected individuals. This decline was largely attributed to **increased access to antiretroviral therapy (ART)**, **scale-up of TB screening**, and **integrated TB-HIV service delivery models** (Hermans et al., 2017).

During this period, the **collection of TB samples from HIV-positive individuals** was prioritized in high-burden regions due to the elevated risk of disease progression and transmission. Many countries introduced national TB programs which allowed routine screening for TB in PLHIV as part of their standard of care (Gupta et al., 2016). The widespread availability of **GeneXpert MTB/RIF testing** further contributed to early diagnosis and better case management outcomes.

During COVID-19 Pandemic

The emergence of COVID-19 in early 2020 created widespread disruptions in TB diagnostic services. Lockdowns, healthcare worker redeployment, and reduced patient mobility contributed to a decline in TB screening and testing. According to the **Stop TB Partnership (2021)**, over **1 million fewer TB cases** were detected globally in 2020 alone, with **HIV-positive individuals disproportionately affected** due to their dependence on routine screening and integrated care services.

Several studies indicated that the **number of TB samples collected from PLHIV decreased significantly** during the pandemic due to the closure or limited operation of diagnostic facilities and reduced access to outpatient services (Komiya et al., 2021). Moreover, the similarity in respiratory symptoms between TB and COVID-19 often led to **misdiagnosis or delayed TB testing**, particularly in resource-limited settings (McQuaid *et al.*, 2020). As healthcare systems prioritized COVID-19 containment, **routine HIV care and TB screening were deprioritized**, resulting in diagnostic backlogs and underreporting of TB among PLHIV.

Post-COVID-19 Period

In the aftermath of the pandemic, efforts have been made to restore essential health services, including TB diagnostics. However, **TB sample collection among HIV-positive individuals has not fully returned to pre-pandemic levels** in many countries. In 2023, TB was estimated to have caused **1.25 million deaths globally**, including **161,000 deaths among PLHIV**, indicating a persistent vulnerability of this group (WHO, 2024).

While some improvements have been noted, several systemic challenges remain. Continued strain on diagnostic infrastructure, healthcare worker shortages, and economic instability have limited the speed of recovery in TB testing capacity. Nevertheless, there is growing advocacy for **leveraging COVID-19 diagnostic innovations** (e.g., molecular testing, community screening models) to strengthen TB surveillance and improve sample collection from at-risk groups such as PLHIV (Datta et al., 2022).

Moreover, emerging studies suggest that **lessons learned from COVID-19, particularly regarding decentralized testing and digital health tools can be adapted to enhance TB screening**, especially for HIV-positive populations (Hogan et al., 2020). For example, **mobile clinics and community-based sample collection initiatives** have shown promise in reaching underserved areas and improving access to diagnostic services post-pandemic (Cilliers et al., 2022).

2.8.3 Examination of the trend and contributing factors for the Rif-resistance TB cases

Pre-COVID-19 Period

Before the onset of the COVID-19 pandemic, the global burden of drug-resistant TB was steadily increasing. In 2019, an estimated 465,000 people developed MDR/RR-TB, with 206,030 cases detected and notified globally, marking a 10% increase from 186,883 cases in 2018 (WHO, 2020). Despite the improved detection rates, the treatment success rate for RR-TB remained low at 57%, indicating persistent challenges in effective disease management.

The upward trend in case detection during this period was largely attributed to the expanded use of molecular diagnostic tools, increased investment in TB programs, and global efforts under the End TB Strategy (Dheda et al., 2017). The World Health Organization (2020) also highlighted the role of active case finding, surveillance, and integrated TB-HIV services in improving RR-TB detection rates.

During the COVID-19 Pandemic

The emergence of COVID-19 in early 2020 significantly disrupted global TB control efforts, especially in the diagnosis and treatment of drug-resistant TB. Several countries reported a drastic decline in TB testing and notifications, largely due to lockdown measures, healthcare worker redeployment, and a shift in diagnostic infrastructure toward COVID-19 testing (McQuaid et al., 2020).

A key finding during this period was the reduction in the number of people diagnosed and treated for RR-TB, indicating major gaps in the detection of drug-resistant strains. Stephenson (2022) noted a sharp drop in treatment initiation for both drug-resistant TB and latent TB infection (LTBI). This decline was fuelled by limited access to healthcare services and delayed TB diagnosis, which often led to undetected transmission of RR-TB within communities.

Moreover, the overlapping symptoms of COVID-19 and TB, such as cough and fever, complicated clinical diagnosis and may have contributed to misdiagnosis or delayed detection of RR-TB (McQuaid *et al.*, 2020). The Global Fund (2021) reported that RR-TB patients were among the hardest to reach during the pandemic, particularly in regions with already fragile health systems.

Post-COVID-19 Period

In the post-pandemic recovery period, TB programs began regaining some ground. However, data suggests that RR-TB detection and treatment levels have not yet returned to pre-pandemic levels. In 2023, approximately 175,923 people were diagnosed and treated for MDR/RR-TB, representing 44% of the estimated 400,000 people (95% uncertainty interval: 360,000–440,000) who developed the condition globally (WHO, 2024). This gap indicates that more than half of the RR-TB burden remains undiagnosed or untreated.

This shortfall is attributed to underdiagnosis, continued healthcare access limitations, and delayed restoration of diagnostic services in many low- and middle-income countries.

The pandemic also exposed the fragility of TB surveillance systems, highlighting the need for more resilient and decentralized approaches to RR-TB detection (Naidoo et al., 2021).

However, the pandemic also led to innovations that could benefit RR-TB management. For instance, molecular diagnostic platforms developed for COVID-19 have potential to be repurposed for TB testing, enabling faster detection and broader reach (Datta et al., 2022). Additionally, telemedicine, digital health interventions, and community-based sample collection models are emerging as strategies to close the detection gap in the post-COVID era (Zimmer et al., 2022).

2.8.4 Impact of COVID-19 on TB Diagnosis and Management

The diagnosis and management of tuberculosis (TB) have long been shaped by a range of social, structural, and health system challenges. These pre-existing issues were significantly exacerbated during the COVID-19 pandemic, which introduced new barriers to TB care delivery. As governments-imposed lockdowns tried to contain the spread of SARS-CoV-2, access to healthcare facilities was restricted, delaying medical consultations and limiting movement (Kant and Tyagi, 2021). Symptom overlap between COVID-19 and TB such as cough, fever, and fatigue led many individuals to misattribute symptoms to COVID-19, prompting self-isolation rather than timely health-seeking behaviour (Meo et al., 2020). In many countries, TB diagnostic infrastructure was diverted to support COVID-19 testing, resulting in sample backlogs and further delays, especially in diagnosing drug-resistant TB (Gunsaru, Henrion and McQuaid, 2024). The suspension of non-emergency services and restricted access to private healthcare compounded these issues, particularly in resource-limited settings already burdened by weak health systems (Franke et al., 2022). Together, these factors contributed to a global decline in TB detection and treatment during the pandemic.

Structural and Social Determinants of TB Care Access

Beyond pandemic-specific barriers, structural challenges such as poverty, poor transportation networks, and healthcare worker shortages have long impeded TB control efforts. During the pandemic, these challenges were intensified by economic instability, especially among individuals from lower socioeconomic backgrounds. Fear of stigma and isolation, both from TB and COVID-19, deterred many from seeking timely diagnosis and treatment (Marco, Ahmedov and Castro, 2024). In households already struggling with basic needs, the perceived risk of being quarantined or isolated added to the fear and reluctance to engage with formal health services (Franke et al., 2022).

Franke et al. (2022) also noted that stigma, indirect costs, and food insecurity served as significant barriers to both accessing and adhering to TB care. In some communities, traditional healing practices were more accessible than biomedical interventions, contributing to delays in seeking appropriate diagnosis and treatment. Despite these barriers, health worker motivation was cited as a vital enabler of TB service delivery, with committed staff often playing key roles in sustaining care under difficult circumstances.

Delayed Diagnosis and Household Transmission

Home confinement during the pandemic increased the risk of TB transmission among household contacts due to prolonged close contact in poorly ventilated spaces. This domestic spread became a serious concern, especially in high-burden settings (Marco, Ahmedov and Castro, 2024). At the same time, diagnostic services were often overwhelmed or under-resourced, contributing to the underreporting of cases and a general decline in notification rates, as highlighted in the 2020 Global TB Report (WHO, 2020).

Post-Pandemic Recovery and Persistent Barriers

In the post-COVID-19 context, efforts to restore TB diagnostic services have been challenged by ongoing socioeconomic and health system barriers. One of the most persistent obstacles is the catastrophic cost burden faced by TB patients and their households. According to the World Health Organization (2024), approximately 50% of individuals undergoing TB diagnosis and treatment incur costs that exceed 20% of their annual household income. These costs include direct medical expenses, transportation, lost income, and other non-medical expenditures. This figure significantly surpasses the WHO's End TB Strategy target of zero catastrophic costs and reflects the need for enhanced social protection mechanisms and broader progress toward Universal Health Coverage (UHC).

Additionally, insufficient awareness about TB, inadequate funding for national TB programs, and a lack of integration between TB and primary healthcare systems remain key challenges (Lönnroth et al., 2017). Recovery strategies must therefore include health system strengthening, improved public awareness, and policy reforms to ensure equitable access to diagnosis and treatment, especially in vulnerable populations.

2.9 Summary

This chapter reviewed the trends and contributing factors affecting TB diagnosis, treatment, and management before, during, and after the COVID-19 pandemic, focusing on the number of TB samples collected, people living with HIV, TB-positive cases, and Rifampicin-resistant TB cases. It highlighted how healthcare disruptions, stigma, economic hardship, and limited diagnostic access led to reduced TB sample collection and delayed treatment during the pandemic. Structural barriers such as poverty, healthcare worker shortages, and high patient costs were identified as persistent challenges. The review also emphasized the importance of post-pandemic recovery strategies, including strengthened health systems, social protection, and innovative community-based TB care approaches.

3 CHAPTER 3: METHODOLOGY

3.1 Introduction

The chapter looks at the study setting, study population, study period, sample size and the sampling techniques that will be used in the research. In addition, the data collection tools that will be used and methods of data analysis that will be used are also described under this section.

3.2 The Research Design

Research studies are categorized as qualitative or quantitative based on the nature of data being gathered. In this research, a mixed research design was employed, involving the retrospective collection of quantitative data from eleven TB diagnostic sites in Masvingo Province using the GeneXpert machine from January 2018 to December 2023, as well as the collection of qualitative data from provincial and district TB Coordinators. The quantitative data include the total TB samples, TB samples from HIV-positive cases, TB-positive cases, and Rif-resistant TB cases during the pre-COVID-19 period (2018-2019), the COVID-19 period (2020-2021), and the post-COVID-19 period (2022-2023) in Masvingo province. The qualitative data was based on the interview guide on the appendices.

3.3 Population and Sampling

The researcher used non-probability convenience sampling. The study targeted eleven TB diagnostic centres/laboratories in Masvingo province. These include Masvingo Provincial Hospital, Morgenster Mission Hospital, Chivi District Hospital, Matibi Mission Hospital, Neshuro District Hospital, Chikombedzi Mission Hospital, Chiredzi General Hospital, Musiso Mission Hospital, Ndanga District Hospital, Gutu Mission Hospital, and Silveira mission hospital. These were selected because they have the GeneXpert machine that tests for TB drug resistance. Out of the eleven targeted sites, ten sites were selected for the study because they managed to submit the required quantitative data. Chiredzi did not submit the data hence it was excluded from the study.

3.4 Data Collection Instruments

The necessary tuberculosis (TB) data was collected from ten laboratories, extracted from laboratory records and reports generated by the GeneXpert machines. Unfortunately, data verification, which was intended to be conducted through data triangulation of the laboratory register, Laboratory Information Management System, and GeneXpert reports to prevent underreporting and overreporting, could not be carried out due to the absence of patient age information in the GeneXpert reports. To address this, a standard reporting tool was developed and distributed to all data assistants in the districts. Additionally, data assistants received training on proper documentation procedures prior to the commencement of the data collection exercise.

3.5 Pilot Study

Pre-testing of data collection tools was conducted at Morgenster Mission Hospital and Masvingo Provincial Hospital laboratories and identified challenges were addressed before the data collection exercise started.

3.6 Data Collection Procedure

Authority was obtained from the Ministry of Health and Child Care (MoHCC) to utilize tuberculosis (TB) data from the diagnostic centers listed above for research purposes. Quantitative data was gathered using a standardized data collection tool, which is included in the appendices. Additionally, qualitative data was collected through interviews with TB coordinators, guided by an interview framework also found in the appendices. Data collection assistants from district, mission, and provincial hospital laboratories were recruited for the study. These assistants received training prior to the data collection process, which lasted for three weeks.

3.7 Data Analysis and Organisation of Data

The researcher adopted a mixed-methods approach that includes both quantitative and qualitative results to investigate the trend analysis and contributing factors for total TB samples, TB samples from HIV-positive cases, TB-positive cases, and Rif-resistant TB cases during the pre-COVID-19 period (2018-2019), the COVID-19 period (2020-2021), and the post-COVID-19 period (2022-2023) in Masvingo province. The quantitative results were based on secondary data collected from 2018 to 2023 for 10 facilities. Data capturing and cleaning, which involved correcting errors, removing duplicates, addressing missing data fields, and correcting inconsistent and out-of-range data, were performed in Microsoft Excel. The quantitative analysis was conducted in SPSS version 20, categorized into two classes: descriptive statistics and inferential statistics. The former included frequencies and percentages, while the latter comprised two-sample proportional tests and a multiple Poisson regression model. Frequencies and percentages were presented for the total TB samples, TB samples from HIV-positive cases, TB-positive cases, and Rif-resistant TB cases by age group, sex, facility, year, and period. The proportional tests assessed the significant differences in the trend analysis of total TB samples, TB samples from HIV-positive cases, TB-positive cases,

and Rif-resistant TB cases: comparing pre-COVID-19 and during COVID-19, pre-COVID-19 and post-COVID-19, and during COVID-19 and post-COVID-19. The multiple Poisson regression model was employed to determine the factors contributing to the number of total TB samples, TB samples from HIV-positive cases, TB-positive cases, and Rif-resistant TB cases. The results obtained from the quantitative analysis were insufficient to fully justify the trends, prompting the researcher to conduct interviews based on the quantitative results to seek clarity regarding certain findings. The interviews were conducted in the seven districts of Masvingo, represented by the TB coordinators and one provincial TB coordinator. Table 3.1 below presents the demographic characteristics of the participants in the interviews.

Figure 6: Demographic characteristics of the participants of the interviews

The information obtained the interviews was integrated with results deduced from quantitative analysis so as to supplement the trends analysis and contributing factors of the total TB samples, TB samples from HIV-positive cases, TB-positive cases and Rif-resistance TB cases: pre-COVID-19 and during COVID-19, pre-COVID-19 and post COVID-19 and during COVID-19 and post COVID-19.

3.8 Ethical Considerations

The research proposal was submitted to Africa University ethics committee known as the Africa University Research Ethics Committee (AUREC) for approval and ethical clearance. After AUREC approval, permission to conduct the study and to use TB diagnostic data from laboratories in Masvingo province was obtained from the Ministry of Health and Childcare through the PMDs (provincial medical director) office. The researcher signed the oath of confidentiality form at all the laboratories visited, and these were be filled in the laboratories. Upon receipt of data the researcher re-identified the data and kept it in a password protected laptop.

Participant code	Facility	Gender	Years in service	Position	Qualification
PTBC	Masvingo Provincial Medical Directors' office	Male	12	Provincial TB and Leprosy Coordinator	Environmental Health Technician and Data Analyst
DTBC 1	Gutu Distict Health Office	Male	14	District TB and Leprosy Coordinator	Environmental Health Technician
DTBC 2	Zaka District Health Office	Male	18	District TB and Leprosy Coordinator	Environmental Health Technician
DTBC 3	Mwenezi District Health Office	Male	16	District TB and Leprosy Coordinator	Environmental Health Technician
DTBC 4	Chivi District Health Office	Female	8	District TB and Leprosy Coordinator	Environmental Health Technician
DTBC 5	Chiredzi District Health Office	Male	19	District TB and Leprosy Coordinator	Environmental Health Technician
DTBC 6	Masvingo District Health Office	Male	17	District TB and Leprosy Coordinator	Environmental Health Technician

DTBC 7	Bikita District Health Office	Male	10	District TB and Leprosy Coordinator	Environmental Health Technician

3.9 Summary

The chapter reviewed the methodology of the research study, which involved administering data collection tools to eleven TB diagnostic centres in Masvingo province, along with interviews with seven district TB coordinators and the provincial TB coordinator. The processes undertaken are detailed under the headings of study design, study setting, population under study, data collection tools, data analysis, and the ethical considerations that were implemented before, during, and after the study.

