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IMPACT OF COVID-19 ON TUBERCULOSIS DIAGNOSIS AND TREATMENT OUTCOMES IN BUHERA DISTRICT, 2022

BY

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Abstract

Zimbabwe implemented a nationwide lockdown starting the 30th of March 2020 to curb the spread of COVID-19. Early in the pandemic, COVID-19 cases were clustered around towns and later spread to rural areas in relatively low numbers. At that time Buhera district did not record a high number of COVID-19 cases until the second quarter of 2020. Since then, the district experienced severe disruptions in the provision of TB care and service delivery more likely from strict lockdown restrictions than COVID-19 infections. A comparative retrospective study was conducted to analyse the impact of COVID-19 on TB case detection, diagnosis, and treatment outcomes in Buhera district. Quarterly TB aggregate data was extracted from the DHIS2. The study periods were divided into the pre-COVID- 19 period (April 2019 to March 2020) and the COVID-19 period (April 2020 to March 2021). Statistical analysis was done using Stata version 13. Comparisons were made between the COVID-19 period and the pre-COVID-19 period, and data were presented as frequencies, percentages, and percentage differences. Overall, 3 870 presumptive TB cases were screened from April 2020 to March 2021 versus 5 804 screened from April 2019 to 2020, representing a 33.3% decrease. The decline was greater in females compared with males (38.6% versus 18.7%; $p<0.05$) respectively, and among adults compared with children (36.3% versus 14.7%, $p<0.05$), respectively. TB testing declined by 37.2% and 34.6% in health facility-initiated referrals and community-initiated referrals respectively. On an encouraging note, laboratory-confirmed TB cases increased by 13.5% during the COVID-19 period though they were a 37.3%, and 22% decrease from April to June and July to September coinciding with the expiry of Xpert MTB/RIF assays cartridges. From April 2020 to March 2021, TB case notifications declined by 5.8%, with a precipitous drop of 41% in the second quarter. The treatment success rates slightly declined throughout the COVID-19 period (90.5% versus 88.6%, $p=0.391$) with lower rates of LTFU (2.5% versus 1.1%), and slightly high rate of not evaluated (0.5% versus 2.1%) compared with the baseline period. The study also found that the mode of diagnosis ($p<0.05$) and type of DOT ($p<0.01$) were statistically significantly associated with treatment success, with bacteriologically confirmed cases increasing by 15.6% over the 12 months of COVID-19. Findings further indicated that the health facility directly observed therapy decreased by 84% whereas the community directly observed therapy increased by 1.4% over the 12 months of the COVID-19 pandemic. A positive change in community treatment was largely attributed to the strengthened use of community health workers in providing adherence and treatment support. Shortened TB clinic hours, temporal closure of TB clinics, movement restrictions, and transportation difficulties among other possible reasons could have led to the drop in the use of the health-facility DOT approach. These results may hold policy implications for the DOTS approach in the Buhera district and suggest the need for more resources to minimize interruption of TB service delivery during and in future pandemics.

Keywords: Buhera; COVID-19; diagnosis; treatment outcomes; Tuberculosis

Declaration

I declare that 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 submitted to another university for the award of a degree.

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List of Acronyms and Abbreviations

ARVs	Anti-Retroviral Therapy
CDC	Centers for Diseases Control and Prevention
CHW	Community Health Worker
COVID-19	Coronavirus Disease 2019
DHIS2	District Health Information System 2
DOT	Direct Observed Treatment
DST	Drug Susceptibility Testing
EHT	Environmental Health Technician
EPTB	Extra Pulmonary Tuberculosis
HBC	High Burdened Countries
HIV	Human Immunodeficiency Virus
IPC	Infection Prevention and Control
LMIC	Low-Middle Income Countries
LTFU	Lost to Follow Up
MoHCC	Ministry of Health and Child Care
MDR	Multi-Drug Resistant
MTB	Mycobacterium Tuberculosis
NGOs	Non-Governmental Organization

NTP	National Tuberculosis Program
PLWHIV	People Living With HIV
PPE	Personal Protective Equipment
PTB	Pulmonary Tuberculosis
RIF	Rifampicin
SDG	Sustainable Development Goal
TB	Tuberculosis
TPT	TB Preventive Therapy
USAID	United States Agency for International Development
WHO	World Health Organization
ZIMPHIA	Zimbabwe Population-based HIV Impact Assessment

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CHAPTER 1 INTRODUCTION

1.1 Introduction

China reported an outbreak of atypical viral pneumonia caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in Wuhan City in late December 2019 (World Health Organization [WHO], 2020). The virus spread with frightening rapidity within China and across the world causing coronavirus disease 2019 (COVID-19). On the 11th of March 2020, COVID-19 infection was declared a global pandemic (WHO, 2020). By mid-August 2020, over 19. 5 million confirmed COVID-19 cases and 728 013 deaths had been reported to WHO globally (WHO, 2020). Noting the high morbidity and mortality rates, more and more countries shifted their political attention, enormous resources, and finances toward the health sector to cope with the escalating COVID-19 cases.

A series of multifaceted COVID-19 mitigation measures were adopted by many countries in response to the pandemic, particularly lockdown measures which drastically reduced movement forcing people to stay indoors most of the time. Mitigation measures included the closure of non-essential activities, banning of all public gatherings, and cancellation of all public transportation. Health services provision was reduced to a minimum due to travel restrictions, other daily outpatient services were suspended to reduce the chances of nosocomial transmissions (WHO, 2020).

While these strategies have been essential in the control of the 1st wave of the COVID-19 pandemic, Togun, Kampmann, Stoker & Lipman (2020) predicted that these measures could have an unintended impact on the control of other existing communicable diseases such as tuberculosis (TB) endemic. This view was reinforced by Pang, Liu, Du, Gao & Li (2020) who posited that a reduction in clinic visits by affected patients due to lockdown could severely impact TB diagnosis and treatment outcomes.

TB is more prevalent in developing countries such as Sub-Saharan countries because of its inextricable links to poverty, housing status, and limited access to health services. In line with global trends, most countries had significantly accelerated their response toward TB control to reach the 2035 milestone of the WHO End TB strategy (WHO, 2019). However, COVID-19 could have posed significant challenges to expediting these efforts. A recent modelling study by Hogan et al. (2020) predicted that new TB cases could increase by 6.3 million in the next 5 coming years since COVID-19 response measures have disrupted the implementation of the national TB program activities. Meanwhile, Stop TB Partnership (2020) and WHO (2020) advised member states to adjust their national TB programs to ensure that TB patients are protected from this ravaging pandemic.

Zimbabwe ranks 17th position among the 22 high TB burden countries with an approximated TB incidence rate of 562 per 100 000 cases (WHO, 2019). To eliminate TB by 2035, the government adopted the End TB strategy and managed to report 25 775 TB case notifications with above 80% treatment rates (WHO, 2019). However, the pandemic might have deteriorated the progress toward TB elimination. The first cases of COVID-19 were clustered around urban cities and were slow to spread to rural areas due to travel restrictions. This would partly justify the paucity of research on the COVID-19 impact on TB care particularly in rural areas.