4 CHAPTER 4: DATA ANALYSIS AND PRESENTATION

4.1 Introduction

The chapter presents the results extracted from quantitative and qualitative analysis for investigating the trend analysis and contributing factors for the total TB samples, TB samples from HIV-positive cases, TB-positive cases and Rif-resistance TB cases pre-COVID-19 period (2018-2019), during COVID-19 period (2020-2021) and post COVID-19 period (2022-2023).

4.2 Descriptive statistics of total TB samples, TB samples from HIV-positive cases, TB-positive cases, and Rif-resistance TB cases by facility

Table 1 presents the descriptive statistics of the total number of TB samples, TB samples from HIV-positive cases, TB-positive cases, and Rif-resistance TB cases by facility for Masvingo province from 2018 to 2023. The majority of the TB samples collected, TB samples from HIV-positive cases, TB-positive cases, and Rif-resistance TB cases were collected from Masvingo, which accounted for 23.25% (n=9,988 of 42,957), and Neshuro, which accounted for 21.09% (n=9,058 of 42,957).

Facility	Total TB samples		HIV Positives		TB Positives		Rif-resistance TB	
	f	%	f	%	f	%	f	%
Chikombedzi	1330	3.10	1051	4.70	184	5.36	5	4.90
Chivi	6761	15.74	2336	10.45	466	13.56	10	9.80
Gutu	5554	12.93	1787	8.00	313	9.11	6	5.88
Masvingo	9988	23.25	3644	16.31	837	24.36	37	36.27
Morgenster	1840	4.28	1470	6.58	269	7.83	3	2.94
Musiso	2603	6.06	2266	10.14	254	7.39	9	8.82
Neshuro	9058	21.09	7816	34.98	515	14.99	19	18.63
Ndanga	760	1.77	255	1.14	33	0.96	1	0.98
Rutenga	907	2.11	431	1.93	66	1.92	4	3.92
Silveira	4156	9.67	1289	5.77	499	14.52	8	7.84
Total	42957	100.00	22345	100.00	3436	100.00	102	100.00

Table 1: Distribution of the total TB samples, TB samples from HIV-positive cases, TB-positive cases, and Rif-resistance TB cases by facility

Despite Masvingo recording more TB samples collected during this period, Neshuro reported a higher percentage of TB samples from HIV-positive cases, with 34.98% (n=7,816 of 22,345) compared to Masvingo's 16.31% (n=3,644 of 22,345). In contrast, TB-positive cases were higher in Masvingo, accounting for 24.36% (n=837 of 3,436), while Neshuro had 14.99% (n=515 of 3,436). A similar trend was observed with Rif-resistance TB, where Masvingo had the highest cases of Rif-resistance TB at 37.27% (n=37 of 102), compared to Neshuro's 18.63% (19 of 102). The facilities with the least total number of TB samples collected from 2018 to 2023 were Ndanga with 1.77% (n 760 of 42 957) and Rutenga with 2.11% (n =907 of 42 957). Similarly, the researcher noticed the same trend in the TB samples from HIV-positive cases, TB-positive cases, and Rif-resistance TB.

From table 1, while Neshuro had highest TB samples from HIV-positive cases, Masvingo recorded the highest number of TB samples, TB-positive cases and Rif-resistance TB cases which was confirmed by the qualitative results through the District TB Coordinator DTBC 6 from Masvingo District Health Office who highlighted, "*Masvingo is an urban area with a higher population size and industrial activities and a higher TB testing capacity than the other districts. At some point, Masvingo provincial hospital was processing samples for both Chiredzi district and Masvingo district. The samples from Chiredzi were coming from Collin Saunders and Hippo Valley private hospitals who do not have GeneXpert machines to process TB samples*". In the same way, the high number of Rif-resistance TB cases was explained by PTBC who stated, "*The district size, population size and economic activity are high in Masvingo, Mwenezi, and Chiredzi. So, a fusion of the three; land size, population size, and economic activities exposes the population to TB risk factors causing high TB and Rif-resistance cases. Additionally, Masvingo district has a higher crime rate compared to other districts so those who are sent to prison are also exposed to TB".* Similarly, DTBC 5 resonated with the high number of TB-positive cases in Masvingo by sharing his perception that, "*Mwenezi, Chiredzi,* *and Masvingo are TB hotspots due to border with SA, high industrial activities like mining, mobile residents, and a higher population density. All these factors predispose the community to TB*".

Neshuro high numbers of TB samples from HIV-positive cases was explained by DTBC 3 as "*In terms of HIV, Mwenezi being a boarder district has a higher number of diaspora clients, compared to Masvingo. The clients default HIV treatment and are difficult to manage. These clients are in South Africa where TB is more prevalent and therefore a high number of HIV/TB co-infection".*

Also, from table 1 the quantitative results show that Ndanga had low samples submitted compared to other districts. The qualitative results confirmed this through DTBC 2 who iterated, "*The reason might be Ndanga sometimes have challenges with gene expert cartridges. GeneXpert machine is the one used to analyze TB samples. So, in general we frequently face shortages of commodities for testing clients*".

4.3 Distribution of total TB samples, TB samples from HIV positive cases, TB-positive cases and Rif-resistance TB by gender and age group

Table 2 reports the descriptive statistics of the total number of TB samples collected, TB samples from HIV-positive cases, TB-positive cases, and Rif-resistance TB cases by gender and age group for Masvingo province from 2018 to 2023. The results indicate that females aged over 5 years submitted the highest number of TB samples for testing, accounting for 53.74% (n=23,086 of 42,957), while their male counterparts accounted for 45.56% (n=19,572 of 42,957).

Gender	Age Group (years)	Total TB samples		HIV Positives		TB Positives		Rif-resistance TB	
		F	%	f	%	f	%	f	%
Females	(0-5)	147	0.34	41	0.18	1	0.03	0	0.00
Females	>5	23086	53.74	12597	56.38	1211	35.24	41	40.20
Males	(0-5)	152	0.35	59	0.26	5	0.15	0	0.00
Males	>5	19572	45.56	9648	43.18	2219	64.58	61	59.80
Total		42957	100.00	22345	100.00	3436	100.00	102	100.00

Table 2: Distribution of total TB samples, TB samples from HIV positive cases, TB positive cases and Rif-resistance TB cases by gender and age group

A similar pattern was observed among TB samples from HIV-positive cases, where females aged over 5 years represented 56.38% (n=12,597 of 22,345), compared to males in the same age group, who accounted for 43.18% (n=9,648 of 22,345). Despite females aged over 5 years having more numbers of TB samples and higher numbers of TB samples from HIV-positive cases, males had a higher incidence of TB-positive cases, comprising 64.58% (n=2,219 of 3,436). A similar trend was noted in Rif-resistance TB cases, where males accounted for 64.54% (n=61 out of 102), while females constituted 35.24% (n=41 of 102) in the same age group. These results suggest that females may be more susceptible to HIV-positive cases, whereas males appear to be more susceptible to TB-positive cases.

The quantitative results in table 2 shows that generally children had few samples collected compared to adults during the same period. The results obtained from the qualitative analysis explained this difference through PTBC who articulated, *"This is due to poor diagnosis and knowledge gap for staff. In terms of specimen collections, old nurses are the ones who know about gastric lavage sample collection. The new nurses would say that when we were trained, they were not taught about these things, so they don't even have the know-how to perform a gastric specimen collection on children. As a result, children's samples are not being taken for TB screening. The adoption of stool sample processing for TB diagnosis during and post COVID-19 will be a game changer….." In the same way, DTBC 5 supported the same notion, "Sometime ago we used to think that TB in children is not a problem, so we targeted mostly adults. Then on the issue of diagnosis of TB in children, we used to rely on GeneXpert sputum testing of which children cannot produce sputum. Then, gastric lavage was the only sample used to detect TB in children. With the introduction of TB LAM and stool for GeneXpert for TB diagnosis in children, we are now accelerating childhood TB..." DTBC 4 also shared his perception regarding low screening rate in children by commenting, "I think paediatric screening was very low. I think the other reason is that in the previous years only gastric lavage sample was the only one used in TB diagnosis in children. Most people couldn't collect those gastric washes, unlike these days where there are many methods of screening, the likes of stool for GeneXpert".*

Consequently, the higher TB-positive samples that were observed from male adults compared to female adults was explained through qualitative analysis results where DTBC 4 stated, *"It might be because males are the ones who mostly work in areas like mines and some of them will be employed in construction companies where they will be* *exposed to dust. Again, most males do smoke, taking alcohol, I think that could be another reason..."* Furthermore, DTBC 4 justified why more TB samples from HIV-positive are coming from women saying "*Most of our positives are coming from mining areas, especially the Ngundu areas down up to Gororo and Nyahombe. Again, even the proximity to the boarder as well contributes to more cases. There are some of the migrants who will be coming from South Africa, which is one of the high burdened countries in terms of TB. Females are tested for HIV more than males. In the HIV program the male population is becoming a special population were strategies and innovations are being implemented to try and screen them for HIV. Examples of these programs are the Mbereko Men Plus program and the midnight outreaches that are focusing on men. So, in other words the findings are just showing gaps in HIV testing in men*".

Likewise, females greater than 5 years old had higher TB samples from HIV positive cases (see table 2). The results from the qualitative analysis of the respondents correspond with the quantitative results. PTBC had this to say, "*During the lockdown, sexual activities were high, yet people couldn't visit clinics to get preventive measures like condoms, attributing to a peak in HIV-positive patients. Most of the idle time people would use it for sexual activities. The other issue is Gender Based Violence, yes, they were not heralded but they were very high during that period in the sense that people were home fulltime which may have led to more of sexual infringement which probably was the room for a rise in new HIV cases*".

Table 2 also shows higher TB positivity and Rif-resistance cases in males than females. To buttress the findings, PTBC said "*Generally, besides the TB drug resistance being dominant in males, even the drug sensitive TB is also dominant in males when you look on your demographic data for any given period. We the males after taking alcohol we do* *not eat nutritious food. So, issues to do with low blood sugar levels or unbalanced diet due to feeding habits promote TB, and DR-TB. Another end is that usually males play most of the transmission in the sense that the sources of transmission especially HIV is more predominant in males. The other issue is our health behaviour, we were taught to be brave as men. We do not usually go to the hospital for small issues. So, by the time we go to the clinic, the condition will be extreme. If you look at the cases like DR-TB cases, most of them are linked to clients who run away from South Africa through Limpopo, and come to Mwenezi, Chiredzi and then get picked. So, because of our social stricture, males usually go out to look for work and when we get there, we look for other wives yet the housing conditions there are not good. All these are predisposing factors to TB and DR-TB*''.

4.4 Distribution of total number of TB samples, TB samples from HIV positive cases, TB-positive cases and Rif-resistance TB by year

Table 3 presents the descriptive statistics of the total number of TB samples, TB samples from HIV-positive cases, TB-positive cases, and Rif-resistance TB cases by year for Masvingo province from 2018 to 2023. In 2018, the highest number of TB samples was recorded, accounting for 22.86% (n=9,819 out of 42,957). However, the highest percentage of TB samples from HIV positive cases was reported in 2021, with 22.03% (n=4,922 out of 22,345), despite having submitted fewer TB samples than in 2018.

Year	Total TB samples		HIV Positives		TB Positives		Rif-resistance TB	
	f	%	f	%	f	%	f	%
2018	9819	22.86	3905	17.48	703	20.46	17	16.67

2019	7939	18.48	3668	16.42	655	19.06	27	26.47
2020	5561	12.95	2897	12.96	540	15.72	17	16.67
2021	7712	17.95	4922	22.03	469	13.65	23	22.55
2022	6362	14.81	3742	16.75	583	16.97	10	9.80
2023	5564	12.95	3211	14.37	486	14.14	8	7.84
Total	42957	100.00	22345	100.00	3436	100.00	102	100.00

Table 3: Distribution of total TB samples, TB samples from HIV positive cases, TB positive cases and Rif-resistance TB cases by year

The researcher also noted a spike in TB-positive cases in 2018, which accounted for 20.46% (n=703 of 3,436). Nevertheless, the highest number of Rif-resistance TB cases was recorded in 2019, with 26.47% (n=27 of 102).

The quantitative data from table 3 shows for a pick of Rif-resistance TB and total number of samples in 2021 compared to other years. This concurs with the results from the qualitative analysis where PTBC argued that, "*It might be because there was now knowledge on how to deal with TB during the pandemic. Some who had TB in 2020 were not screened for that because of fear of contracting COVID-19. So, in 2021 people had more knowledge on COVID-19 and TB screening, and we were emphasizing that people should be screened for TB. That is when other people who should have been screened TB in 2020 were screened, causing a rise in TB samples in 2021"*. In support of the notion above PTBC highlighted, "*Before the outbreak of the epidemic, most of the surveillance systems will be somehow relaxed. During the peak of any outbreak, surveillances will be* *on high alert. So, anything that pops up will be thoroughly investigated. I can also attribute this to people coming from beyond our borders, actually, our colleagues returning home, in the sense that no one wanted to die in native land. So, most people were coming back to Zimbabwe, from there they will seek treatment and eventually from there they will be discovered that these people had TB".* DTBC 7 also highlighted that *"A pick of drug resistance in 2021 was caused by patients defaulting of TB drugs due to shutdown of facilities during the lockdowns. Abuse of antibiotics during self-medication at home during lockdowns may be the other factor that may have caused the pick. Another possibility is late diagnosis of TB cases as facilities were shut down and a lack of resources for diagnosis since the GeneXpert was now being used for COVID-19 diagnosis. The other thing is the lockdowns led to prolonged exposure time with Rif-resistance TB cases in the community".*

4.5 Distribution of total TB samples, TB samples from HIV positive cases, TB-positive cases and Rif-resistance TB by month

Table 4 shows the descriptive statistics of the total number of TB samples, TB samples from HIV-positive cases, TB-positive cases, and Rif-resistance TB cases by months for Masvingo province from 2018 to 2023. The majority of the TB samples were submitted in September with 10.87% (n=4 670 of 42 957) and the highest number of samples from HIV positive cases were recorded in the same month with 13.63% (n=3 045 of 22 345). However, most of the TB-positive cases and Rif-resistance TB cases, were reported in January with 9.52% (327 of 3 436) and 12.75% (n=13 of 102).

Month	TB samples		HIV Positives		TB Positives		TB Resistance	
	f	%	f	%	f	%	f	%
Jan	3101	7.22	1631	7.30	327	9.52	13	12.75
Feb	3147	7.33	1443	6.46	272	7.92	11	10.78
Mar	4357	10.14	2245	10.05	319	9.28	7	6.86
Apr	3041	7.08	1557	6.97	245	7.13	7	6.86
May	3142	7.31	1529	6.84	261	7.60	9	8.82
Jun	3401	7.92	1744	7.80	263	7.65	7	6.86
Jul	4109	9.57	2148	9.61	316	9.20	4	3.92
Aug	3892	9.06	1930	8.64	291	8.47	10	9.80
Sep	4670	10.87	3045	13.63	300	8.73	9	8.82
Oct	3636	8.46	1728	7.73	265	7.71	7	6.86
Nov	3814	8.88	1942	8.69	307	8.93	9	8.82
Dec	2647	6.16	1403	6.28	270	7.86	9	8.82
Total	42957	100.00	22345	100.00	3436	100.00	102	100.00

Table 4:Distribution of total TB samples, TB samples from HIV positive cases, TB-positive cases and, Rif-resistance TB cases by month.

The least number of TB samples were recorded in December 6.16% (n=2 647 of 42 957) and in the same month the least number of TB samples from HIV-positive cases were reported with 6.28% (n=1 403 of 22 345). However, the least TB-positive cases were observed in the month of April with 7. 13% (n=245 of 3 436), while the least Rif-resistance TB cases were noticed in the month of July with 3.92% (n=4 of 102).

From table 4 above, there are peaks in TB samples collected during the first quarter and the third quarter of the year. This result is further supported by qualitative insights from the respondents, which highlight the influence of such interactions by visitors. In particular DTBC 5 stated, "*Most of the people here in Chiredzi go and work in South Africa and come back on holidays. So, when they came back, we would find more TB cases in January, February because of contact, that is why it seems like it's seasonal, with high numbers after public holidays*" This was also supported by DTBC 2 who highlighted, "*During holidays, most of those who are in South Africa and other countries will be at their rural homes. So, if they are not well, they would visit the hospital, that is when we would collect more samples*".

In another incident, an Environmental Health Technician from Masvingo, DTBC 5 in support of the fact that there are peaks in TB samples collected during the first quarter and the third quarter of the year said, *"Transportation of TB samples is really affected by the rains. TB sputum samples are transported from the facilities to testing laboratories by IST (Integrated Sample Transportation) riders of the Ministry of Health and Child Care. Mobility of these riders is affected by bad roads during the rainy season that is why the number of samples pick before and after the rains. Furthermore, screening of TB tends to pick just after the public holidays and during winter".*

On a different note, DTBC 1 suggested that "There's a period when our community will be farming. There's a time when people come back home for farming and then go back to work, where they will be exposed to harsh conditions. I think they go back to work usually *the beginning of April up to October and then come back. During that period, I think that's when they will be exposed".*

4.6 Trend analysis for pre COVID-19, during COVID-19 and post c COVID-19 periods

Table 5 presents the descriptive statistics for the total number TB samples, TB samples from HIV-positive cases, TB-positive cases, and Rif-resistance TB cases by period. The total number of TB samples collected was higher during the pre-COVID-19 period, accounting for 41.34% (n=17,758 of 42,957).

Characteristics	Pre COVID-19		During COVID-19		Post COVID-19		Total	
	F	%	f	%	f	%	f	%
TB samples	17758	41.34	13273	30.90	11926	27.76	42957	100.00
HIV Positives	7573	33.89	7819	34.99	6953	31.12	22345	100.00
TB Positives	1358	39.52	1009	29.37	1069	31.11	3436	100.00
TB Resistance	44	43.14	40	39.22	18	17.65	102	100.00

Table 5: Distribution of total TB samples, TB samples from HIV-positive cases, TB-positive cases and Rif-resistance TB cases by period

In contrast, TB samples from HIV-positive cases peaked during the COVID-19 period, representing 34.99% (n=1,009 of 22,345). TB-positive cases were also higher in the pre COVID-19 period, with 39.52% (n=1,358 of 3,436), while Rif-resistance TB cases in the pre COVID-19 period accounted for 43.14% (n=44 of 102).

A drop in the total number of TB samples collected was explained by DTBC 6 as **"***During COVID-19, people focused only on COVID than any other condition. When COVID-19 started, information was not clear in clinics. Some were even saying people should not visit clinics. Only a few people would visit the clinics, and the clinics were even closed until they were told that they should not completely close the clinics. For those few people who visited the clinic, nurses would only concentrate on those with COVID-19 symptoms than any other issue. Information was then revealed and samples were taken, lab technicians did not have enough information, due to the COVID-19 samples workload they would say surely how can you bring us samples to check for TB. They even went on to look for circulars and protocols for the procedures on how samples are processed on a multiplexing GeneXpert machine. When they found the circulars on how to test TB during COVID-19, people did not accept it. Facilities healthcare workers were not happy to take TB samples because they fear contracting COVID-19. So, TB samples dropped unexpectedly. Those few ones peaked at the end of COVID-19 when people now had more information, that's when people began to take TB samples otherwise when COVID-19 started, there was completely nothing in terms of TB.* DTBC 1 supported saying "*During the COVID-19 period, almost everyone had diverted their minds, neglecting the TB program, focusing on COVID-19. This was because COVID-19 had an effect of taking many people's lives therefore the community was in the panic mode. Usually as healthcare workers, everyone who came with TB signs and symptoms was labelled a COVID-19 case, like if we look at COVID-19, it had similar symptoms with TB. That's when we missed some of the cases that when a person comes presenting TB signs and symptoms and we say it's COVID-19. The other thing is that there were COVID-19 restrictions, so in terms of us doing active TB case finding, we were not able to do that. We were doing what is known as passive, that is waiting for the patient to come and then* *get screened, of which TB screening was rare, unless the symptoms are extreme like HIV positive, the rest were assumed to be COVID-19 cases. That's where we missed TB cases and had a lower presumption rate*".

4.7 Trend analysis of the total number of TB samples collected

Table 6 presents the total number of TB samples collected from each facility by period. The highest number of TB samples recorded during the pre-COVID-19 period came from Masvingo and Morgenster, accounting for 20.00% (n=4,327 of 21,635).

Facility	Pre COVID-19		During COVID-19		Post COVID-19		Total	
	f	%	f	%	f	%	f	%
Chikombedzi	524	2.42	465	3.50	341	2.86	1330	2.84
Chivi	3177	14.68	2021	15.23	1563	13.11	6761	14.44
Gutu	3044	14.07	1364	10.28	1146	9.61	5554	11.86
Masvingo	4327	20.00	3614	27.23	2047	17.16	9988	21.33
Morgenster	4327	20.00	37	0.28	1353	11.34	5717	12.21
Musiso	1041	4.81	737	5.55	825	6.92	2603	5.56
Neshuro	3429	15.85	3553	26.77	2076	17.41	9058	19.34
Ndanga	0	0.00	0	0.00	760	6.37	760	1.62
Rutenga	456	2.11	194	1.46	254	2.13	904	1.93
Silveira	1310	6.06	1285	9.68	1561	13.09	4156	8.87

Total	21635	100.00	13270	100.00	11926	100.00	46831	100.00

Table 6:Distribution of TB samples by period

During the COVID-19 period, Masvingo recorded the highest number of TB samples at 27.2% (n=3,614 of 13,270), followed by Neshuro at 26.77% (n=3,533 of 13,270). In the post COVID-19 period, Masvingo and Neshuro had the highest recorded TB samples, with 21.33% (n=9,988 of 11,926) and 19.34% (n=9,058 of 11,926), respectively.

Table 7 shows the distribution of TB samples by gender and period. Females aged over 5 years had the highest reported TB samples collected in the pre COVID-19 period, with 53.54% (9,492 of 17,758). The same trend was observed during the COVID-19 period and the post COVID-19 period, with 55.99% (7,432 of 13,273) and 51.7% (6,612 of 11,926), respectively.

Gender	Age group	Pre COVID-19		During COVID-19		Post COVID-19		Total	
		f	%	f	%	F	%	f	%
Females	(0-5)	60	0.34	30	0.23	57	0.5	147	0.34
Females	>5	9492	53.45	7432	55.99	6162	51.7	23086	53.74
Males	(0-5)	42	0.24	46	0.35	64	0.5	152	0.35
Males	>5	8164	45.97	5765	43.43	5643	47.3	19572	45.56
Total		17758	100.00	13273	100.00	11926	100.0	42957	100.00

Table 7: Distribution of TB samples by gender, age group and period

The results suggest that during COVID-19, there were more TB samples recorded, followed by the pre period, and lastly, the post-COVID-19 period. The total number of TB samples collected dropped during COVID-19 for females less than 5 and males above 5 years then it picked in females above 5 years and males below 5 years.

Table 8 presents the proportions of TB samples recorded in the pre COVID-19, during COVID-19, and post COVID-19 periods, along with the 95% confidence intervals and p-values to assess significant differences among the TB samples. In the pre COVID-19 period, the proportion of TB samples collected was higher (0.4314) compared to those gathered during the COVID-19 period (0.3089). The p-value of 0.000, which is below the 5% significance level, confirms a significant difference between these two periods.

Method	Pre COVID-19	During COVID-19
Proportions	0.4134	0.3089
95% Confident Interval	(0.0980,0.1108)	
p-value	0.000	
	During COVID-19	Post COVID-19
Proportions	0.3089	0.2776
95% Confident Interval	(0.0252,0.0375)	
p-value	0.000	
	Pre COVID-19	Post COVID-19
Proportions	0.4134	0.2776

95% Confident Interval	(0.4134,0.2776)
p-value	0.000

Table 8: Hypothesis testing for proportions of TB samples by period

During the COVID-19 period, the sample proportion (0.3089) exceeded that of the post COVID-19 period (0.2776). Again, a p-value of 0.000 indicates a significant difference between the TB samples collected during these two periods. Similarly, the sample proportion for the pre COVID-19 period (0.4134) was greater than that of the post COVID-19 period. The p-value of 0.000 reinforces the conclusion that a significant difference exists between TB samples from the pre COVID-19 and post COVID-19 periods. These results indicate that post COVID-19 the TB samples collected had reduced compared to pre COVID-19 and during COVID-19 periods.

Table 9 reports the estimates and p-values corresponding to the period, gender, age groups, and facility for the Poisson multiple linear regression. The p-values for the periods (post- COVID-19 and pre COVID-19) are 0.000, which is below the 5% significance level. This indicates that the post COVID-19 and pre- COVID-19 periods are statistically significant in determining the number of TB samples collected. The negative estimate for the post COVID-19 period signifies a decline in the number of TB samples collected, while the positive estimate for the pre COVID-19 period suggests an increase in the number of TB samples collected.

Variable	Estimate	p-value
Intercept	-2.8371	0.0000

Period	Post COVID-19	-0.1070	0.0000
	Pre COVID-19	0.2911	0.0000
Gender & Age group	Females & > 5 years	5.0566	0.0000
	Males & 0-5 years	0.0338	0.7700
	Males & < 5 years	4.8914	0.0000
Facility	Chivi	1.6260	0.0000
	Gutu	1.4293	0.0000
	Masvingo	2.0162	0.0000
	Morgenster	0.3246	0.0000
	Musiso	0.6715	0.0000
	Neshuro	1.9185	0.0000
	Ndanga	-0.5596	0.0000
	Rutenga	-0.3828	0.0000
	Silveira	1.1394	0.0000

Table 9: Poisson multiple linear regression for TB samples collected

For females and males aged 5 years and older, the p-value is also 0.000, which is less than the 5% significance level. This result indicates that gender and age (5 years and older) are statistically significant in determining the number of TB samples collected. The positive estimates for both females and males suggest a positive contribution to the total number of TB samples collected. Most facilities had a p-value of 0.000, which is below the 5% significance level, except for Ndanga. These results suggest that most facilities contributed to the number of TB samples collected. Most facilities had positive estimates, indicating an increase in the number of TB samples, while Ndanga and Rutenga significantly decreased the number of TB samples due to negative estimates.

The qualitative analysis results obtained are consistent with the quantitative results in table 6, which indicate that shows a downward trend in the number of samples processed. This is evident from DTBC 4 who stated, "*Lockdown regulations affected patient flow to the facility, resulting in a reduction in sample collection. There were no clear SOPs/guidelines on the services the healthcare facilities should offer leading to closure of healthcare facilities thus affecting TB continuum of care. People were afraid of contracting Covid therefore they didn't seek medical care during the Covid period. Health care workers shifted focus from any other illness to fight the outbreak in so doing neglecting patients who came for TB services. Misdiagnosis, TB signs and symptoms are the same as Covids so anyone who presented with cough during the COVID period was screened for COVID only. The machine that was being used to process COVID samples is the same used for TB diagnosis. These machines are Point of Care machines which processes fewer number of samples (4 per hour). During the COVID period a lot of COVID samples were collected and these were being prioritized than TB samples leading to a very long turnaround time of TB results. As a result, facilities were no longer collecting the TB samples*".

Likewise, DTBC 1 shared his perception on the downward trend in the number of samples processed by stating, "*The leakages during transportation and processes might have caused the number of samples which were collected not to be equal to the numbers which were received at the testing laboratories. Again, there are some testing errors that occurs* *in that laboratory during testing. Since COVID-19 samples were being processed on the GeneXpert machine which is used for TB samples some TB samples that were sent to the laboratory failed to be processed due to the high workload".*

4.8 Trend analysis of TB samples from human immune virus (HIV) positive cases

Table 10 presents the TB samples from HIV positive cases from each facility by period. Neshuro recorded the highest number of TB samples from HIV positive cases both the pre COVID-19 and during COVID-19 periods, with 34.49% (n=2,612 of 7,573) and 44.73% (n=3,296 of 7,368), respectively.

Facility	Pre COVID-19		During COVID-19		Post COVID-19		Total	
	f	%	f	%	f	%	f	%
Chikombedzi	368	4.86	391	5.31	292	4.58	1051	4.93
Chivi	977	12.90	770	10.45	589	9.23	2336	10.96
Gutu	743	9.81	584	7.93	460	7.21	1787	8.38
Masvingo	1195	15.78	1195	16.22	32	0.50	2422	11.36
Morgenster	85	1.12	32	0.43	1553	24.33	1670	7.83
Musiso	921	12.16	633	8.59	712	11.16	2266	10.63
Neshuro	2612	34.49	3296	44.73	1908	29.90	7816	36.66
Ndanga	0	0.00	0	0.00	255	4.00	255	1.20
Rutenga	240	3.17	91	1.24	100	1.57	431	2.02

Silveira	432	5.70	376	5.10	481	7.54	1289	6.05
Total	7573	100.00	7368	100.00	6382	100.00	21323	100.00

Table 10: Distribution of TB samples from HIV-positive cases by period

Similarly, Neshuro reported the highest number of TB samples from HIV-positive cases in the post COVID-19 period, accounting for 29.90% (n=1,908 of 6,382). These results suggest a surge in HIV-positive cases during the COVID-19 period in Neshuro.

Table 11 reports the TB samples from HIV-positive cases from each gender and aged group by period. Females aged more than 5years recorded the highest number of TB samples from HIV cases pre COVID-19 and during COVID-19 periods accounting for 55.50% (n=4 203 of 7 573) and 59.93% (n=4 686 of 7 819).

Gender	Age group	Pre COVID-19		During COVID-19		Post COVID-19		Total	
		f	%	f	%	f	%	f	%
Females	(0-5)	8	0.11	14	0.18	19	0.27	41	0.18
Females	>5	4203	55.50	4686	59.93	3708	53.33	12597	56.38
Males	(0-5)	15	0.20	18	0.23	26	0.37	59	0.26
Males	>5	3347	44.20	3101	39.66	3200	46.02	9648	43.18
Total		7573	100.00	7819	100.00	6953	100.00	22345	100.00

Table 11: Distribution of the total number of TB samples from HIV positive cases by gender with age group and period

In similar manner, females aged more than 5years reported the highest number of HIV positive cases with 53.33% (n=3 708 of 6 953). The results indicate that there was spike of HIV positive cases during COVID-19 period.

Table 12 presents the proportions of TB samples from HIV cases reported in the pre COVID-19, during COVID-19, and post COVID-19 periods, along with the 95% confidence intervals and p-values to assess significant differences among the proportions of TB samples from HIV cases. In the pre COVID-19 period, the proportion of TB samples from HIV cases were lower (0.3389) compared to those gathered during the COVID-19 period (0.3499). The p-value of 0.0147, which is less than the 5% significance level, indicate a significant difference between these two periods.

Method	Pre COVID-19	During COVID-19
Proportions	0.3389	0.3499
95% Confident Interval	(-.0.0199, -0.0022)	
p-value	0.0147	
	During COVID-19	Post COVID-19
Proportions	0.3499	0.3112
95% Confident Interval	(0.0300, 0.0475)	
p-value	0.000	
	Pre COVID-19	Post COVID-19
Proportions	0.3389	0.3112

95% Confident Interval	(0.0190, 0.0365)
p-value	0.000

Table 12: Hypothesis testing for proportions of TB samples from HIV positive cases by period

During the COVID-19 period, the TB samples from HIV-positive cases proportion (0.3499) exceeded that of the post COVID-19 period (0.3112). Again, a p-value of 0.000 suggest a significant difference between the TB samples from HIV-positive cases recorded during these two periods. Similarly, the TB samples from HIV cases for the pre COVID-19 period (0.3389) was more than that of the post COVID-19 period (0.3112). The p-value of 0.000 confirms the conclusion that a significant difference exists between the proportions of TB samples from HIV positive cases from the pre COVID-19 and post COVID-19 periods. These results indicate that during COVID-19 period there were spikes of HIV-positive cases compared to pre COVID-19 and post- COVID-19.

Table 13 shows the estimates and p-values corresponding to the period, gender, age groups, Rif-resistance TB status, TB status, and facility for TB samples from HIV positive cases using Poisson multiple linear regression. The p-value for the post COVID-19 period is 0.000, which is below the 5% significance level. This indicates that the post COVID-19 period is statistically significant in determining the number of TB samples from HIV positive cases. The positive estimate for the post COVID-19 period signifies an increase in the number of TB samples from HIV cases.