As the pandemic continued unabated, it was essential to analyze the response and mitigate the potential immediate effects. Therefore, this study aimed to critically evaluate the effects of the COVID-19 pandemic on TB diagnosis and treatment outcomes in the Buhera district across two study periods that are (i) the pre-COVID-

19 period (baseline) (April 2019 to March 2020) and (ii) the COVID-19 period (April 2020 to March 2021).

1.2 Background to the Study

Tuberculosis remains a leading infectious killer disease in the world with an estimated 1.2 million deaths in 2019 (WHO, 2020). TB is an airborne infection just like COVID-19. Its causative agent is called Mycobacterium tuberculosis and can be acquired through breathing contaminated air droplets coughed or sneezed by a closeby someone with active TB or ingesting unpasteurized milk products contaminated with Mycobacterium Bovis (Centers for Disease Control and Prevention [CDC], 2016). The bacteria are present worldwide and typically spread in overcrowded conditions. TB affects all age groups but is most common in adults who are in their productive years with several predisposing factors such as Human Immunodeficiency Virus (HIV), diabetes, malnutrition, and tobacco smoking (WHO, 2019).

The emergence of COVID-19 infection saw multiple governments adopting various mitigation and containment measures including population-wide lockdowns to curb the transmission of the disease (WHO, 2020). Lockdown restrictions were imposed in different phases depending on different timelines of the COVID-19 wave in varying settings. However, the consequences of these movements' restrictive measures on the TB program were not known. During the national shutdowns, people were ordered to stay indoors restricting their access to health services. Given that successful TB control requires early diagnosis and prompt treatment initiation, diagnostic delays are a hindrance to TB elimination efforts. A study by Togun, Kampmann, Stoker & Lipman (2020) amply demonstrated that patients with TB symptoms experienced difficulties in accessing healthcare facilities leading to delayed diagnostics and adverse TB treatment outcomes.

In 2018, 7 million people were reported to have been reached with quality TB care globally, an improvement from 2017 when 6.4 million people were reached with TB-related deaths dropping by 6.3% in 2018 compared with 2017. However, the same report revealed that, in that same reporting period, 10 million people were infected with TB of which 1.1 million were children under 15 years (WHO, 2019). Although significant improvements were noted globally in the recent years before the COVID-19 pandemic, models predicted an increase in TB deaths by 20% in low-middle-income countries in the next 5 years (Hogan et al., 2020).

This study only modelled the potential effects of the COVID-19 pandemic on TB care but did not provide high-level information to fully characterize the utilization of TB services such as diagnosis and treatment services during the pandemic. Where in fact, sufficient data was necessary in providing a better understanding of the status of services that have been affected more by the pandemic to facilitate corrective actions for mitigating future pandemics.

TB diagnostics capability had been suboptimal in low-middle-income African countries due to fragile health systems, inadequate infrastructure, and a high burden of other infectious diseases (Buonsenso, Iodice, Sorba & Goletti, 2021). The COVID-19 pandemic was likely to have worsened the latter such that many TB cases in the communities were left undiagnosed due to interruptions in care seeking and diagnosis. Beyene, Sitotaw, Tegegn & Bobosha (2021) substantiated this position by obtaining factual evidence from their study findings that revealed a significant decline in patients seeking TB diagnostic services during the pandemic. Similar observations were drawn in a study conducted during the Ebola virus outbreak by Bah et al. (2017) in Sierra Leone where utilization of TB services declined due to travel restrictions and negatively affected the treatment success rate.

In Zimbabwe, tuberculosis is propelled by the serious parallel HIV pandemic making it the 2nd leading cause of death. The TB mortality rate is four times more among HIV/TB patients with 132 per100 000 cases compared to 33 per 100 00 cases among patients with TB only (Ministry of Health and Child Care [MoHCC], 2015). To eradicate TB by 2035, the government of Zimbabwe through the MoHCC, partners, and the entire communities have collaborated and mobilized capacities to fight the TB endemic. However, the COVID-19 situation could have deterred the implementation of these efforts and slowed progress toward these targets and milestones.

Zimbabwe confirmed its first COVID-19 case on 20 March 2020 and announced 21 days of national lockdown on 30 March 2020. As of December 2020, more than 3 000 confirmed cases with 200 deaths have been recorded (MoHCC, 2020). Essential COVID-19 public health prevention and control measures were being modified or lifted across the three different COVID-19 waves experienced by the country. The 1st wave began from 30 June to 4 September, followed by the 2nd wave started 21 December 2020 to 1 February, and the 3rd wave from 29 June to 22 July 2021.

Early on the COVID-19 crisis, like other countries, Zimbabwe redirected some of the TB resources to COVID-19 care (Makoni, 2020). Other consultation rooms were seen being transitioned to COVID-19 isolation places, and surgical masks and other protective equipment reserved for use in the TB clinic were issued to the frontline staff. TB diagnostic equipment such as the gene expert machines were now being used for COVID-19 testing which appeared more urgent (Mukwenha, Dzinamarira, Mugurungi, & Musuka, 2020). All these changes could have caused severe dysfunctions in tuberculosis diagnostic and treatment services.

Access to and retention in TB care remains a challenge for patients, particularly those living in rural and remote settings. The direct and indirect effects of the pandemic on

TB services provision were likely to vary between rural and urban areas due to different levels of health system disruption and the existing TB burden (Mutyambizi et al., 2020). Buhera district is one of the tuberculosis burdened districts in Manicaland with 20350 clients on ART (Zimbabwe Population-based HIV Impact Assessment [ZIMPHIA], 2020). Before the year 2020, the district made some progress in reducing the burden of TB with a 50% reduction in TB notifications from 866 cases reported in 2012 to 417 cases reported in 2018.

The district scaled up innovations on active TB case finding through collaborative approaches. Several NGOs have partnered with the district in the fight to end TB. However, the district's plan to sustain the best performance in TB control came under threat following the advent of the pandemic and could have reverted to the levels seen a decade ago. At first, the district experienced a lower incidence of COVID-19 until the second quarter of 2020. However, the strict implementation of lockdown measures was likely to have severe effects on the existing TB control program. Therefore, a study of this nature was critical to evaluate the impact of COVID-19 on TB diagnosis and treatment outcomes to proffer evidence-based solutions.

The National TB Program (NTP) under the MoHCC is the main driver for the diagnosis and treatment of TB in Zimbabwe. Primary health centers and community healthcare workers are the first points of contact for health services with TB patients. Ideally, clinics are manned by nurses and EHTs who are the key players in TB screening, sample collection, and referral to the district, initiating patients on care and following them up. Presumptive TB patients meaning persons with suggestive TB symptoms such as cough, fever, night sweats, and weight loss contact either community health care workers or clinics as their first point of care. Nurses and EHTs document their clinical and demographic data in the presumptive TB register before collecting and sending their sputum to Murambinda mission hospital and Birchenough district hospital (referral hospitals) through riders or MoHCC vehicles.