Variables		Estimate	p-value
	Intercept	-3.3212	0.0000

Period	Post COVID-19	0.0765	0.0000
	Pre COVID-19	-0.0139	0.4169
Gender and Age group	Females & > 5 years	5.2666	0.0000
	Males & 0-5 years	0.3637	0.0737
	Males & > 5 years	5.0320	0.0000
TB Resistance Status	Positive	0.0297	0.0547
TB Status	Positive	0.0668	0.0000
Facility	Chivi	0.5073	0.0000
	Gutu	0.3432	0.0000
	Masvingo	0.6713	0.0000
	Morgenster	0.2463	0.0000
	Musiso	0.7010	0.0000
	Neshuro	1.4851	0.0000
	Ndanga	-1.3324	0.0000
	Rutenga	-0.8244	0.0000
	Silveira	-0.0254	0.5470
TB samples		0.0038	0.0000

Table 13: Poisson multiple linear regression for TB samples from HIV positive cases

For females and males aged over 5 years, the p-values are 0.000, which is below the 5% significance level, except for males aged between 0 and 5 years. This indicates that individuals above 5 years are statistically significant in determining the number of TB samples from HIV cases. The positive estimates associated with this group suggest a beneficial contribution to the number of TB samples from HIV cases. In contrast, the p-value of 0.0547 related to Rif-resistance TB status exceeds the 5% significance level, indicating that Rif-resistance TB does not significantly influence the number of TB samples from HIV cases. On the other hand, a p-value of 0.000 for TB status reveals that being TB positive is statistically significant in determining TB samples from HIV cases. The positive estimate in this context implies a direct contribution of TB-positive status to the increase in TB samples from HIV cases. Regarding the facilities, the majority show p-values of 0.000, which are statistically significant at the 5% level, with the exception of Ndanga and Silveria. Most facilities exhibit positive estimates, reflecting an increase in TB samples from HIV positive cases. However, Ndanga, Rutenga, and Silveria present negative estimates, indicating a reduction in the number of TB samples from HIV positive cases at those locations.

The results derived from qualitative analysis are consistent with results obtained from quantitative analysis which suggests that there a peak in HIV-positive TB patients. This was validated by DTBC 1 who shared, "*As I alluded to earlier, during COVID-19, we were mostly concerned with the issue of risk groups. COVID-19 mostly affected co-morbidity groups, of which that's when we would say those with HIV, we would take samples. Them knowing that they are at risk, they would come and we take samples for testing both HIV and TB. That's where our strength was in terms of co-morbidity and integration of services"* Also in support of the same notion DTBC 5, an environmental health technician stated, "*During pre-COVID, samples were high (HIV positive, TB positive and TB-resistance). During COVID, some samples dropped but HIV positive remained high. For HIV positive, the reason might be because during COVID people were forced to stay at home, not accessing health services. Again, some women were being abused (rape), having nowhere to report and get assistance in terms of HIV testing and getting some medication(prophylaxis). The other issue is, since we were not allowed to travel and access things like condoms or preps, people ended up having unprotected sex, increasing the chances of HIV*".

4.9 Trend analysis of tuberculosis (TB) positive cases

Table 14 presents the TB-positive cases from each facility by period. Masvingo had the highest recorded TB-positive cases pre COVID-19 and during COVID-19 period with 25.63% (348 of 1 358) and 24.48% (247 of 1 009) respectively.

Facility	Pre COVID-19		During COVID-19		Post COVID-19		Total	
	f	%	f	%	f	%	f	%
Chikombedzi	61	4.49	77	0.076	46	4.30	184	5.36
Chivi	183	13.48	171	16.95	112	10.48	466	13.56

Gutu	146	10.75	103	10.21	64	5.99	313	9.11
Masvingo	348	25.63	247	24.48	242	22.64	837	24.36
Morgenster	110	8.10	4	0.40	155	14.50	269	7.83
Musiso	85	6.26	82	8.13	87	8.14	254	7.39
Neshuro	237	17.45	138	13.68	140	13.10	515	14.99
Ndanga	0	0.00	0	0.00	33	3.09	33	0.96
Rutenga	34	2.50	12	1.19	20	1.87	66	1.92
Silveira	154	11.34	175	17.34	170	15.90	499	14.52
Total	1358	100.00	1009	100.00	1069	100.00	3436	100.00

Table 14: Distribution of TB-positive cases by period

Similarly, Masvingo reported the highest number of TB-positive cases post COVID-19 period 22.64% (n= 242 of 1 069). The results suggest there was a spike of TB-positive cases pre COVID-19 period in Masvingo.

Table 15 shows the TB-positive cases from each gender and age group by period. Males aged more than 5 years reported the highest TB cases pre COVID-19 and during COVID-19 period accounting for 61.05% (n=829 of 1 358) and 66.60% (n=672 of 1 009). Similarly, Males aged more than 5 years reported the highest number of TB-positive cases with 67.17% (n=718 of 1 069). The results indicate that there was surge of TB-positive cases post COVID-19 period.

Gender	Age group	Pre COVID-19	During COVID-19	Post COVID-19	Total

		f	%	f	%	f	%	f	%
Females	(0-5)	1	0.07	0	0.00	0	0.00	1	0.03
Females	>5	528	38.88	333	33.00	350	32.74	1211	35.24
Males	(0-5)	0	0.0	4	0.40	1	0.09	5	0.15
Males	>5	829	61.05%	672	66.60	718	67.17	2219	64.5
Total		1358	100.00	1009	100.00	1069	100.00	3436	100.00

Table 15: Distribution of TB-positive cases for gender with age group and period

Table 16 presents the proportions of TB positive cases reported in the pre COVID-19, during COVID-19, and post COVID-19 periods, along with the 95% confidence intervals and p-values to assess significant differences among the proportions of TB positive cases. In the pre COVID-19 period, the proportion of TB positive cases were higher (0.3959) compared to those gathered during the COVID-19 period (0.2937). The p-value of 0.000, which is less than the 5% significance level, indicate a significant difference between these two periods.

Method	Pre COVID-19	During COVID-19
Proportions	0.3952	0.2937
95% Confident Interval	(0.0789,0.1242)	
p-value	0.000	
	During COVID-19	Post COVID-19

Proportions	0.2937	0.3111
95% Confident Interval	(-0.0394,0.0045)	
p-value	0.121	
	Pre COVID-19	Post COVID-19
Proportions	0.3952	0.3111
95% Confident Interval	(0.0613,0.1069)	
p-value	0.000	

Table 16: Hypothesis testing for proportions of TB positive cases by period

During the COVID-19 period, the TB positive cases proportion (0.2937) were lower compared to post COVID-19 period (0.3111). A p-value of 0.121 suggest a significant indifference between the TB positive cases recorded during these two periods. The TB positive cases for the pre COVID-19 period (0.3652) were more than that of the post COVID-19 period (0.3111). The p-value of 0.000 confirms the conclusion that a significant difference exists between TB positive cases from the pre COVID-19 and post COVID-19 periods. These results indicate that pre-COVID period there was a surge of TB positive cases compared to during COVID-19 and post COVID-19 period.

Table 17 shows the estimates and p-values corresponding to the period, gender, age groups, Rif-resistance TB, TB status, and facility for TB positive cases using Poisson multiple linear regression. The p-value for the post COVID-19 period is 0.000, which is below the 5% significance level. This indicates that the post COVID-19 period is statistically significant in determining the number of TB samples from HIV-positive cases. The positive estimate for the post COVID-19 period signifies an increase in the number of TB samples from HIV cases.

Variable		Estimate	p-value
Intercept		-7.0835	0.0000
Period	Post COVID-19	0.1239	0.0052
	Pre COVID-19	0.1652	0.0002
Gender and age group	Females & > 5 years	6.8245	0.0000
	Males & 0-5 years	1.6099	0.1417
	Males & > 5 years	7.4567	0.0000
Rif-resistance TB Status	Positive	0.1517	0.0000
HIV Status	Positive	-0.0069	0.0000
Facility	Chivi	0.6322	0.0000
	Gutu	0.2659	0.0058
	Masvingo	1.0355	0.0000
	Morgenster	0.3698	0.0001
	Musiso	0.3004	0.0019
	Neshuro	0.8552	0.0000
	Ndanga	-1.7184	0.0000

	Rutenga	-1.0267	0.0000
	Silveira	0.8255	0.0000
TB samples		0.0088	0.0000

Table 17: Poisson multiple linear regression for TB-positive cases

The p-values corresponding to females and males having age greater than 5years are less than the 5% significance level. This suggests females and males having age greater than 5years are statistically significant in determining the number of TB positive cases. Their respective estimate is positive suggesting that they increase the number of TB positive cases. Similarly, the p-values corresponding to Rif-resistance TB cases and TB samples from HIV positive status are less than the 5% significance level. This indicates that Rif-resistance TB cases and TB samples from HIV positive status are statistically significant in determining the number of TB positive cases. The estimate of Rif-resistance TB cases is positive suggesting that those cases increase by TB positive status. In contrast, the estimate of TB samples from HIV positive cases is negative indicating that those cases decrease the number of TB positive cases. Regarding the facilities, the majority of them have p-values that are less 5% significance level except Ndanga. Those facilities that have positive estimates, this includes Chivi, Gutu, Masvingo, Morgenster, Musiso and 0.8552, this suggests these facilities increases the number of TB positive cases. Those facilities that have negative estimates, this includes Ndanga and Rutenga, this indicates these facilities decreases the number of TB positive cases. The p-values of 0.0000 corresponding TB samples are less than 5% significance level, signifying that TB samples are statistically significant in determining the number of TB positive cases. Its positive estimate suggest that the number of TB samples increase the number of TB positive cases.

The results from quantitative analysis were reinforced with the results obtained from qualitative analysis which shows that there is a decreasing pattern in TB positives cases pre COVID-19, during COVID-19 and post COVID-19. For instance, DTBC 5 shared, "*Post-COVID, there was drop because when COVID-19 ended, people were now encouraged to go for health services freely without restrictions. Testing services and access to preventive measures resumed. Health education helped us to have a relationship with our patients, letting them know that if anything happens what should be done. Therefore, the health promotion programs and activities that were offered contributed to the drop in TB positives. Resumption of services reduced TB treatment interruption and defaulters*" Similarly DTBC 7 in support highlighted, "*Number of TB positives and Rif-resistance TB is directly proportional to the total number of TB samples collected. Therefore, since there was a drop in the number of total numbers of TB samples collected it may have caused a drop in the number of TB positive and Rif-resistance cases*".

4.10 Trend analysis of Rif-resistance TB cases

Table 18 below presents the Rif-resistance TB cases from each facility by period. Masvingo had the highest reported Rif-resistance TB cases pre COVID-19 and during COVID-19 period with 34.09% (15 of 44) and 38.00% (18.50) respectively. Similarly, Masvingo recorded the highest number of Rif-resistance TB cases post COVID-19 period 37.00% (n= 4 of 8). The results indicate there was a surge of Rif-resistance TB cases during COVID-19 period in Masvingo.

Facility	Pre COVID-19		During COVID-19		Post COVID-19		Total	
	f	%	f	%	f	%	f	%
Chikombedzi	1	2.27	2	6.00	2	12.50	5	4.90
Chivi	3	6.82	6	14.00	1	0.00	10	9.80
Gutu	4	9.09	2	4.00	0	0.00	6	5.88
Masvingo	15	34.09	18	38.00	4	37.50	37	36.27
Morgenster	1	2.27	2	4.00	0	0.00	3	2.94
Musiso	5	11.36	4	8.00	0	0.0	9	8.82
Neshuro	9	20.45	3	18.00	7	12.50	19	18.63
Ndanga	0	0.00	0	0.00	1	12.50	1	0.98
Rutenga	1	2.27	2	6.00	1	0.00	4	3.92
Silveira	5	11.36	1	2.00	2	25.00	8	7.84
Total	44	100.00	50	100.00	8	100.00	102	100.00

Table 18: Distribution of Rif-resistance TB cases by period

Table 19 shows the Rif-resistance TB cases from each gender and aged group by period. Males aged more than 5 years recorded the highest Rif-resistance TB cases pre COVID-19 and during COVID-19 period accounting for 59.09% (n=26 of 44) and 60.00% (n=24 of 40). In similar manner, males aged more than 5 years reported the highest number of Rif-resistance TB cases with 61.11% (n=11 of 18). The results suggest that there was a spike of Rif-resistance TB cases pre COVID-19 period.

Gender	Age group	Pre COVID-19		During COVID-19		Post COVID-19		Total	
		f	%	f	%	f	%	f	%
Females	(0-5)	0	0.00	0	0.00	0	0.00	0	0.00
Females	>5	18	40.91	16	40.00	7	38.89	41	40.20
Males	(0-5)	0	0.00	0	0.00	0	0.00	0	0.00
Males	>5	26	59.09	24	60.00	11	61.11	61	59.80
Total		44	100.00	40	100.00	18	100.00	102	100.00

Table 19: Distribution of Rif-resistance TB cases for gender with age group and period

Table 20 presents the proportions of Rif-resistance TB cases reported in the pre COVID-19, during COVID-19, and post COVID-19 periods, along with the 95% confidence intervals and p-values to assess significant differences among the proportions of Rif-resistance TB cases. In the pre COVID-19 period, the proportion of Rif-resistance TB cases were higher (0.4314) compared to those gathered during the COVID-19 period (0.3922). The p-value of 0.6695, which is greater than the 5% significance level, indicate a significant indifference between these two periods.

Method	Pre COVID-19	During COVID-19
Proportions	0.4314	0.3922
95% Confident Interval	(-0.1056, 0.1840)	
p-value	0.6695	

	During COVID-19	Post COVID-19
Proportions	0.3922	0.1765
95% Confident Interval	(0.0857, 0.1765)	
p-value	0.001	
	Pre COVID-19	Post COVID-19
Proportions	0.4318	0.1765
95% Confident Interval	(0.1238,0.3860)	
p-value	0.000	

Table 20: Hypothesis testing for proportions of Rif-resistance TB cases by period

During the COVID-19 period, the Rif-resistance TB cases proportion (0.3922) exceeded that of the post COVID-19 period (0.1765). A p-value of 0.001 suggest a significant difference between the Rif-resistance TB cases recorded during these two periods. Similarly, the Rif-resistance TB cases for the pre COVID-19 period (0.44318) were more than that of the post COVID-19 period (0.1765). The p-value of 0.000 confirms the conclusion that a significant difference exists between Rif-resistance TB cases from the pre COVID-19 and post COVID-19 periods. These results indicate that pre COVID-19 period there was surge of TB resistance cases compared to during COVID-19 and post COVID-19.

Table 21 shows the estimates and p-values corresponding to the period, gender, age groups, HIV status, TB status, and facility for Rif-resistance TB cases using Poisson multiple linear regression.

The p-value for the post COVID-19 period is 0.000, which is below the 5% significance level. This indicates that the post COVID-19 period is statistically significant in determining the number of Rif-resistance TB cases. The negative estimate for the post COVID-19 period signifies decrease in the number of Rif-resistance TB cases.

Variable		Estimate	p-value
Intercept		-21.2702	0.9816
Period	Post COVID-19	-0.8418	0.0035
	Pre COVID-19	-0.1051	0.6562
Gender and age group	Females & > 5 years	17.8681	0.9845
	Males & 0-5 years	-0.0025	1
	Males & > 5 years	17.9601	0.9845
TB Status	Positive	0.16	0
HIV Status	Positive	0.0022	0.6967
Facility	Chivi	0.3017	0.5985
	Gutu	0.0109	0.9859
	Masvingo	1.1822	0.031
	Morgenster	-0.6891	0.3485
	Musiso	0.5012	0.3695
	Ndanga	0.0752	1
	Neshuro	0.8993	0.0846
	Ndanga	-1.3876	0.2057

	Rutenga	-0.0593	0.9297
	Silveira	-0.0445	0.9399
TB samples		-0.0015	0.7754

Table 21: Poisson multiple linear regression for Rif-resistance TB cases

The p-values corresponding to gender and age group are greater than the 5% significance level. This indicates that gender and age group statistically insignificant in determining the number of Rif-resistance TB cases. However, the p-value of 0.000 corresponding to the TB positive status is less than the 5% significance level. This suggests that TB positive status statistically significant in determining the number of Rif-resistance TB cases. The estimate of TB positive status is positive suggesting that the number of Rif-resistance TB is increased by TB positive status. In contrast, the p-value of corresponding to the TB samples from HIV positive cases is greater than 5% significance level. This indicates that TB samples from HIV positive cases does not significantly influence the number of TB-positive cases. Regarding the facilities, only Masvingo had a p-value of 0.0310, which is less than 5% significance level. The positive estimate in this context implies a direct contribution of Masvingo to the increase in TB-positive cases. TB samples p-values corresponding to TB samples is greater than 5% significance level, this may suggest that the number of TB samples collected may have a statistically insignificant effect in determining the Rif-resistance TB cases.