The district manages patients referred from the clinics and plays a major role in conducting TB investigations since there is an onsite laboratory. At the laboratory, patient demographic details and specimen results are documented in the lab register. The laboratory scientist and the team carry out TB investigations using sputum smear microscopy or Xpert MTB/RIF assay as per the TB national guidelines (Ministry of Health and Child Care, 2015) and international guidelines (WHO, 2017) to find a bacteriologically confirmed diagnosis of PTB. On another hand, patients with negative sputum results but having TB-related symptoms are referred to a doctor for clinical diagnosis of PTB or EPTB.

Patients diagnosed with TB will be commenced on anti-TB treatment and their results will be sent back to their respective rural health centers or local authority for notification, registration, a continuation of treatment, and patient tracking. At their initial facilities, these patients are registered in the health facility Directly Observed Treatment (DOT) register. Guided by the DST results, patients with DS-TB are treated using the standard 6-month regimens, whilst MDR-TB regimens are used for patients with drug-resistant disease. Treatment outcomes are routinely monitored, recorded, and reported as stipulated in the national guidelines. Quarterly, all health facilities report their TB data to the district level where it will be captured in District Health Information System 2 (DHIS2) by the Health Information Officer.

1.2.1 Statement of the Problem

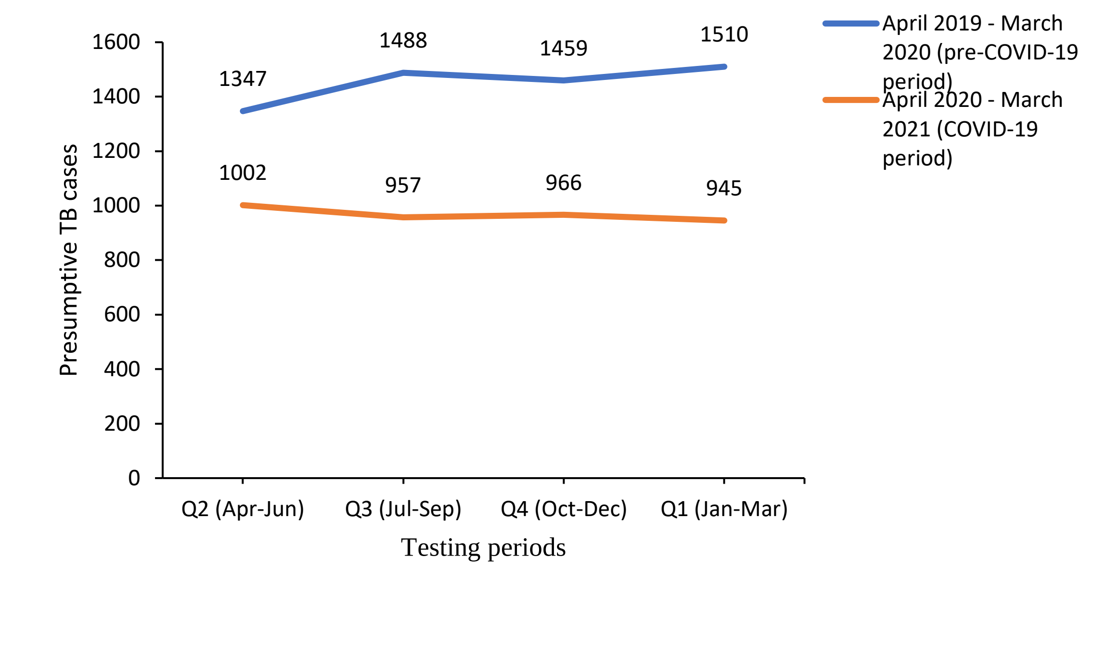

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Figure 1 Presumptive TB cases reported in Buhera district (April 2019 to March 2021)

Source: DHIS2

A preliminary review of TB case detection data for the Buhera district indicated a significant decline in the total number of presumptive TB cases reported during the COVID-19 period (April 2020 - March 2021) compared with the baseline (April 2019 to March 2020) as shown in Figure 1. Given that the TB program aims to identify and treat as many cases as possible, having fewer presumptive cases indicate gaps in TB case detection. One missed TB case may spread the infection to not less than 10 people. The true impact of the pandemic on TB diagnosis and treatment outcomes was still to be evaluated in the Buhera district. Understanding the magnitude to which TB services have been disrupted was critical in determining evidence-based interventions to successfully achieve the end TB goal.

1.3 Research Objectives

The main objective of this study was to determine the impact of the COVID-19 pandemic on TB diagnosis and treatment outcomes during the pre-COVID-19 period (from April 2019 to March 2020) and the COVID-19 period (from April 2020 to March 2021) in the Buhera district.

The specific objectives were to:

i. Analyse the trends of TB case detection during the pre-COVID-19 and COVID-19 periods in Buhera.
ii. Evaluate the effects of the COVID-19 pandemic on the diagnosis of TB during the pandemic in Buhera.
iii. Compare the TB treatment outcomes before the COVID-19 pandemic and during the COVID-19 pandemic in Buhera.

1.4 Research Questions

i. What was the impact of the COVID-19 pandemic on TB case detection in the Buhera district?
ii. What was the impact of the COVID-19 pandemic on TB diagnosis in the Buhera district?
iii. How did the COVID-19 pandemic affect the treatment outcomes in Buhera during the COVID-19 period?

1.5 Significance of the Study

While healthcare systems were likely to be severely affected by the COVID-19 pandemic, there was a need to strike a balance between the fight against COVID-19 and ensuring the continuity of quality TB care. Several studies were conducted in urban at the initial phases of the pandemic, hence there was limited data to fully characterize the effects of the pandemic, particularly in rural communities. Therefore, the potential utility of this study is to provide some insights into the status of TB care and services delivery over the twelve months of the COVID-19 period. Additionally, the study findings will be used to strengthen the capacity of TB resources to respond more effectively to the COVID-19 emergency and influence decision-making and policy formulation on how program implementation could be revised.

Furthermore, the study is envisaged to contribute to the body of knowledge since there is a paucity of research on how the COVID-19 pandemic affected TB services utilization, particularly in rural areas. Therefore, the study is expected to benefit policymakers, public health managers, researchers, and scholars in characterizing the possible influence of the pandemic on TB care and highlighting ways in which TB services can continue in the context of the public health crisis.

1.6 Delimitations of the Study

This study was delimited to aggregate TB monitoring evaluation and reporting data (MER); hence no patient-level data was collected. Therefore, the study could not assess what happened to healthcare workers and patients at an individual level. Operationally, it was restricted to the Buhera district hence findings were not generalizable to other districts. Since the study collected data 1 year before and 1 year after the COVID-19 pandemic, this research only evaluated the mid-term effects of the COVID-19 pandemic on TB diagnosis and treatment outcomes, the long-term effects on TB incidence and mortality are yet to be assessed.