As confirmation for the quantitative results which shows that there is a drop in Rif-resistance TB cases, from the interviews DTBC 1 asserted, *"As institutions we no longer had the resources to use for other conditions other than COVID-19 as resources were shifted to combat the pandemic. Another thing is that people were now relaxed, and most* *people were wiped out by COVID-19, so they were neglecting TB, focusing on COVID as they perceived it as most dangerous compared to TB. So, after the pandemic in 2023, we were now getting back to healthcare workers, training them so that we can start-up the TB program. People had no longer had that zeal for TB screening. Since we had stopped the TB services, starting again needs resources, which we did not have, leading to a drop in TB positive cases*" Similarly DTBC 7 in support of the same view highlighted, "*Number of TB positives and Rif-resistance TB is directly proportional to the total number of TB samples collected. Therefore, since there was a drop in the number of total numbers of TB samples collected it may have caused a drop in the number of TB positive and Rif-resistance cases*".

In another incident DTBC 7 cited, "*Men are more exposed to TB risk factors than women, which are smoking, alcohol abuse, mining activities, prisons, truck driving, and other industrial activities that expose them to dust. Alcohol abuse result in malnutrition which is the greatest risk factor of TB. Health seeking habits of man are poor as compared to women, so when they contract TB, they may try to self-medicate at home and visit the clinic late. By so doing the bacteria become resistant. On the other hand, they can visit the facility in time and get medication, but they default as soon as they feel better causing the bacteria to mutate and become resistant. Men are mobile than women because they need to provide for their families. Some are truck drivers going to placing like South Africa which has a high Rif-resistance TB."* In addition, DTBC 7 also emphasized "*Defaulting of TB drugs due to shutdown of facilities. Abuse of antibiotics during self-medication at home during lockdowns. Late diagnosis of TB cases as facilities were shutdown. Prolonged exposure time with Rif-resistance TB case during lockdowns".*

4.11 Summary

COVID-19 negatively affected the TB continuum of care regressing the gains that had been made towards the END TB Strategy. This is evidenced by the drop in the total number of samples collected due to a reduction in the presumption rate, the pick in TB samples from HIV-positive clients, and a pick in Rif-resistance TB.

5 CHAPTER 5: DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

5.1 Introduction

The main purpose of this chapter is to critically discuss the trends and contributing factors influencing the total number of tuberculosis (TB) samples, TB samples from HIV-positive individuals, TB-positive cases, and rifampicin-resistant (Rif-resistant) TB cases in Masvingo Province, as observed across three distinct periods: the pre-COVID-19 period (2018–2019), the COVID-19 period (2020–2021), and the post-COVID-19 period (2022–2023). This will unpack the implications of the research findings and promote informed decision-making regarding TB surveillance and healthcare interventions. Furthermore, comparing the current study's results with findings from other related studies enriches the knowledge base, offering insight into how similar challenges have been addressed in different contexts. Such comparisons not only help validate the findings but also enhance conceptual understanding.

The chapter begins with a brief summary of the research, highlighting the main objective and how it has been achieved. This is followed by a discussion of the findings, which explores points of convergence and divergence with existing literature. These comparisons will help substantiate, refine, or challenge the study's interpretations, ultimately contributing to a more comprehensive understanding of TB trends in the context of the COVID-19 pandemic.

5.2 Summary of research

The primary aim of this study is to investigate the trends and contributing factors affecting the total number of TB samples, TB samples from HIV-positive individuals, TB-positive cases, and Rif-resistant TB cases in Masvingo Province across three distinct periods: the pre-COVID-19 period (2018–2019), the COVID-19 period (2020–2021), and the post-

COVID-19 period (2022–2023). This was achieved through a mixed-methods research design, which integrated both quantitative and qualitative data to provide a comprehensive understanding of the issues involved.

For the quantitative analysis, data were sourced from the Masvingo District Health Information System (DHIS2), focusing on 10 facilities equipped with GeneXpert machines (diagnostic tools used for rapid TB detection). The selected facilities were: Chikombedzi, Chivi, Gutu, Masvingo, Morgenster, Musiso, Neshuro, Ndanga, Rutenga, and Silveira. The dataset covered the period from 2018 to December 2023 and included variables such as the total number of TB samples collected, TB-positive cases, samples from HIV-positive individuals, and Rif-resistant TB samples.

Descriptive statistics revealed that the majority of TB samples were collected from Masvingo, which accounted for 23.25% (9,988 out of 42,957) of all samples, whilst the lowest portion of 1.77% (760 out of 42,957) was taken up by Ndanga. In terms of gender distribution, females contributed the majority of TB samples collected constituting 54.08% (23,233 out of 42,957), while males accounted for 45.92% (19,724 out of 42,957). Additionally, the statistics indicated that 41.34% of samples were collected during the pre-COVID-19 period, with the lowest proportion (27.76%) collected in the post-COVID-19 period. This trend suggests a potential disruption in TB diagnosis services due to the pandemic, which necessitated further statistical investigation.

To analyze differences in sample collection across the three periods, proportional tests were employed. These tests helped to assess whether the observed variations in the number of TB samples collected over time were statistically significant. Furthermore, multiple Poisson regression was applied to identify the key factors influencing the number of samples collected.

Qualitative analysis was carried out involving eight participants which included seven district TB coordinators and one provincial TB coordinator. The purpose of the qualitative analysis was to gain contextual insights into the operational challenges, policy disruptions, and health system responses during the different COVID-19 phases. This helped to support the quantitative findings and provide a richer, more nuanced interpretation of the data trends.

5.3 Discussion

5.3.1 Trend analysis and contributing factors for total TB samples for the pre-COVID-19 cases, during COVID-19 and post-COVID-19 period.

The proportion of samples collected during the pre-COVID-19 period (0.41) was higher than that collected during the pandemic period (0.31). This difference was statistically significant, as evidenced by a p-value of 0.000, which is below the 5% level of significance. This was supported by qualitative analysis where respondents highlighted limited accessibility to healthcare services during the pandemic, as both patients and medical practitioners faced travel restrictions following government-imposed lockdowns. This disruption in healthcare delivery was a global phenomenon, with governments redirecting significant portions of public health expenditure towards combating COVID-19 and limiting the virus's spread. Supporting this, the World Health Organization (2020) reported a 25% global decline in expected TB sample collections, which was projected to result in a 13% increase in TB-related deaths. The respondents also highlighted the reallocation of TB testing machines to COVID-19 during the pandemic which is consistent with Alexandra Jaye Zimmer (2021)'s observations.

Furthermore, the data indicated that the proportion of samples collected during the COVID-19 period was slightly higher than those collected in the post-COVID-19 period.

Hypothesis testing revealed statistically significant differences, with a p-value of 0.000. In comparing the pre-COVID-19 and post-COVID-19 periods, substantial differences were observed in sample collection rates. These differences were also statistically significant, as indicated by the consistently low p-value of 0.000, reinforcing the impact of the pandemic on TB sample collection rates.

In addition to the trend analysis, a Poisson multiple linear regression model revealed that time period, gender-age group, and health facility location significantly influenced the number of TB samples collected. The model estimated coefficients of -0.1070 for the post-COVID-19 period and 0.2911 for the pre-COVID-19 period. These estimates suggest that the post-COVID-19 period was associated with a reduction in TB sample collection, whereas the pre-COVID-19 period contributed more positively to overall sample collection. This finding aligns with the results from proportional tests, which indicated a higher proportion of samples collected before the onset of the pandemic. More also, Alexandra Jaye Zimmer (2021) also explained that the effects of disruptions in our usual way of living are still being felt causing minute improvements in TB testing.

The analysis also highlighted the influence of gender-age groups on TB sample collection. Females aged above 5 years, males aged 0–5 years, and males aged above 5 years were all found to positively influence TB sample collection, with respective estimates of 5.0566, 0.0338, and 4.8914. All categories, except males aged 0–5 years (p-value = 0.7700), had p-values below the 5% level of significance, indicating a strong influence on the total number of samples collected. The results entail that women were more willing to be tested compared to men. The observation is consistent with the general belief by most scholars that women seek or consult general practitioners more frequently than men (Hunt *et al.*, (2011); Höhn *et al.*, (2020)).

Facility location also played a crucial role in determining the volume of TB samples collected. Masvingo recorded the highest positive estimate of 2.0162, indicating that this location contributed the most to the number of TB samples collected. This could be attributed to the relatively higher number of hospitals and diagnostic centres in the area, improving accessibility for residents. Other facilities that positively influenced sample collection included Chivi, Gutu, Morgenster, Musiso, Neshuro, and Silveira. In contrast, locations such as Ndanga and Rutenga showed negative influences on TB sample collection. These areas are predominantly rural, with limited healthcare infrastructure and lower levels of health awareness, which likely contributed to the reduced number of samples collected.

5.3.2 Trend analysis and contributing factors for TB samples from human immune virus (HIV) positive cases.

The study revealed dynamic trends in TB sample collection among individuals living with HIV across the pre-COVID-19, during COVID-19, and post-COVID-19 periods. Notably, a higher proportion of TB samples were collected from HIV-positive individuals during the COVID-19 period (0.3499) compared to the pre-pandemic period (0.3389). This increase was statistically significant, as shown by a p-value of 0.0147, which is below the 5% threshold. These findings suggest that the intersection of HIV and COVID-19 vulnerabilities led to increased healthcare interactions during the pandemic. Qualitative insights support this interpretation, revealing that people living with HIV (PLHIV) were considered high-risk and consequently had greater contact with medical practitioners. This heightened medical engagement often resulted in dual screening for both COVID-19 and TB, facilitating increased TB sample collection. Supporting this, Wang and Jonas (2021) found that PLHIV had 7 times the odds of being diagnosed with COVID-19 compared to HIV-negative individuals, which may have increased their presence within healthcare facilities and thus opportunities for TB testing.

Additionally, respondents noted that pandemic-related travel restrictions made it difficult for PLHIV to replenish antiretroviral therapy (ART) supplies. This disruption in treatment continuity likely contributed to deteriorating immune health, prompting more frequent clinical visits and diagnostic tests, including for TB. This aligns with findings by Boulle *et al.* (2020), who reported increased clinical vulnerability and health service dependency among immunocompromised individuals during COVID-19 lockdowns.

However, a decline in TB samples from HIV-positive cases was observed post-COVID-19, with the proportion falling from 0.3499 during the pandemic to 0.3112 after. This decrease was statistically significant (p-value = 0.000), suggesting a tangible shift in healthcare utilization or need. This trend may be attributed to restored access to ART, improved public health infrastructure, and better health outcomes post-pandemic, which reduced the necessity for frequent TB screening among PLHIV.

Moreover, when comparing the pre-pandemic era (0.3389) to the post-COVID-19 period (0.3112), there was again a significant reduction in TB samples collected, highlighting potential changes in care-seeking behaviour or reduced TB symptom manifestation due to improved HIV management. These findings echo the conclusions of Dorward et al. (2021), who reported that HIV programs had resumed effective ART service delivery by the end of 2021, contributing to more stable immune responses and less overlap with opportunistic infections such as TB.

Factors influencing the number of TB samples collected from people with HIV

The analysis revealed that the post-COVID-19 period was significantly associated with an increase in TB sample collection from people living with HIV, as indicated by a positive coefficient of 0.0765 and a p-value of 0.000, confirming statistical significance. This trend reflects renewed access to healthcare services post-pandemic, as well as increased clinical follow-ups for individuals at high risk, such as those with HIV. Health systems may have intensified TB screening during routine HIV visits as part of catch-up strategies for missed diagnoses during the pandemic.

In contrast, the pre-COVID-19 period showed a slight negative influence on TB sample collection (coefficient = -0.0139), although this impact was statistically insignificant (p = 0.4169). This suggests that before the pandemic, while services were stable, there might have been less urgency or integration of TB testing among HIV patients.

Within the gender-age group category, females living with HIV aged 5 years and above were more likely to undergo TB testing, reflected by a high estimate of 5.2666. This may indicate higher health-seeking behavior among women, possibly due to maternal health follow-ups or stronger adherence to ART regimens. Males aged over 5 years also showed a significant positive influence (estimate = 5.0320), while males aged 0–5 years contributed positively but not significantly (estimate = 0.3637, p = 0.0737). The lower contribution among younger males is understandable, given the lower prevalence of HIV in early childhood, as perinatally transmitted infections are relatively less common. For those aged above 5 years, increased risk may be linked to early sexual activity or exposure to abuse, raising vulnerability to both HIV and TB.

People living with HIV who also had a positive TB status significantly contributed to the number of TB samples collected, as shown by a positive coefficient of 0.0668 and a highly significant p-value (0.000). This supports the clinical understanding that co-infection with TB is common in HIV-positive individuals, necessitating concurrent diagnostic testing to facilitate timely treatment interventions.

Most health facilities contributed positively to the number of TB samples collected from HIV-positive individuals. However, Ndanga, Rutenga, and Silveira recorded no such samples, suggesting possible gaps in integrated TB/HIV services, underreporting, or limited diagnostic capacity in these rural or underserved areas. These findings highlight the need for equitable distribution of TB diagnostic services, especially in remote settings, to ensure no sub-population is missed in TB control efforts.

A positive association was observed between the total number of TB samples collected and the number of HIV-positive individuals (coefficient = positive). This is an expected outcome, as increased diagnostic activity naturally raises the likelihood of identifying co-infected patients, particularly when TB and HIV are closely associated diseases. This reinforces the importance of routine TB screening as a standard part of HIV care, in line with WHO recommendations.

5.3.3 Trend analysis of tuberculosis (TB) positive cases

The analysis revealed notable temporal variations in tuberculosis (TB) positivity rates across the pre-COVID-19, during COVID-19, and post-COVID-19 periods. A higher proportion of TB positive cases was recorded during the pre-pandemic era (0.3952) compared to the pandemic period (0.2937). This difference was found to be statistically significant at the 95% confidence level, as indicated by a p-value of 0.0000, which is well below the 5% threshold.

This sharp decline during the pandemic aligns with global patterns where health system disruptions led to reduced TB case detection, as explained by Francesco Bonacina *et al.* (2023). The pandemic redirected diagnostic capacity and public health attention toward COVID-19, resulting in a temporary decline in TB testing and reporting. McQuaid et al.

(2020) similarly noted that reduced access to care, coupled with lockdown restrictions, contributed to underreporting of TB cases during the height of the pandemic.

Interestingly, the post-COVID-19 period recorded a higher proportion of TB positive cases (0.3111) than during the pandemic (0.2937). However, this increase was statistically insignificant ($p = 0.121$), suggesting that while some recovery in diagnostic activity may have occurred, it was not substantial enough to yield a statistically meaningful difference. This finding reflects a slow rebound in TB surveillance activities post-pandemic, likely due to persistent resource constraints and a gradual return to normal healthcare operations—a trend also observed in studies by Zimmer et al. (2021).

Furthermore, the comparison between the pre-COVID-19 era (0.3952) and post-COVID-19 period (0.3111) shows a significant decline in TB positivity rates ($p = 0.000$). This reduction may be attributed, in part, to improved health practices adopted during the pandemic, such as mask-wearing, increased hygiene, and enhanced public health awareness, which may have had residual effects in reducing the transmission of airborne diseases like TB. Research by Shen et al. (2022) also suggests that non-pharmaceutical interventions implemented for COVID-19 may have concurrently reduced the incidence of other respiratory infections, including TB.