1.7 Limitations of the Study

While the study sought to contribute to the body of knowledge, the personal development of the researcher, and improve tuberculosis programming in the district, it had the following limitations:

i. Poor internet connectivity to access the DHIS2.
ii. Data captured in DHIS2 was subjected to human errors with missing values, incorrect values, and outliers. The researcher mitigated these issues by querying outliers.

CHAPTER 2 REVIEW OF RELATED LITERATURE

2.1 Introduction

In this chapter the researcher reviews the global and country-specific data available within public domains, to quantify the public health consequences of the COVID-19 pandemic on TB case detection, diagnosis, and treatment outcomes. Discussions on the historical background of tuberculosis and COVID-19 were explored in the first part of the section. Furthermore, this chapter equivalates the differences and similarities between TB and COVID-19 infection in terms of clinical presentations, epidemiological distribution, and other characteristics.

Taking into account the awareness that early on in the COVID-19 pandemic, models predicted an additional million TB cases following substantial health services disruption. In light of this limited experiential evidence on the public health effects of COVID-19 on TB management, it was difficult to quantify the burden of COVID-19 on TB outcomes. Henceforth, the researcher critically reviewed previous studies conducted in other settings and available literature to assess how the COVID-19 pandemic may have modified the TB burden as well as the costs of any mitigation. Findings would be key in highlighting ways in which TB resource allocation and services could be improved.

Figure 2 outlines the conceptual framework critical for the narrative review, specifying how the effects of the COVID-19 mitigation measures would impact the quality of TB outcomes. In addition, the researcher discusses the relevance of the conceptual framework defining and explaining important variables the study intended to measure. Lastly, the chapter concludes with a summary highlighting the knowledge gaps that should be prioritized for study.

2.2 Historical Perspective of TB

Tuberculosis is one of the oldest infectious endemic diseases in the world devastating human health, yet it currently remains an important public health problem (WHO, 2014). It has been ranked in the top ten leading causes of mortality ahead of HIV and AIDS. A re-estimation study done by Houben (2016) using mathematical modelling predicted that about 25% of the people in the world live with latent tuberculosis infection. Latent TB does not show any symptoms or make people sick and can last up to 10 years or more, therefore it is a dormant type of TB. In 2018, they were about 10 million confirmed TB cases with 1.4 million estimated TB-related deaths. More importantly, over 1.3 million of these deaths occurred among people living with HIV (PLWHIV) (WHO, 2019).

History has it that management of the TB program is often compromised by wars, natural disasters, and communicable disease pandemics increasing pressure on the existing TB burden. Several European countries experienced TB epidemics during the First World War and the Second World War accounting for almost 25% of deaths reported during that time (Vynnycky and Fine, 1999). As World War II came to an end in 1945, the TB burden dramatically declined particularly in well-resourced settings due to the introduction of anti-TB medicines and improvements in living and working conditions.

However, a few decades later HIV emerged as a global pandemic and increased susceptibility to TB disease killing millions of people. With the discovery of Anti-retroviral therapy (ARVs) and integrated HIV/TB management approaches over time, TB morbidity and mortality have been gradually declining. More recently, TB control efforts have been threatened by the West African Ebola viral outbreaks of 2014 to 2016 which resulted in delayed diagnosis of new TB cases leading to adverse treatment outcomes in the case of Liberia (Desta, Kessely & Daboi, 2019). Further to that in 2017, Saudi Arabia reported Middle East respiratory syndrome coronavirus (MERS-CoV) outbreaks in several regions of the country. Findings obtained from a study conducted by Alfaraj, Al-Tawfiq, Altuwaijri, and Memish (2017) showed that the MERS-CoV infection and its direct and indirect impacts negatively impacted the TB control program in Saudi Arabia. Consequently, TB morbidity and mortality worsened in subsequent years.

Public health strategies have been put in place in these previous viral pandemics to revitalize TB control efforts towards the achievement of the WHO End TB goal. However, in 2020 COVID-19 pandemic emerged and already high levels of disruptions in the provision and utilization of health services have been witnessed across the globe (Hogan et al., 2020). Therefore, it is important to consider evaluating the potential impact of COVID-19 on endemic diseases such as TB that have been seriously affecting humanity even before the advent of the COVID-19 pandemic.

Given that both COVID-19 and TB are infectious diseases, it was anticipated that patients infected with both COVID-19 and TB diseases were likely to have adverse treatment outcomes. With the nationwide lockdowns, and COVID-19 response measures such as stay-at-home orders, it was probable that TB would spread faster due to close household contact, especially in crowded households with deteriorated living conditions. Low socioeconomic status, poor nutritional status, crowded environments, HIV positive status, and poverty are strong predictors of poor TB outcomes (Lönnroth, Williams, Cegielski, & Dye, 2010). As more people especially in Low to Middle-Income countries were being pushed into hunger and poverty because of the COVID-19 pandemic's catastrophic effects such as loss of jobs or income generating activities, it was inevitable that the less privileged people would become more susceptible to TB infections. The next section briefly discusses the background of COVID-19.

2.3 COVID-19 Background

WHO (2020) declared the Coronavirus Disease-2019 (COVID-19) a pandemic on 11 March 2020. Since then, there has been a massive global setback to the routine monitoring and control of both communicable and non-communicable diseases due to the disruption of healthcare services. This pandemic, with its far-reaching consequences, continued into 2021 driven by the Delta variant, a newer and more transmissible variant, and was projected to extend beyond (CDC, 2021).

McQuaid (2020) estimated that the COVID-19 pandemic could have potentially caused 400,000 excess TB deaths in 2020. The outcomes of these consequences were envisaged to be shared by both high-income countries (HICs) and low-middle-income countries (LMICs) (Nikolayevskyy et al., 2021). A scientific analysis conducted by Hogan et al. (2020) projected that low- middle-income countries classified as TB high burdened countries (HBCs) were more likely to be severely impacted by the pandemic. More clarity on the subject was described by Pai (2020) who noted that LMICs were now battling with a double burden of TB and COVID-19 'syndemic' due to weak healthcare systems. At that point, the extent and pattern of the impact on routine TB service delivery had not been adequately assessed.

Recently, Africa made some substantial progress in reducing TB cases by 90% and TB deaths by 95% by 2035 as outlined in the global End TB Strategy (WHO, 2014). However, the emergence of COVID-19 put additional pressure on health services reducing the number of health facilities offering TB services. Routine health services were suspended and there was reassigning of health services resources as well as reorganizing of health facilities to COVID-19 care. Taken together, these consequences could reverse the recent progress toward achieving the TB global targets (Khan et al., 2021). Therefore, to achieve TB global targets, the implementation of coordinated efforts was not an option to ensure continued access to quality TB care during this pandemic.

It was worth noting that the COVID-19 pandemic did not only increase the TB burden but had also intensified vulnerability to TB through reduced access to TB healthcare services. Therefore, there was a great potential that COVID-19 would cause lung infections post-COVID-19 and heighten poverty within communities considering that a significant number of people especially in African countries lost their main sources of income due to nationwide-wide lockdowns (Lakner, Daniel, Yonza, Castaneda, & Haoyu, 2020).

These vulnerabilities were highly likely to increase the progression to tuberculosis among active TB cases and worsen TB treatment outcomes. However, there is little or no evidence to suggest these adverse changes, countries where only relying on modelling studies (Hogan et al.,2020). The following section highlights the similarities and differences between COVID-19 and tuberculosis.

2.4 Comparison of COVID-19 and TB

COVID-19 has been declared a global health crisis and has so far caused substantial dysfunctions in the provision of health services, including TB care services (Hogan et al., 2020). This section briefly describes the clinical presentations, epidemiology, ways of transmission, and prevention of both TB and COVID-19.

2.4.1 Clinical presentations

Both COVID-19 and TB are infectious diseases that attack the respiratory system and typically affect the lungs. However, COVID-19 is an acute viral disease that is highly contagious whereas TB is a bacterial disease and chronic in nature. These diseases have similar symptoms such as difficulty breathing, fever, and cough, but the duration and severity of these clinical presentations vary. The TB incubation period is longer, and the onset of the disease is slower whereas up to 78% of COVID-19 patients do not show symptoms and may recover spontaneously (WHO, 2022).

2.4.2 Epidemiology

Tuberculosis has since been the leading infectious killer disease in the world with an estimated 1.2 million deaths and 10 million people developing TB in 2019 (WHO, 2020). Whereas, COVID-19 is currently the top leading highly infectious disease, it has overtaken TB and is killing people every day. By mid-August 2020, over 19. 5 million confirmed COVID-19 cases and 728 013 deaths had been reported to WHO globally (WHO, 2020). All continents were affected by the pandemic; however, high burdened TB countries did not experience a high incidence of COVID-19 compared to countries in North America and Europe. Further studies are necessary to assess the difference in this disease pattern and distribution.

2.4.3 High-risk population groups

Adults over 60 years of age who have underlying chronic health conditions such as lung cancer, hypertension, diabetes, and chronic obstructive pulmonary had a higher risk of developing severe complications of COVID-19. These complications include hospital admissions, poor TB treatment outcomes for TB patients, and even COVID-19-related deaths in the worst cases. A retrospective study conducted by Zhou et al. (2020) in China confirmed this hypothesis by finding out that the majority of COVID-19-related deaths were adult men aged above 60 years. These findings on differences in epidemiology were also obtained in a study conducted by Horton, MacPherson, Houben, White, & Corbett (2016) to assess gender differences in TB burden and men were found to be more at risk of developing TB than women.

Growing evidence has indicated that TB patients or previous TB patients were developing adverse COVID-19 outcomes with an estimated three folds in mortality and a relative decrease of 25% chance of recovery for COVID-19 coinfection with tuberculosis (Kumar, Surendran, Manu, Rakesh, & Balakrishnan, 2021). Despite the little evidence available that SARS-Cov-2 infection affects both TB disease progression as well as TB treatment outcomes, there are recognized issues that COVID-19 survivors are likely to develop lung diseases following vulnerability to TB (Sy, Haw, & Uy, 2020). Further studies are needed to investigate this issue and come up with ways in which potential lung damage post-COVID-19 can be mitigated.

2.4.4 Transmission

Both COVID-19 and TB are transmitted through contact with an infected person. They are airborne and droplet-transmissible infections (Yates et al., 2016). The source of infection for COVID-19 can be an asymptomatic or symptomatic patient whereas for TB the source of infection must be a symptomatic patient with active TB (having a productive cough). While COVID-19 has a very short incubation period that ranges from 1 day to 14 days, the incubation of TB has a long range of 2 weeks to two years before developing active TB (Yates et al., 2016).

2.4.5 Prevention

Multifaceted public health preventive measures have been implemented at global levels, regional cascading down to national levels to mitigate the risk of COVID-19 transmission. The common mitigation measures included movement restriction measures, such as total lockdowns of social and economic activities, closure of schools, closure of borders to avoid importation of COVID-19 cases and banning of public gatherings. Coupled with that, many countries took heed of the following COVID-19 containment measures: early case detection, timely isolation of confirmed cases, contact tracing of contacts, quarantine of contacts for 14 days, infection prevention and control activities, social distancing, use of personal protective equipment such mandatory wearing of masks in public spaces, maintaining hand hygiene with water and soap or use of sanitizers, and COVID-19 vaccinations that began the mid-year 2021 in most African countries (WHO, 2020).

Despite the successful implementation of these public health measures, some countries continued to experience a high incidence of COVID-19 cases with increased case fatality rates (Bedford et al., 2020). Further studies are critical to assess why these countries continued to be burdened by COVID-19 morbidity and mortality after the launching of these COVID-19 mitigation measures. Some similar COVID-19 prevention measures have been widely used in the TB control program to reduce the risk of TB transmission. These include early detection of sources, contact tracing, and infection prevention and control activities in health facilities (WHO, 2008). The next section discusses the potential impact of the COVID-19 pandemic on TB case detection, diagnosis, case notifications, and treatment outcomes.

2.5 TB case detection

The provision of TB screening services and access to these services has been severely disrupted worldwide in 2020 (Khan et al., 2021). This could be attributed to the applied strict intra, and inter-city travel restrictions adopted by many countries which resulted in presumptive TB patients having difficulties in accessing clinics and seeking medical care. Concerning the supply, Hogan et al. (2020) observed the diversion of human resources for health, diagnostic equipment, and other resources meant for TB programs to COVID-19 care. Odume et al (2020) felt that the impact of reassigning healthcare workers to meet the COVID-19 testing demand and TB equipment for COVID-19 care was a reduction or discontinuation of TB screening activities. The ripple effects included a disrupted presumptive TB tracing and referral system, temporal closure of TB outpatient clinics, and consequently a decline in TB detection rates (Hogan et al., 2020). Of the various possible approaches to handle TB and COVID-19 'syndemic', a preferred strategy is one that continues to provide high-quality TB care during the pandemic and resists the ongoing verticalization of COVID-19 services. Integration of the TB and COVID-19 services with awareness campaigns, effective implementation of infection, prevention and control (IPC) measures including appropriate use of PPE is crititical in simultaneously addressing both COVID-19 and TB case finding.

Both community and facility-based TB screening activities to actively find TB cases were hindered during the pandemic. In Malawi, the clinics under the study by Thekkur et al (2021) reported a sharp decline in the total number of patients presenting to health facilities with presumptive TB during the first 6 months of the COVID-19 pandemic because of limited access to community TB testing. Qualitative findings from another study done in Malawi by Soko et al. (2021) further obtained that most people faced transport challenges to access healthcare facilities due to movement restrictions and others feared contracting SARS-CoV-2 infection during clinic visits.