Factors influencing the number of positive TB cases

Multiple linear regression showed that the number of TB-positive is influenced by the period, gender-age group, Rif-resistance TB status, HIV status, facility and TB samples. The results showed that both pre and post-COVID-19 checks resulted in increased number of positive TB cases shown by estimates of 0.1652 and 0.1239. However, only pre-COVID samples significantly contributed to an increase in positive cases as shown by a p-value of 0.0002. Within the gender-age group category, results showed that males with HIV, aged 5 years and above were contributed the most towards the recorded positive TB cases as shown by a high estimate of 7.4567, compared to females. Females aged 5 years and above and males between the age of 0 to 5 also increase the number of positive TB cases recorded with estimates of 6.8245 and 1.6099. The influence of each of these categories was significant with the exception of males between 0 to 5 years where a p-value of 0.1417 was observed, above the 5% level of significance. The observation can be justified since we expect few children to be infected with TB.

The results also showed that people living with HIV negatively and significantly influenced the total number TB-positive cases. This is supported by the negative estimate of -0.0069 and an associated p-value of 0.000, less than the 5% level of significance.

Facility also played a crucial role in determining the volume of TB samples collected. Masvingo recorded the highest positive estimate of 1.0355, indicating that this location contributed the most to increased sample collection. This could be attributed to the relatively higher number of hospitals and diagnostic centres in the area, improving accessibility for residents. Other facilities that positively influenced sample collection included Chivi, Gutu, Morgenster, Musiso, Neshuro, and Silveira. In contrast, locations such as Ndanga and Rutenga showed negative influences on TB sample collection. These areas are predominantly rural, with limited healthcare infrastructure and lower levels of health awareness, which likely contributed to the reduced number of samples collected.

Those with a positive Rif-resistance TB Status positively and significantly contributed to the number of TB-positive cases collected. This can be expressed by a positive estimate of 0.1517 and a p-value of 0.000 less than the 5% level of confidence. A positive relationship was also observed between the number of TB-samples and the number of

TB-positive cases. This is reasonable since the more the number of tests carried out, the greater the chance of having TB-positive case.

5.3.4 Trend analysis of Rif-resistance TB cases

The study findings revealed a notable variation in the proportion of Rifampicin-resistant tuberculosis (RR-TB) cases across the pre-COVID-19, during COVID-19, and post-COVID-19 periods. Specifically, the highest proportion of RR-TB cases was observed in the pre-COVID-19 period at 43.14%, compared to 39.22% during the COVID-19 pandemic. This may reflect disruptions in TB diagnostic services, where undetected or unreported cases masked actual prevalence rates. According to McQuaid et al. (2020), many countries experienced reduced TB case notifications during the pandemic due to lockdowns, limited access to diagnostic services, and repurposing of resources toward COVID-19, rather than reflecting a true decline in TB transmission or resistance. However, this difference was statistically insignificant ($p = 0.6695$), suggesting that the observed change could be due to random variation rather than a systemic shift attributable to the pandemic onset.

In contrast, a significant decline in RR-TB cases was noted between the COVID-19 period (39.22%) and the post-COVID-19 period (17.65%), with a p-value of 0.001, indicating a statistically significant difference at the 5% level. The significant decline in RR-TB cases could suggest a recovery of healthcare services, improved surveillance systems, or potentially altered patient behavior, such as increased adherence to treatment due to health awareness raised during the pandemic. Moreover, a comparison between the pre-COVID-19 and post-COVID-19 periods also showed a statistically significant reduction in RR-TB prevalence (43.18% vs. 17.65%; $p = 0.0000$), reinforcing the conclusion that RR-TB cases markedly declined following the pandemic period. Furthermore, the high RR-TB proportion observed pre-pandemic underscores the pre-existing burden of drug-resistant TB in the population, highlighting the need for sustained investment in diagnostics, particularly GeneXpert testing, which plays a crucial role in early RR-TB detection Francesco (Bonacina *et al.*, 2023).

Factors influencing the number of Rif-Resistant TB cases

The results from the multiple Poisson linear regression analysis revealed time period, gender-age group, TB status, HIV status, facility location, and the number of TB samples collected influence the number of Rif-resistant TB cases recorded with further details given below.

The regression model estimated a coefficient of -0.8418 for the post-COVID-19 period and -0.1051 for the pre-COVID-19 period, suggesting that the post-pandemic era was associated with a sharper reduction in TB sample collection and RR-TB detection. This aligns with findings from proportional tests that showed a higher proportion of samples collected in the pre-pandemic period. These results underscore the disruptive impact of the COVID-19 pandemic on routine TB surveillance and diagnostics. As Zimmer (2021) observed, disruptions to health services during COVID-19 continue to have lingering effects, with only minimal recovery observed in TB testing capacities in several low-resource settings. The implications are critical, as delayed testing may contribute to silent transmission chains and missed opportunities for early detection of drug-resistant TB cases.

Gender-age group analysis showed that females aged above 5 years and males aged above 5 years had positive but statistically insignificant associations with RR-TB case detection, with estimates of 17.8681 and 17.9601 respectively ($p = 0.9845$ for both). In contrast, males aged 0–5 years demonstrated a negative and insignificant contribution ($p = 1.0000$), suggesting limited impact on RR-TB detection among this age group. While the lack of statistical significance may reflect small sample sizes in these subgroups, the findings still raise important considerations about screening practices and access disparities among children. Similar observations were reported by Dodd et al. (2020), who emphasized that childhood TB, especially among boys, is often underdiagnosed due to nonspecific symptoms and limited paediatric TB diagnostics.

Positive TB status was found to significantly predict RR-TB case detection (estimate = 0.1600, p = 0.0000), reaffirming the clinical fact that resistance can only manifest in individuals already infected with TB. This finding highlights the importance of routine drug susceptibility testing as a standard component of TB diagnosis, especially in high-burden regions.

Although positive HIV status was positively associated with RR-TB detection (estimate = 0.0022), the association was statistically insignificant (p = 0.6967). This may suggest that people living with HIV, aware of their health vulnerabilities, adhere more strictly to treatment and follow-up regimens. Studies such as those by Kwan and Ernst (2011) have indicated that HIV-positive individuals often receive more comprehensive healthcare support, potentially mitigating the risk of drug resistance through better treatment adherence and early interventions.

Facility location was another critical determinant of RR-TB case detection. Masvingo recorded the highest positive estimate (1.1822), indicating a significant contribution to overall RR-TB cases. This can be attributed to higher population density, better access to diagnostic services, and the presence of multiple healthcare facilities. Similarly, Chivi, Gutu, Musiso, and Neshuro also positively influenced RR-TB detection. These findings support literature suggesting that urban and peri-urban areas often yield higher diagnostic outputs due to increased health-seeking behavior and proximity to services (Kendall et al., 2021).

Conversely, rural areas such as Ndanga, Rutenga, and Silveira showed negative associations, which could be explained by limited infrastructure, low TB awareness, and barriers to accessing health facilities. These findings resonate with those of Lönnroth et al. (2009), who reported that geographic and economic disparities are key obstacles in TB control, especially in under-resourced settings.

A positive relationship was observed between the number of TB samples collected and the number of RR-TB cases recorded (coefficient = 0.0088), which is both expected and intuitive. As diagnostic coverage expands, the likelihood of detecting drug-resistant cases naturally increases. This highlights the importance of strengthening TB case-finding efforts, especially in the wake of pandemic-related disruptions. As noted by the WHO (2022), scaling up diagnostic testing is essential to closing the global detection gap and curbing the spread of drug-resistant TB strains.

5.4 Recommendations

To enhance TB control efforts, the following recommendations are proposed:

1. **Enhance Active TB Case Finding**: Increase client presumption and implement targeted screening campaigns in high-risk areas, such as mines and prisons, to identify and treat cases more effectively.
2. **Improve Diagnosis in Young Children**: Increase the presumption and diagnosis of TB in children under the age of 5 by integrating TB services into the Expanded Program on Immunization (EPI) activities, ensuring that this vulnerable population is adequately screened and treated.

3. **Mentorship for Specimen Collection**: Provide mentorship to healthcare workers on the proper collection of stool specimens for GeneXpert testing, ensuring accurate and timely diagnoses.
4. **Optimize Treatment Outcomes**: Focus on improving treatment outcomes for clients with Rifampicin-resistant TB (RR-TB) through tailored management strategies and follow-up care.
5. **Conduct Contact Investigations**: Implement contact investigations in accordance with established guidelines, ensuring that child contacts are screened to prevent further transmission of TB.
6. **TB Preventive Therapy for HIV-positive Clients**: Ensure that all HIV-positive clients are placed on TB Preventive Therapy (TPT) to mitigate the risk of contracting TB and improve overall health outcomes.
7. **Standardize Reflex Testing**: Standardize reflex testing for all TB-positive clients to identify Rifampicin-resistant TB earlier. This will facilitate appropriate management and help reduce the spread of drug-resistant TB strains.
8. **Develop Contingency Plans for Sample Transportation**: Create contingency plans for the transportation of samples during rainy seasons when Integrated Sample Transport (IST) riders may face mobility challenges, ensuring that sample integrity is maintained.
9. **Implement Quality Improvement Projects**: Facilities should undertake Quality Improvement projects aimed at addressing TB indicators, fostering a culture of continuous quality improvement to enhance service delivery and patient outcomes.

By adopting these recommendations, healthcare providers can significantly improve TB detection, treatment, and prevention efforts, ultimately contributing to better health outcomes in the affected populations.

5.5 Limitations

The researcher intended to collect data from the TB register, GeneXpert reports, and LIMS reports, followed by data triangulation before data analysis. However, since the GeneXpert reports did not include patient ages, the researcher relied solely on the data from the TB registers. As a result, triangulation among the TB register, GeneXpert report, and LIMS report was not performed before the analysis.

5.4 Conclusion

With all the challenges faced during COVID-19 and its effects on TB care, the only way to get back on track is by implementing the recommendations listed above. It is the duty of the government to avail all the resources needed to support TB activities so that facility staff will implement the program with fidelity.

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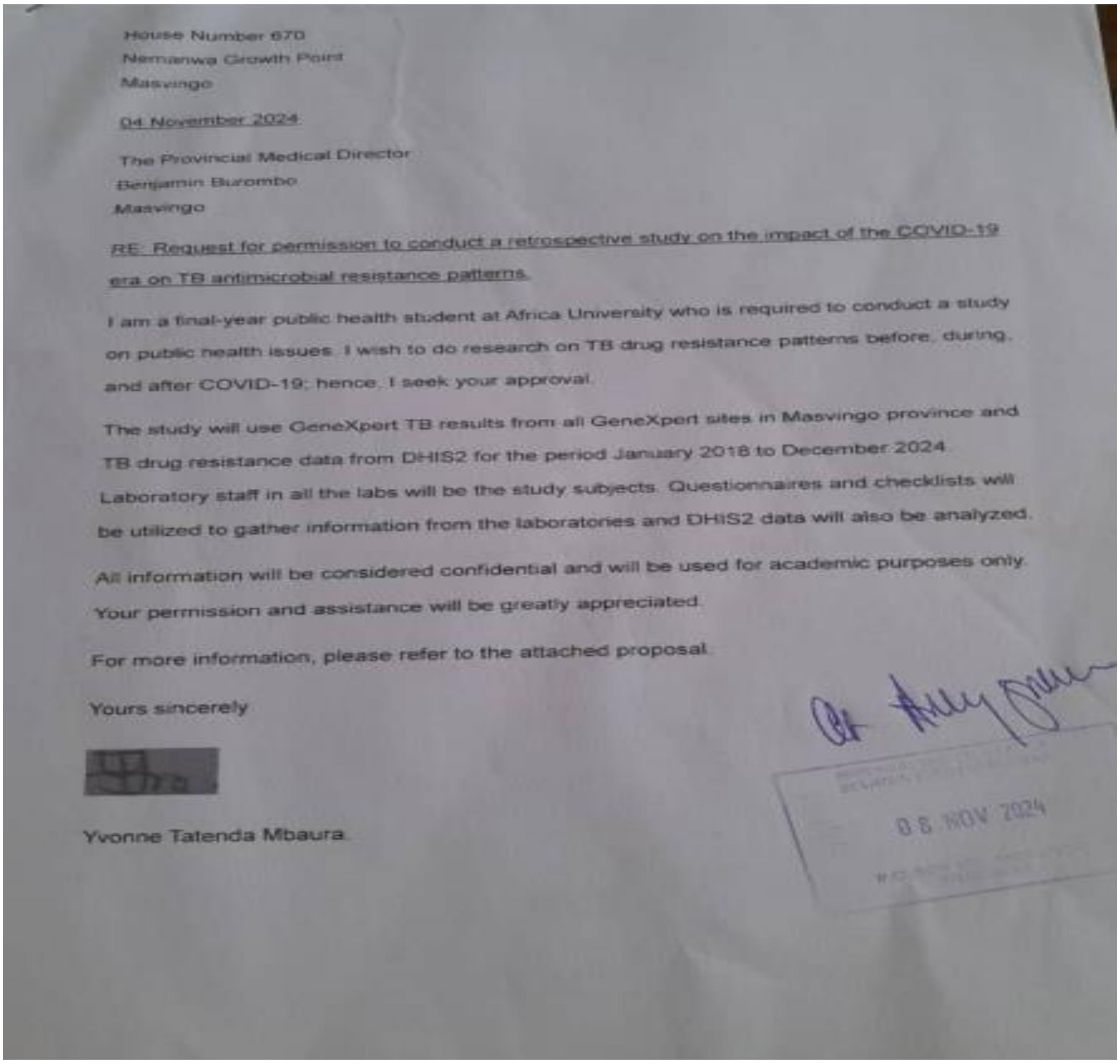
7. APPENDICES

7.1 MoHCC Approval letter



House Number 670
Nemanwa Growth Point
Masvingo

04 November 2024

The Provincial Medical Director
Benjamin Burombo
Masvingo

RE: Request for permission to conduct a retrospective study on the impact of the COVID-19 era on TB antimicrobial resistance patterns.

I am a final-year public health student at Africa University who is required to conduct a study on public health issues. I wish to do research on TB drug resistance patterns before, during, and after COVID-19; hence, I seek your approval.

The study will use GeneXpert TB results from all GeneXpert sites in Masvingo province and TB drug resistance data from DHIS2 for the period January 2018 to December 2024. Laboratory staff in all the labs will be the study subjects. Questionnaires and checklists will be utilized to gather information from the laboratories and DHIS2 data will also be analyzed.

All information will be considered confidential and will be used for academic purposes only. Your permission and assistance will be greatly appreciated.

For more information, please refer to the attached proposal.

Yours sincerely

Yvonne Tatenda Mbaura

08 NOV 2024

7.2 AUREC approval letter

AFRICA UNIVERSITY
A United Methodist-Related Institution
"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 3774/25

17 March, 2025

YVONNE TATENDA MBAURA
C/O Africa University
Box 1320
MUTARE

RE: ***THE EFFECTS OF THE COVID-19 REGULATIONS/POLICIES ON RIFAMPICIN-RESISTANT TB PATTERNS IN MASVINGO PROVINCE, MASVINGO, ZIMBABWE***

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 3774/25
  This number should be used on all correspondences, consent forms, and appropriate document
- **AUREC MEETING DATE** NA
- **APPROVAL DATE** March 17, 2025
- **EXPIRATION DATE** March 17, 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.