The declining trends in TB detection rates were consistent with other studies conducted in health facilities in Zambia by Mwamba et al. (2020), Ethiopia by Arega et al. (2022), Sierra Leone by Lakoh (2021), and Nigeria by Adewole (2020), where fear of contracting COVID-19 disease due to its nature (highly infectious, deadly, no effective treatment) and transportation difficulties were thought to deter patients from seeking

TB services. The provision of correct and consistent health education to communities was key so that patients continue seeking medical care even amid the pandemic.

Studies conducted in Malawi by Thekkur et al. (2021) and Sierra Leone by Lakoh (2021) found that women and children were the most affected with lower TB case detection rates compared to men and adults in 2020. However, there was insufficient literature to explain these findings, so the reasons were based on assumptions. Despite women having more medical care-seeking behaviours compared to men, it was likely that mothers and their children could have felt more vulnerable to COVID-19 and preferred staying at home with their families reducing their desire to visit health facilities. A recent study conducted by Thekkur et al. (2021) similarly demonstrated a large decline in children presenting with presumptive TB in clinics in Harare city and this would support this hypothesis.

Zimbabwe was taken over for a short period banning large meetings, schools and colleges were closed, public transportation restricted (translated to limited vehicle capacity as a result transport costs doubled), sporting and religious gatherings halted, and quarantine and isolation imposed. However, 2 years after the pandemic began, there was relatively little hard data available to explain the intensity of COVID-19's impact on TB case detection. Most available data was limited to the first six months of 2020, with little data on quarters three and four when services might have been restored. The substantial decrease in patients presenting to health facilities with presumptive TB does not necessarily show a decrease in TB incidence but may indicate that there is a reservoir of undiagnosed cases in the communities. Limited TB screening services facilitate the ongoing transmission of TB amounting to high rates of latent TB infection.

To mitigate the impact of the pandemic and its direct effects on TB services, Arega et al. (2022) recommended the use of virtual care and digital health technology to facilitate TB screening as well as strengthen community linkages. However, in resource-constrained countries such as Zimbabwe, this option is not viable due to bad internet connectivity. In Mumbai, India they ensured continuity of TB screening services through formulating policies that guided the integration of services for TB and COVID-19, effective implementation of infection prevention and control activities to protect the health of both health care workers and patients, limiting non-essential clinic visits and linking patients to COVID-19 care given that there was an overlap of clinical symptoms for the two diseases (Meneguim et al., 2020). To end TB, both the health facility delivery services approach and the community health model should strengthen active case finding and improve the identification of missed cases. This strategy has been suggested to improve the tracking and monitoring of persons with presumptive TB (WHO, 2020).

2.6 TB diagnosis

The golden standard for investigating TB is to find Mycobacterium tuberculosis (MTB) in patient clinical samples such as sputum, stool, or other specimens (WHO, 2014). However, with the decreased access to tuberculosis diagnostic services due to COVID infection and its lockdown restrictions, bacteriologically confirmed cases significantly declined across the globe during the first six months of 2020 compared to 2019 (Hogan et al., 2020). This could be attributed to several factors.

First, as discussed earlier, due to the diversion of resources, many countries transferred their TB laboratory staff and equipment to COVID-19 testing which resulted in some temporary closure of TB clinics leaving TB patients with nowhere to go for sputum examination. Second, some TB patients delayed or missed their sputum examination dates in fear of contracting COVID-19 infection during clinic visits (Chen & Zhang, 2020), which is similar to the findings in the case of the Ebola epidemic and TB control in West Africa (Desta, Kessely, & Daboi, 2019). Unlike TB treatment which can be provided through digital methods, TB diagnosis typically requires direct contact between the healthcare workers and the patients thus increasing TB vulnerability.

In Zimbabwe, TB diagnostic services heavily rely on imported consumables, test kits, and medications. During the COVID-19 pandemic, the closure of borders and the grounding of flights and ships disrupted the TB supply chain of commodities. This coincided with the expiry of cartridges for Xpert MTB/RIF assays such that sputum specimens were not being collected for investigations (Thekkur et al., 2021).

Contrastingly, studies conducted in Sierra Leone by Lakoh (2021) and Malawi by Thekkur et al. (2021) found that despite having fewer presumptive TB cases tested during the COVID-19 period, there was a surge in laboratory-confirmed TB cases compared with the pre-COVID-19 period. It is plausible that the laboratory operations remained intact with readily available reagents to cater to diagnostic services. Further to that, health facilities were doing selective referrals to critically ill patients for TB investigations. Since this is not the last pandemic, government governments should consider putting in place robust procurement systems that ensure that the commodities stockpiles of the country are maintained for these unprecedented disruptions.

There are one hundred and seventy public health laboratories in Zimbabwe with seven of them accredited in the following tests: GeneXpert MTB/RIF, HIV viral load testing, HIV dried blood spot (DBS) tests, and Ziehl–Neelsen staining for acid-fast bacilli (AFB). These laboratories conduct several tests such as early infant diagnosis (EID) HIV viral load testing, and TB tests using different platforms. However, with the emergence of the COVID-19 pandemic, TB-related equipment was authorized to be used for SARS-CoV-2 testing because of the urgent attention it needed. The multiplexing use of TB diagnostic equipment such as the GeneXpert (Cepheid) has subsequently overwhelmed TB testing services because of the rising demand for the limited available resources. During the first six months of the pandemic, 14 GeneXpert machines were set aside to perform COVID-19 tests increasing pressure on other services such as testing that required the same resources.

2.7 TB case notifications

A proper diagnosis of TB that is carried out well in time according to international standards allows for early treatment initiation, prevents further transmission, reduces ill health in people who have developed tuberculosis and TB related deaths (WHO, 2021). The World Health Organization End TB Strategy requirements for the case fatality ratio target to be reduced from 10% by 2020 and 6.5% by 2025 with the latter being possible if all people affected with TB are diagnosed well in time and initiated on treatment.

Since the mid-1990s, TB notification data defined as the number of people diagnosed with TB has been collected at national levels and reported to the World Health Organization annually based on the WHO standard case definitions and guidance on data recording and reporting. The TB notification case data is essential in monitoring the number of persons diagnosed with TB against those reported officially to the national TB program. In addition, this data is useful for tracking progress toward achieving the WHO global targets for TB case detection and treatment outcomes.

However, disruptions in TB services provision and access to diagnostic and treatment facilities following the advent of the COVID-19 pandemic have negatively impacted the timely diagnosis of TB and notification of these cases to the national surveillance systems. In 2020, 5.8 million TB cases were diagnosed and notified globally, however, it was a significant drop from 7.1 million TB cases in 2019, representing a decrease of 18%. These downturns were felt in all six WHO regions between 2019 and 2020 (WHO, 2021).

Between 2013 and 2019, two countries that are Indonesia and India have been observed to be the major contributors to the increment of the TB notifications globally, with a combined annual total of 1.2 million notifications in that reporting period (WHO, 2021). Given a target of achieving 40 million TB case notifications by 2025, only 50% that is 19.8 million people were diagnosed with TB and officially reported to WHO from 2018 to 2020. Unfortunately, with the COVID-19 pandemic disruptions, this target is off track.

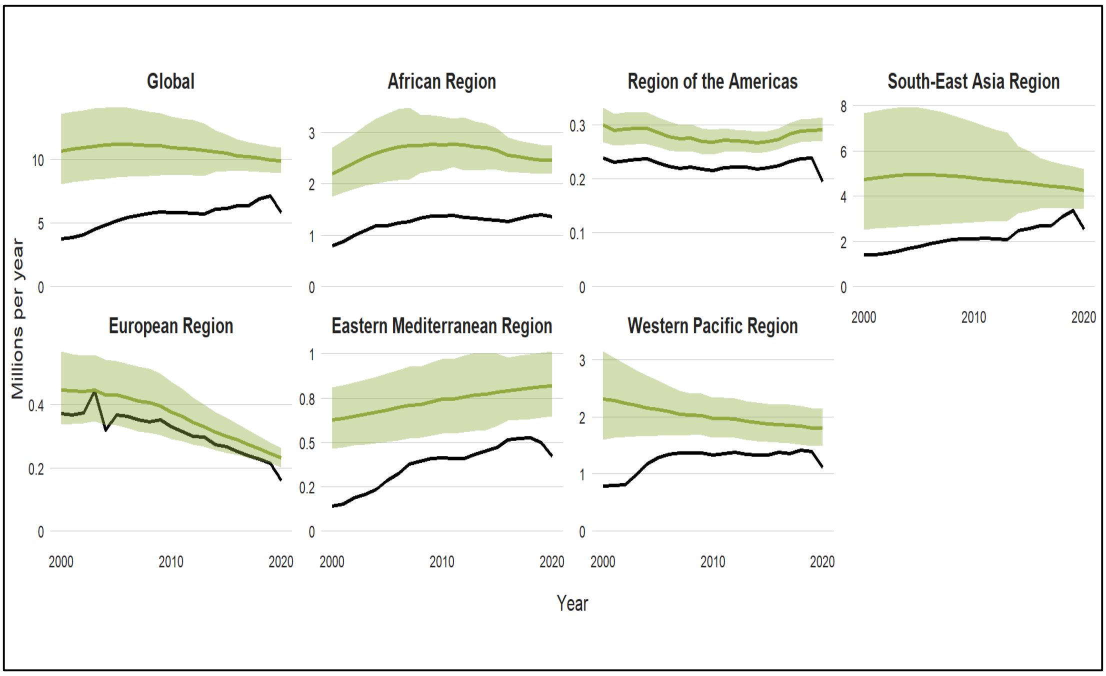


Figure 2 TB case notifications (represented by a black trend) against estimated TB incident cases (represented by a green trend) reported to the World Health Organization from 2000–2020.

Source: WHO (2021) Global Tuberculosis Report

Figure 2 shows TB case notifications against estimated TB incident cases at the global level and in each of the 6 WHO regions. These statistics were reported from 30 high TB burdened countries. Analysis of these trends indicated that there was a gap of over 4 million people newly diagnosed with TB against estimated TB incident cases in 2020, globally. Figure 2 further shows that all the 6 WHO regions recorded a downward trend of TB case notifications between 2019 and 2020, though in the African region, the reduction was relatively modest, representing a drop of 2.5%. This deficit is mainly attributed to underreporting of TB cases detected as well as underdiagnosis. This usually happens either when people with true TB fail to access healthcare services, or these people do not receive diagnostic services after accessing health services.

In line with WHO (2021) observations on TB case notification data, the United States Agency for International Development (2020) estimated a decrease in TB case notifications by more than a million in 24 high-burdened countries in 2020 with a 7%, 15%, and 27% relative risk reduction in Africa, Central Asia, and Europe, respectively compared to 2019 beginning of the covid-19 pandemic. On the same note, a modeling study by Cilloni et al. (2020) conducted beginning of the pandemic, suggested that suspension of TB services in the first 3 months due to lockdown and then a restoration of services back to normal would cause an additional 1.2 million TB cases in India, 25 000 in Kenya, and 4 000 in Ukraine, mainly attributed to the accumulation of undetected TB during the lockdown. A further modeling analysis in low-middle HBCs predicted a 20% surge in TB mortality, mostly occurring following untimely diagnosis of new cases of TB (Hogan et al., 2020).

A more recent report by WHO (2020) demonstrated a 21% reduction in TB case notifications across 84 countries in 2020 compared to 2019 attributed essentially to the COVID-19 pandemic. The above statistics, alarming as they are, were obtained during the initial stages of the COVID-19 pandemic when service disruption was hoped to be temporary. The reality, however, was that service disruption in HBCs including Zimbabwe continued to 2022 and was likely to extend beyond, with even worse impacts on the TB endemic than originally forecasted.

Real-time surveillance conducted by Thekkur et al. (2021) in 10 clinics in Harare City showed a decline in TB case notification rates over the 12 months of COVID-19. These findings were in support of other studies done elsewhere where TB case notifications in health facilities dropped by 3% in Sierra Leone (Lakoh, 2021), 19% in Malawi (Thekkur et al. 2021), 38% in Zimbabwe (Thekkur et al. 2021), 48% in China (Wu et al., 2020), 56% in India (Golandaj, 2021) in the first three quarters of 2020 compared with the corresponding periods. The bacteriological positivity rate in those being investigated for presumptive PTB was low compared to 2019 which could be partly explained by the underdiagnosis of TB cases.

TB case notifications were disproportionately shared among sex with major declines in women and girls compared to men and boys (WHO, 2021). HIV-negative patients experienced the same epidemiological distributions compared with HIV-positive patients (Chikovore et al., 2014). These findings may reflect variations in epidemiology, differential access to TB health care services, and use. The possible explanation is that men as breadwinners in most instances could have disregarded COVID-19 movement restrictions and continued to access health services during the pandemic whereas women might have preferred staying at home taking care of children following the closure of schools. These are social and gender norms that can hinder the attainment of the End TB goal. These findings may also reflect differential diagnostic and varied reporting practices. However, this TB case notification data understates the TB disease burden being shared by men since the ratio of males to females among adults is usually higher.

There are special concerns with TB diagnosis in children. Previous studies have recognized issues of underreporting TB notifications among children by paediatricians. This may be attributed to use of variable case definitions in the public and private sectors. Therefore, many countries need to pay more attention to TB notification data, particularly for children.

2.8 TB treatment outcomes

The World Health Organization (1994) recommends that once a patient is registered in the TB register and commenced on anti-TB treatment, he or she should be monitored and tracked throughout the treatment phase. Treatment support should be context-specific and be done conveniently in a friendly manner either at a health facility, community, workplace, or home depending on the local arrangement.