AFRICA UNIVERSITY
RESEARCH ETHICS COMMITTEE (AUREC)
APPROVED
P.O. BOX 1320, MUTARE, ZIMBABWE

Yours Faithfully

Chinzou

MARY CHINZOU
FOR CHAIRPERSON
AFRICA UNIVERSITY RESEARCH ETHICS COMMITTEE

7.3 Unprocessed Quantitative Data

7.3.1 Overall Statistics

Characteristics	Pre CVD		During CVD		Post CVD		Total	
	f	%	f	%	f	%	f	%
Samples	17758	41.34	13273	30.90	11926	27.76	42957	100.00
HIV Positives	7573	33.89	7819	34.99	6953	31.12	22345	100.00
TB Positives	1358	39.52	1009	29.37	1069	31.11	3436	100.00
RR- TB	44	43.14	40	39.22	18	17.65	102	100.00

7.3.2 Overall statistics by month

Month	Samples		HIV Positives		TB Positives		RR-TB	
	f	%	f	%	f	%	f	%
JAN	3101	7.22	1631	7.30	327	9.52	13	12.75
FEB	3147	7.33	1443	6.46	272	7.92	11	10.78
MAR	4357	10.14	2245	10.05	319	9.28	7	6.86
APR	3041	7.08	1557	6.97	245	7.13	7	6.86
MAY	3142	7.31	1529	6.84	261	7.60	9	8.82
JUN	3401	7.92	1744	7.80	263	7.65	7	6.86
JUL	4109	9.57	2148	9.61	316	9.20	4	3.92
AUG	3892	9.06	1930	8.64	291	8.47	10	9.80
SEP	4670	10.87	3045	13.63	300	8.73	9	8.82
OCT	3636	8.46	1728	7.73	265	7.71	7	6.86

NOV	3814	8.88	1942	8.69	307	8.93	9	8.82
DEC	2647	6.16	1403	6.28	270	7.86	9	8.82
Total	42957	100.00	22345	100.00	3436	100.00	102	100.00

7.3.3 Overall statistics by facility

Facility	Samples		HIV Positives		TB Positives		RR-TB	
	f	%	f	%	f	%	f	%
CHIKOMBEDZI	1330	3.10	1051	4.70	184	5.36	5	4.90
CHIVI	6761	15.74	2336	10.45	466	13.56	10	9.80
GUTU	5554	12.93	1787	8.00	313	9.11	6	5.88
MASVINGO	9988	23.25	3644	16.31	837	24.36	37	36.27
MORGENSTER	1840	4.28	1470	6.58	269	7.83	3	2.94
MUSISO	2603	6.06	2266	10.14	254	7.39	9	8.82
NESHURO	9058	21.09	7816	34.98	515	14.99	19	18.63
NGANGA	760	1.77	255	1.14	33	0.96	1	0.98
RUTENGA	907	2.11	431	1.93	66	1.92	4	3.92
SILVEIRA	4156	9.67	1289	5.77	499	14.52	8	7.84
Total	42957	100.00	22345	100.00	3436	100.00	102	100.00

7.3.4 Overall statistics by year

Year	Samples		HIV Positives		TB Positives		RR-TB	
	f	%	f	%	f	%	f	%
2018	9819	22.86	3905	17.48	703	20.46	17	16.67
2019	7939	18.48	3668	16.42	655	19.06	27	26.47
2020	5561	12.95	2897	12.96	540	15.72	17	16.67
2021	7712	17.95	4922	22.03	469	13.65	23	22.55
2022	6362	14.81	3742	16.75	583	16.97	10	9.80
2023	5564	12.95	3211	14.37	486	14.14	8	7.84
Total	42957	100.00	22345	100.00	3436	100.00	102	100.00

7.3.5 Overall statistics by gender and age

Gender	Age Group (years)	Samples		HIV Positives		TB Positives		RR-TB	
		f	%	f	%	f	%	f	%
Females	(0-5)	147	0.34	41	0.18	1	0.03	0	0.00
Females	>5	23086	53.74	12597	56.38	1211	35.24	41	40.20
Males	(0-5)	152	0.35	59	0.26	5	0.15	0	0.00
Males	>5	19572	45.56	9648	43.18	2219	64.58	61	59.80
Total		42957	100.00	22345	100.00	3436	100.00	102	100.00

7.3.6 RR-TB by facility

Facility	Pre CVD		During CVD		Post CVD		Total	
	f	%	f	%	f	%	f	%
CHIKOMBEDZI	1	2.27	2	6.00	2	12.50	5	4.90
CHIVI	3	6.82	6	14.00	1	0.00	10	9.80
GUTU	4	9.09	2	4.00	0	0.00	6	5.88
MASVINGO	15	34.09	18	38.00	4	37.50	37	36.27
MORGENSTER	1	2.27	2	4.00	0	0.00	3	2.94
MUSISO	5	11.36	4	8.00	0	0.00	9	8.82
NESHURO	9	20.45	3	18.00	7	12.50	19	18.63
NGANGA	0	0.00	0	0.00	1	12.50	1	0.98

RUTENGA	1	2.27	2	6.00	1	0.00	4	3.92
SILVEIRA	5	11.36	1	2.00	2	25.00	8	7.84
Total	44	100.00	50	100.00	8	100.00	102	100.00

7.3.7 RR-TB by gender and age

Gender	Age group	Pre CVD		During CVD		Post CVD		Total	
		f	%	f	%	f	%	f	%
Females	(0-5)	0	0.00	0	0.00	0	0.00	0	0.00
Females	>5	18	40.91	16	40.00	7	38.89	41	40.20
Males	(0-5)	0	0.00	0	0.00	0	0.00	0	0.00
Males	>5	26	59.09	24	60.00	11	61.11	61	59.80
Total		44	100.00	40	100.00	18	100.00	102	100.00

7.4 TB Coordinator Interview Guide

TB Coordinator Interview Guide

Section A: Trend in TB sample collection, HIV positives, TB positives, and Rif resistance.

1. What caused the downward trend in the number of samples processed?
2. Which factors contributed to a pick in HIV-positive TB patients?
3. What are the possible attributes of a drop in both TB positives and Rif-resistance cases?

Section B: Prevalence of drug-sensitive TB and Rif-resistance TB in males

4. What are the reasons for males being more susceptible to TB than females?

Section C: Childhood TB

5. Are there any challenges in screening children for TB and sample collection in children?

Section D: TB hotspots (Masvingo, Mwenezi, Chiredzi, Province)

6. Why are there high TB cases and Rif-res cases in your district?

Section E: Low numbers in Zaka (Ndanga)

7. Why does Ndanga have fewer samples compared to Musiso which is in the same district?

Section F: Year-on-year Rif-resistance analysis

8. What may be the reasons for a pick of Rif-resistance TB in 2021?

Section G: Month-on-month analysis of the number of samples collected?

9. Why are there picks in TB samples collected during the first quarter and the third quarter of the year?

7.4.1 PTBC interview responses

Section A: Trend in TB sample collection, HIV positives, TB positives, and Rif resistance.	
1. What caused the downward trend in the number of samples processed?	The main confounder was the restriction to movements. Other reasons could be health worker fear, no one wanted to work with COVID-19 patients, in the sense that there were no security measures to protect healthcare workers from contracting the disease. Those are some of the reasons why we have a relatively lower presumption rates with regards to TB when someone presented at health facility.
2. Which factors contributed to a pick in HIV-positive TB patients?	During the lockdown, sexual activities were high, yet people couldn't visit clinics to get preventive measures like condoms, attributing to a peak in HIV-positive patients. Most of the idle time people would use it for sexual activities. The other issue is Gender Based Violence, yes, they were not heralded but they were very high during that period in the sense that people were home fulltime which may have led to more of sexual infringement which probably was the room for a rise in new HIV cases.
3. What are the possible attributes of a drop in both TB positives and Rif-resistance cases?	
Section B: Prevalence of drug-sensitive TB and Rif-resistance TB in males	
4. What are the reasons for males being more susceptible to TB than females?	Generally, besides the TB drug resistance being dominant in males, even the drug sensitive TB is also dominant in males when you look on your demographic data for any given period. We the males after taking alcohol we do not eat nutritious food. So, issues to do with low blood sugar levels or unbalanced diet due to feeding habits promote TB, and DR-TB. Another end is that usually males play most of the transmission in the sense that the sources of transmission especially HIV is more predominant in males. The other issue is our health behaviour, we were taught to be brave as men. We do not usually go to the hospital for small issues. So, by the time we go to the clinic, the condition will be extreme. If you look at the cases like DR-TB cases, most of them are linked to clients who run away from South Africa through Limpopo, and come to Mwenezi, Chiredzi and then get picked. So, because of our social stricture, males usually go out to look for work and when we get there, we look for other wives yet the housing conditions there are not good. All these are predisposing factors to TB and DR-TB.
Section C: Childhood TB	
5. Are there any challenges in screening children for TB and sample collection in children?	This is due to poor diagnosis and knowledge gap for staff. In terms of specimen collections, old nurses are the ones who know about gastric lavage sample collection. The new nurses would say that when we were trained, they were not taught about these things, so they don't even have the know-how to perform a gastric specimen collection on children. As a result, children’s samples are not being taken for TB screening. The adoption of stool sample processing for TB diagnosis during and post COVID-19 will be a game changer. The health workers were not yet trained because it was only late last year, that's when the use of stool was advocated for, for TB diagnosis.
Section D: TB hotspots (Masvingo, Mwenezi, Chiredzi, Province)	
6. Why are there high TB cases and Rif-res cases in your district?	District size, population size and economic activity. So, fusion of the three; land size, population size and economic activities causes high TB and Rif-resistance cases.
Section E: Low numbers in Zaka (Ndanga)	
7. Why does Ndanga have fewer samples compared to Musiso which is in the same district?	
Section F: Year-on-year Rif-resistance analysis	
8. What may be the reasons for a pick of Rif-resistance TB in 2021?	Before the outbreak of the epidemic, most of the surveillance systems will be somehow relaxed. During the peak of any outbreak, surveillances will be on high alert. So, anything that pops up will be thoroughly investigated. I can also attribute this to people coming from beyond our borders, our colleagues returning home, in the sense that no one wanted to die in a native land. So, most people were coming back to Zimbabwe, from there they will seek treatment and eventually from there they will be picked as Rif-resistance cases.
Section G: Month-on-month analysis of the number of samples collected?	
9. Why are there picks in TB samples collected during the first quarter and the third quarter of the year?	

7.4.2 DTBC 1 interview responses

Section A: Trend in TB sample collection, HIV positives, TB positives, and Rif resistance.	
1. What caused the downward trend in the number of samples processed?	During the COVID-19 period, almost everyone had diverted their minds, neglecting the TB program, focusing on COVID-19. This was because COVID-19 had an effect of taking many people's lives therefore the community was in the panic mode. Usually as healthcare workers, everyone who came with TB signs and symptoms was labelled a COVID-19 case, like if we look at COVID-19, it had similar symptoms with TB. That's when we missed some of the cases that when a person comes presenting TB signs and symptoms and we say it's COVID-19. The other thing is that there were COVID-19 restrictions, so in terms of us doing active TB case finding, we were not able to do that. We were doing what is known as passive, that is waiting for the patient to come and then get screened, of which TB screening was rare, unless the symptoms are extreme like HIV positive, the rest were assumed to be COVID-19 cases. That's where we missed TB cases and had a lower presumption rate.
2. Which factors contributed to a pick in HIV-positive TB patients?	As I alluded to earlier, during COVID-19, we were mostly concerned with the issue of risk groups. COVID-19 mostly affected co-morbidity groups, of which that’s when we would say those with HIV we would take samples. Them knowing that they are at risk, they would come, and we take samples for testing both HIV and TB. That's where our strength was in terms of co-morbidity and integration of services.
3. What are the possible attributes of a drop in both TB positives and Rif-resistance cases?	As institutions we no longer had the resources to use for other conditions other than COVID-19 as resources were shifted to combat the pandemic. Another thing is that people were now relaxed, and most people were wiped out by COVID-19, so they were neglecting TB, focusing on COVID as they perceived it as most dangerous compared to TB. So after the pandemic in 2023, we were now getting back to healthcare workers, training them so that we can start-up the TB program. People had no longer had that zeal for TB screening. Since we had stopped the TB services, starting again needs resources, which we did not have, leading to a drop in TB positive cases.
Section B: Prevalence of drug-sensitive TB and Rif-resistance TB in males	
4. What are the reasons for males being more susceptible to TB than females?	In most cases, males are the ones who hustle more, especially in mines. Males are the ones who provide for the family, so when they look for jobs they mix and mingle with many people, some of them will be infected with TB. Even in prisons where TB is prevalent, males are predominant, and they will the exposed to different TB-causing conditions. The other issue is that most males rarely go to hospitals or clinics for medical services and treatment. They can get sick and look for pills somewhere, without going to the clinic. Males can get TB but fail to comply with TB medication, they do not finish the course.
Section C: Childhood TB	
5. Are there any challenges in screening children for TB and sample collection in children?	During COVID-19 there were restrictions, and usually children would not come to hospitals. Pre-COVID-19 we were using gastric aspirates or gastric lavage for childhood TB diagnosis. Just after COVID-19 that's when we got a training for childhood screening that was requiring health workers to use stools for GeneXpert testing in children. So, the time when we received that training that's when I think we had a peak. Pre-COVID-19, childhood TB screening was usually referred to referral centres because health workers at clinics were not competent to collect gastric lavage, in other words gastric lavage was only done by a doctor. That's why there was an introduction of stools for GeneXpert testing.
Section D: TB hotspots (Masvingo, Mwenezi, Chiredzi, Province)	
6. Why are there high TB cases and Rif-res cases in your district?	Due to the location of our district, we do not have more migrants, of course we have them here and there. Our district is different from districts like Chiredzi and Mwenezi, which are closer to the border. Therefore, migrants are very few.
Section E: Low numbers in Zaka (Ndanga)	
7. Why does Ndanga have fewer samples compared to Musiso which is in the same district?	
Section F: Year-on-year Rif-resistance analysis	

8. What may be the reasons for a pick of Rif-resistance TB in 2021?	
Section G: Month-on-month analysis of the number of samples collected?	
9. Why are there picks in TB samples collected during the first quarter and the third quarter of the year?	There's a period when our community will be farming. There's a time when people come back home for farming and then go back to work, where they will be exposed to harsh conditions. I think they go back to work usually beginning of April up to October and then come back. During that period, I think that's when they will be exposed.

7.4.3 DTBC 2 interview responses

Section A: Trend in TB sample collection, HIV positives, TB positives, and Rif resistance.	
1. What caused the downward trend in the number of samples processed?	During the COVID-19 era, we can see that most clinicians were now concentrating more on screening COVID-19 than TB and any other disease. So, it resulted in the decline even in our presumptive cases from that period.
2. Which factors contributed to a pick in HIV-positive TB patients?	It might be the cases that were coming from clinics and other areas. So those people maybe at that period they were suspecting that they have COVID-19. So, they would come and seek medication, that's why there was a peak in these cases during that period.
3. What are the possible attributes of a drop in both TB positives and Rif-resistance cases?	
Section B: Prevalence of drug-sensitive TB and Rif-resistance TB in males	
4. What are the reasons for males being more susceptible to TB than females?	Masvingo is closer to Beitbridge and most of those cases are coming from South Africa. Mostly, men are very mobile, they would come from South Africa after they have contracted the disease.
Section C: Childhood TB	
5. Are there any challenges in screening children for TB and sample collection in children?	The most challenge that I have noted is that most of the clinicians are not comfortable in doing gastric lavage used for TB diagnosis in children. So, you would find that because of that, screening of childhood TB was very low up until recently when we now have two other means of screening TB which are TB LAM and stool for GeneXpert.. Up to now gastric lavage needs some training because some clinicians are not comfortable in doing that.
Section D: TB hotspots (Masvingo, Mwenezi, Chiredzi, Province)	
6. Why are there high TB cases and Rif-res cases in your district?	
Section E: Low numbers in Zaka (Ndanga)	
7. Why does Ndanga have fewer samples compared to Musiso which is in the same district?	The reason might be Ndanga sometimes have challenges with gene expert cartridges. GeneXpert machine is the one used to analyze TB samples. So, in general we frequently face shortages of commodities for testing clients.
Section F: Year-on-year Rif-resistance analysis	
8. What may be the reasons for a pick of Rif-resistance TB in 2021?	
Section G: Month-on-month analysis of the number of samples collected?	
9. Why are there picks in TB samples collected during the first quarter and the third quarter of the year?	During holidays, most of those who are in South Africa and other countries will be at their rural homes. So, if they are not well, they would visit the hospital, that is when we would collect more samples.

7.4.4 DTBC 3 interview responses

Section A: Trend in TB sample collection, HIV positives, TB positives, and Rif resistance.	
1. What caused the downward trend in the number of samples processed?	The leakages during transportation and processes might have caused the number of samples which were collected not to be equal to the numbers which were received at the testing laboratories. Again, there are some testing errors that occurs in that laboratory during testing. Since COVID-19 samples were being processed on the GeneXpet machine which is used for TB samples some TB samples that were sent to the laboratory failed to be processed due to the high workload
2. Which factors contributed to a pick in HIV-positive TB patients?	Mwenezi being a boarder district has a higher number of diaspora clients, compared to Masvingo. The clients default HIV treatment and are difficult to manage. These clients are in South Africa where TB is more prevalent and therefore a high number of HIV/TB co-infection.
3. What are the possible attributes of a drop in both TB positives and Rif-resistance cases?	
Section B: Prevalence of drug-sensitive TB and Rif-resistance TB in males	
4. What are the reasons for males being more susceptible to TB than females?	In most cases TB is a co-infection with HIV. Even in HIV you will find that more females are being affected. Those with HIV are more exposed to TB infection. Most of the males go to South Africa searching for work, that is where they contract the infection. Most of them come back and get diagnosed with TB. So, it's almost 50-50, females are infected and so as males.
Section C: Childhood TB	
5. Are there any challenges in screening children for TB and sample collection in children?	In Mwenezi, most of the healthcare workers were trained in childhood TB management, how to identify and to collect the TB samples for diagnosis. However, there's a challenge. TB in children present in various conditions. Sometimes when a child comes with TB symptoms, technicians can simply say this child has pneumonia or upper respiratory tract infection. So, in this case it means this child is not presumed for TB. So, this is why samples are very few for children because of misdiagnosis. Again, the procedure for collecting samples using the gastric tube, some people have attitudes leading them not to collect specimen. But they are now using the stool.
Section D: TB hotspots (Masvingo, Mwenezi, Chiredzi, Province)	
6. Why are there high TB cases and Rif-res cases in your district?	As I alluded to earlier that we are nearer to South Africa, many of our workforce are going to South Africa for greener pastures. South Africa is a higher burdened country for TB. You can even find that in our registers, most of these cases are being diagnosed from South Africa. They fall sick and they come back to their homes in Zimbabwe. When they come now, we pick those cases and diagnose TB resistant cases. Some of them work as artisanal miners, exposing themselves in dusty areas, increasing the chances of getting TB.
Section E: Low numbers in Zaka (Ndanga)	
7. Why does Ndanga have fewer samples compared to Musiso which is in the same district?	
Section F: Year-on-year Rif-resistance analysis	
8. What may be the reasons for a pick of Rif-resistance TB in 2021?	
Section G: Month-on-month analysis of the number of samples collected?	

9. Why are there picks in TB samples collected during the first quarter and the third quarter of the year?	Transportation of TB samples is really affected by the rains. TB sputum samples are transported from the facilities to testing laboratories by IST (Integrated Sample Transportation) riders of the Ministry of Health and Child Care. Mobility of these riders is affected by bad roads during the rainy season that is why the number of samples pick before and after the rains. Furthermore, screening of TB tends to just after the public holidays and during winter.

7.4.5 DTBC 4 interview responses

Section A: Trend in TB sample collection, HIV positives, TB positives, and Rif resistance.	
1. What caused the downward trend in the number of samples processed?	People were just concentrating on COVID-19 during that period.
2. Which factors contributed to a pick in HIV-positive TB patients?	Most of our positives are coming from mining areas, especially the Ngundu areas down up to Gororo and Nyahombe. Again, even the proximity to the boarder as well contributes to more cases. There are some of the migrants who will be coming from South Africa, which is one of the high burdened countries in terms of TB. Females are tested for HIV more than males. In the HIV program the male population is becoming a special population were strategies and innovations are being implemented to try and screen them for HIV. Examples of these programs are the Mbereko Men Plus program and the midnight outreaches that are focusing on men. So, in other words the findings are just showing gaps in HIV testing in men
3. What are the possible attributes of a drop in both TB positives and Rif-resistance cases?	
Section B: Prevalence of drug-sensitive TB and Rif-resistance TB in males	
4. What are the reasons for males being more susceptible to TB than females?	It might be because males are the ones who mostly work in areas like mines and some of them will be employed in construction companies where they will be exposed to dust. Again, most males do smoke, taking alcohol, I think that could be another reason.
Section C: Childhood TB	
5. Are there any challenges in screening children for TB and sample collection in children?	I think paediatric screening was very low. I think the other reason is that in the previous years only gastric lavage sample was the only one used in TB diagnosis in children. Most people couldn't collect those gastric washes, unlike these days where there are many methods of screening, the likes of stool for geneXpert.
Section D: TB hotspots (Masvingo, Mwenezi, Chiredzi, Province)	
6. Why are there high TB cases and Rif-res cases in your district?	
Section E: Low numbers in Zaka (Ndanga)	
7. Why does Ndanga have fewer samples compared to Musiso which is in the same district?	
Section F: Year-on-year Rif-resistance analysis	
8. What may be the reasons for a pick of Rif-resistance TB in 2021?	
Section G: Month-on-month analysis of the number of samples collected?	
9. Why are there picks in TB samples collected during the first quarter and the third quarter of the year?	

7.4.6 DTBC 5 interview responses

Section A: Trend in TB sample collection, HIV positives, TB positives, and Rif resistance.	
1. What caused the downward trend in the number of samples processed?	During COVID-19, people were deprived of accessing health services. On the other hand, during that period, people concentrated mostly on people with COVID-19 symptoms, neglecting the TB program. On the other hand, during COVID-19, people were also encouraged to wear facemasks as well as maintaining social distance, thereby reducing the chances of spreading TB.
2. Which factors contributed to a pick in HIV-positive TB patients?	During pre-COVID, samples were high (HIV positive, TB positive and TB-resistance). During COVID, some samples dropped but HIV positive remained high. For HIV positive, the reason might be because during COVID-19 people were forced to stay at home, not accessing health services. Again, some women were being abused (rape), having nowhere to report and get assistance in terms of HIV testing and getting some medication(prophylaxis). The other issue is, since we were not allowed to travel and access things like condoms or preps, people ended up having unprotected sex, increasing the chances of HIV.
3. What are the possible attributes of a drop in both TB positives and Rif-resistance cases?	Post-COVID, there was drop because when COVID-19 ended, people were now encouraged to go for health services freely without restrictions. Testing services and access to preventive measures resumed. Health education helped us to have a relationship with our patients, letting them know that if anything happens what should be done. Therefore, the health promotion programs and activities that were offered contributed to the drop in TB positives. Resumption of services reduced TB treatment interruption and defaulters.
Section B: Prevalence of drug-sensitive TB and Rif-resistance TB in males	
4. What are the reasons for males being more susceptible to TB than females?	Most of the males' working conditions expose them to TB, for instance, most of the people who work in mines are males. The other thing is that since the males are the head of the family, they have a burden of providing for the family and most of the jobs expose them to TB.
Section C: Childhood TB	
5. Are there any challenges in screening children for TB and sample collection in children?	Sometime ago we used to think that TB in children is not a problem, so we targeted mostly adults. Then on the issue of diagnosis of TB in children, we used to rely on GeneXpert sputum testing of which children cannot produce sputum. Then, gastric lavage was the only sample used to detect TB in children. With the introduction of TB LAM and stool for GeneXpert for TB diagnosis in children, we are now accelerating childhood TB.
Section D: TB hotspots (Masvingo, Mwenezi, Chiredzi, Province)	
6. Why are there high TB cases and Rif-res cases in your district?	Mwenezi, Chiredzi, and Masvingo are TB hotspots due to border with SA, high industrial activities like mining, mobile residents, and a higher population density. All these factors predispose the community to TB.
Section E: Low numbers in Zaka (Ndanga)	
7. Why does Ndanga have fewer samples compared to Musiso which is in the same district?	
Section F: Year-on-year Rif-resistance analysis	
8. What may be the reasons for a pick of Rif-resistance TB in 2021?	
Section G: Month-on-month analysis of the number of samples collected?	
9. Why are there picks in TB samples collected during the first quarter and the third quarter of the year?	Most of the people here in Chiredzi go and work in South Africa and come back on holidays. So, when they come back, we would find more TB cases in January, February because of contact, that is why it seems like it's seasonal, with high numbers after public holidays.

7.4.7 DTBC 6 interview responses

Section A: Trend in TB sample collection, HIV positives, TB positives, and Rif resistance.	
1. What caused the downward trend in the number of samples processed?	During COVID-19, people focused only on COVID than any other condition. When COVID-19 started, information was not clear in clinics. Some were even saying people should not visit clinics. Only a few people would visit the clinics, and the clinics were even closed until they were told that they should not completely close the clinics. For those few people who visited the clinic, nurses would only concentrate on those with COVID-19 symptoms than any other issue. Information was then revealed and samples were taken, lab technicians did not have enough information, due to the COVID-19 samples workload they would say surely how can you bring us samples to check for TB. They even went on to look for circulars and protocols for the procedures on how samples are processed on a multiplexing GeneXpert machine. When they found the circulars on how to test TB during COVID-19, people did not accept it. Facilities healthcare workers were not happy to take TB samples because they fear contracting COVID-19. So, TB samples dropped unexpectedly. Those few ones peaked at the end of COVID when people now had more information, that's when people began to take TB samples otherwise when COVID started, there was completely nothing in terms of TB.
2. Which factors contributed to a pick in HIV-positive TB patients?	
3. What are the possible attributes of a drop in both TB positives and Rif-resistance cases?	
Section B: Prevalence of drug-sensitive TB and Rif-resistance TB in males	
4. What are the reasons for males being more susceptible to TB than females?	Rif-resistance is more common in males. Most of these cases they are exposed to artisanal mining, it's more of an occupational condition. When they get money, they misuse it and end up being exposed to HIV and other sexually transmitted infections. That's why we find more cases in males than females because in those pits where they work, they are exposed to TB bacteria. The other reason is, generally males have poor health seeking behaviours. When they are given anti-TB drugs, they do not take them properly, then sometimes mix with beer. They do not finish their complete anti-TB courses exposing the bacteria to mutation. No one is assigned to monitor whether they take their drugs like what we normally do in other villages with community health workers, whereby we send a village health worker to monitor drug uptake. So, you will find out that males usually default treatment whenever they feel like.
Section C: Childhood TB	
5. Are there any challenges in screening children for TB and sample collection in children?	There's a knowledge gap for staff. In terms of sputum collections, old nurses are the ones who know about gastric lavage. The new nurses would say when we trained, we were not taught about these things, so they don't even have a know-how to do children gastric sputum. As a result, children's samples are not being taken. These are the gaps we thought are going to be addressed, nurses being taught how to do it, whether it's a sample that should be taken at the doctor's level. So, the knowledge gap is too much, causing these samples not to be taken. So, TB LAM will help in the collection of children samples because in terms of gastric collection there is a very wide gap.
Section D: TB hotspots (Masvingo, Mwenezi, Chiredzi, Province)	
6. Why are there high TB cases and Rif-res cases in your district?	Masvingo is an urban area with a higher population size and industrial activities and a higher TB testing capacity than the other districts. At some point, Masvingo provincial hospital was processing samples for both Chiredzi district and Masvingo district. The samples from Chiredzi were coming from Collin Saunders and Hippo Valley private hospitals who do not have GeneXpert machines to process TB samples.
Section E: Low numbers in Zaka (Ndanga)	
7. Why does Ndanga have fewer samples compared to Musiso which is in the same district?	
Section F: Year-on-year Rif-resistance analysis	

8. What may be the reasons for a pick of Rif-resistance TB in 2021?	It might be because there was now knowledge on how to deal with TB during the pandemic. Some who had TB in 2020 were not screened for that because of fear of contracting COVID-19. So, in 2021 people had more knowledge on COVID-19 and TB screening, and we were emphasizing that people should be screened for TB. That is when other people who should have been screened TB in 2020 were screened, causing a rise in TB samples in 2021.
Section G: Month-on-month analysis of the number of samples collected?	
9. Why are there picks in TB samples collected during the first quarter and the third quarter of the year?	Masvingo provincial hospital, I'm not quite sure for the period under review, what was happening in some districts. But normally there was time when some specimen would come from Hippo valley and Colin Saunders for processing because at Masvingo Provincial Hospital because the two private hospitals do not have GeneXpert machines to analyse the sputum samples. Some patients prefer to be treated at Masvingo Provincial Hospital so they would come on their own to be screened here in Masvingo. The district itself has more sites and population as compared to other districts. The district has now been divided into 2, some sputum samples are taken to Morgenster Mission Hospital and others to Masvingo Provincial Hospital.

7.4.8 DTBC 7 interview responses

Section A: Trend in TB sample collection, HIV positives, TB positives, and Rif resistance.	
1. What caused the downward trend in the number of samples processed?	1. Lockdown regulations affected patient flow to the facility, resulting in a reduction in sample collection. There were no clear SOPs/guidelines on the services the healthcare facilities should offer leading to closure of healthcare facilities thus affecting TB continuum of care. People were afraid of contracting Covid therefore they didn't seek medical care during the Covid period. Health care workers shifted focus from any other illness to fight the outbreak in so doing neglecting patients who came for TB services. Misdiagnosis, TB signs and symptoms are the same as Covids so anyone who presented with cough during the COVID period was screened for COVID only. The machine that was being used to process COVID samples is the same used for TB diagnosis. These machines are Point of Care machines which processes fewer number of samples (4 per hour). During the COVID period a lot of COVID samples were collected and these were being prioritised than TB samples leading to a very long turnaround time of TB results. As a result, facilities were no longer collecting the TB samples.
2. Which factors contributed to a pick in HIV-positive TB patients?	Lockdown regulations saw the closure of all kinds of businesses and since most Zimbabweans are self-employed it affected the socioeconomic status of many livelihoods. In a bid to raise funds some resorted to sex work, and this caused a rise in HIV cases. Since borders were closed people were now using truck drivers to transport goods. As we all know that truck drivers are key populations when it comes to HIV and TB, this may have been a driver in HIV and TB cases. As people were spending most of their times at home there was a rise in sexual activities leading to more sexually transmitted diseases. In addition, the rise in sexual abuse and exploitation that happened during the COVID period may be another cause of a pick in HIV cases in women.
3. What are the possible attributes of a drop in both TB positives and Rif-resistance cases?	Number of TB positives and Rif-resistance TB is directly proportional to the total number of TB samples collected. Therefore, since there was a drop in the number of total numbers of TB samples collected it may have caused a drop in the number of TB positive and Rif-resistance cases.
Section B: Prevalence of drug-sensitive TB and Rif-resistance TB in males	
4. What are the reasons for males being more susceptible to TB than females?	Men are more exposed to TB risk factors than women, which are smoking, alcohol abuse, mining activities, prisons, truck driving, and other industrial activities that expose them to dust. Alcohol abuse result in malnutrition which is the greatest risk factor of TB. Health seeking habits of man are poor as compared to women, so when they contract TB, they may try to self-medicate at home and visit the clinic late. By so doing the bacteria become resistant. On the other hand, they can visit the facility in time and get medication, but they default as soon as they feel better causing the bacteria to mutate and become resistant. Men are mobile than women because they need to provide for their families. Some are truck drivers going to placing like South Africa which has a high Rif-resistance TB.
Section C: Childhood TB	
5. Are there any challenges in screening children for TB and sample collection in children?	Children only contract TB from parents or guardians through contact. Therefore, low screening of children means that TB contact tracing and investigation is not being done with fidelity. In addition, children are being missed in baby clinics when they come for their routine checkups. They are not screened for Tb. Therefore, healthcare workers need to integrate TB services into the EPI programs. The other reason is the screening method which was being used to collect a TB sample from a child was complex and most healthcare workers were not experienced on the procedure. Gastric lavage collection was and is still a challenge in the majority of healthcare workers. There was lack of trainings in collection of this type of specimen. After COVID-19 there were trainings in TB management that took place and healthcare workers were trained that stool samples can be used to test for TB in children. We anticipate seeing an improvement in childhood TB since 10% of the TB samples collected must come from children under 5 years.
Section D: TB hotspots (Masvingo, Mwenezi, Chiredzi, Province)	
6. Why are there high TB cases and Rif-res cases in your district?	Mwenezi, Chiredzi, and Masvingo are TB hotspots due to border with SA, high industrial activities like mining, mobile residents, high population.

Section E: Low numbers in Zaka (Ndanga)	
7. Why does Ndanga have fewer samples compared to Musiso which is in the same district?	TB machine breakdown (GeneXpert), reagents stockouts, documentation challenges of samples in the registers
Section F: Year-on-year Rif-resistance analysis	
8. What may be the reasons for a pick of Rif-resistance TB in 2021?	A pick of drug resistance in 2021 was caused by patients defaulting of TB drugs due to shutdown of facilities during the lockdowns. Abuse of antibiotics during self-medication at home during lockdowns may be the other factor that may have caused the pick. Another possibility is late diagnosis of TB cases as facilities were shut down and a lack of resources for diagnosis since the GeneXpert was now being used for COVID-19 diagnosis. The other thing is, the lockdowns led to prolonged exposure time with Rif-resistance TB cases in the community.
Section G: Month-on-month analysis of the number of samples collected?	
9. Why are there picks in TB samples collected during the first quarter and the third quarter of the year?	Holiday traveling led to exposure to TB and also when relatives in SA or any other country with high TB prevalent comes for the Holidays.