However, it is evident that further to reducing TB case detection, diagnosis rates, and case notification rates the pandemic has also hampered the treatment of TB patients worldwide. With the view that the provision of quality TB care has been considered suboptimal even before the pandemic (Cazabon et al., 2017), the emergence of COVID-19 has only worsened the treatment outcomes of TB patients due to drug stockouts and limited treatment support (Nkereuwem et al., 2021).

Several countries experienced setbacks in the delivery of anti-TB drugs from central and zonal stores and provision of facility-based directly observed treatment (DOT) became impossible since patients had limited access to health facilities following the COVID-19 movement restrictions (Zimmer et al., 2021). These disruptions in the provision of TB treatment could have heightened the risk of treatment interruption, and poor treatment adherence resulting in worsening TB treatment outcomes (Nkereuwem, Kampmann, & Togun, 2021). According to Stop TB Partnership (2019) failure to ensure adequate and timely treatment is considered a TB-related human rights violation. Hence public health officers should rigidly strengthen community-based TB treatment supports so that patients will timely receive their medicines (Chiang, 2020).

Preliminary COVID-19 studies conducted in health facilities in China by Liu et al. (2021), and Ethiopia by Mohammed et al. (2020) indicated that the TB treatment monitoring by DOTs and supply of both first line and second line TB drugs slightly worsened by 5- 15% relative reduction. On the contrary brief reports from China by Fei (2020) and real-time monthly surveillance of TB activities set in cities of Malawi Thekkur et al. (2021) and Sierra Leone Lakoh (2021) did not show strong evidence of a significant decline in treatment success. However, definitive data on changes in TB treatment outcomes attributed to the pandemic may not be available for several months since the TB treatment duration is very long often taking 6 months for DST TB and 2 or more years for MDR TB.

Some European countries such as Portugal have however resorted to digital treatment support (telemedicine) such as Video-Observed Therapy (VOT) and follow up via telephone calls during the pandemic. This has been effective in limiting follow-up visits and improving compliance. In most instances, policies were disseminated by email or social media, and in a few instances, the respondents provided links to relevant websites. In Sierra Leone, instead of using the traditional DOT model, resorting to monthly dispensing of anti-TB therapy improved their treatment success during the COVID-19 period. The shift to self-administration of anti-TB medications accompanied by virtual care support reduced the need to frequently visit health facilities. Additionally, the strengthened use of the multi-month dispensing (MMD) and home delivery of treatment strategies so that patients would be given their TB medication supplies for longer periods than usual also meant to minimise catastrophic costs such as inflated transport costs to health facilities because of limited movements (Zimmer et al., 2021).

Similarly, brief reports from the Philippines by the Republic of Philippines Department of Health (2020), Zimbabwe by USAID (2020), and Ethiopia by Togun, Kampmann, Stoker, & Lipman (2020) indicated that facilities were now providing 1-month supplies of anti-TB medication instead of daily doses after noting a substantial decrease in TB treatment during the first quarter of 2020.

Conclusions drawn by Keene et al. (2020) and Klinton, Oga-Omenka, & Heitkamp, (2020) from their studies indicated there was an introduction of home-based options such as delivering medications in homes to make treatment more accessible, however, counselling and treatment literacy support were often lacking such that in some settings the treatment outcomes still deteriorated. The increased uptake of telemedicine initiatives such as vDOT option was observed to be not viable in settings with internet connectivity challenges or amongst people who are incapacitated to buy data (Zimmer et al., 2021). Zimbabwe was not spared from this situation due worsening economic crisis and the dearth of electrical infrastructure. Community-based interventions should remain available together with the vDOT initiatives to provide more flexible treatment options to TB patients during and beyond the COVID-19 pandemic.

Zimbabwe has been using directly observed therapy (DOT) to treat TB for more than a decade and has a track record of effectiveness. Patients in this program are expected to visit DOT centers every day, especially during the first 4 months of a 6-month TB treatment cycle. However, Visca, Tiberi, Pontali, Spanevello, & Migliori (2020) modelled that health facility-dependent services were more likely to be impacted during public health emergencies, either due to the economic burden, lockdown restrictions, or the disease's stigma.

A comparative retrospective study conducted by Arega et al. (2022) in Addis Ababa, Ethiopia, indicated that the TB treatment success rate dropped from 82.4% to 77.6% during the COVID-19 pandemic, representing a decrease of 4.8%. The major reason for poor treatment outcomes was delayed diagnosis and poor monitoring and supervision of patients commenced on treatment. These findings were in line with a Korean study conducted by Youn (2020) that found a drop of 4.9% in a treatment success rate that is declining from 89.4% to 84.5% after the COVID-19 epidemic. Major possible reasons cited included a significant number of patients with an interruption in treatment, patients missing their review days due to movement restrictions and suspension of routine TB services and underreporting of treatment success. Reduced TB treatment success raises the probability of poor treatment results and the development of DR-TB, aggravating the ongoing DR-TB problem in high TB-burdened countries.

In Ethiopia, national TB programs have traditionally focused on increasing access to effective TB treatment through government health institutions. Since 2003, however, the National Tuberculosis Programs (NTPs) have expanded their use of CHWs (Community Health Workers), health extension workers, and community volunteers to provide effective TB care (Assefa, Gelaw, Hill, Taye, & Van Damme, 2019). They are responsible for finding patients with suspected TB and reporting them to health centers for diagnosis, as well as providing treatment support, tracing those who have gone missing, and conducting contact investigations (Khatri, 2020). However, in this research, CHWs detected less than 2% of the total patients with TB, and the community TB case detection rate was significantly lower during the assessment period.

Treatment support enables patients to adhere to their treatment regimens, complete the treatment therapy and cure the disease. Evidence has shown that both patient support groups and peer support groups help to promote treatment adherence. However, the whole purpose of the DOT approach would be lost if there is limited access to care, with patients being turned away from treatment or adding to their problems (Soko et al., 2021).

Supervision of treatment is beneficial to both healthcare workers and patients. For the health services providers, it helps to monitor patients' health and promptly detect treatment interruptions whereas for the patients it improves adherence to treatment regimens. Taking into cognizance that TB is infectious and a public health problem, its spread poses a risk to the public, the National TB Program should ensure and facilitate treatment adherence by all patients to achieve 100% treatment success.

To mitigate the impact of COVID-19 on routine services, a pulse survey conducted by (WHO, 2020) recommended the following; scrapping of user fees, task shifting, community sensitization on probable service changes, triaging to rank priorities; using telemedicine instead of in person consultation, use of non-medical facilities to supply medicines, and redirecting of patients to open health facilities. Accelerated implementation of these responses by governments could help address the COVID-19 pandemic and create healthy populations.

Methodological strengths and weaknesses of reviewed studies

Consideration of methodological strengths and weaknesses of existing studies around the impact of COVID-19 on TB management can help to refine this study as well as inform future research. Regarding the literature review conducted, the key strengths included the use of large, standardized datasets to collect and analyse data on TB case detection, diagnosis, and treatment as well as the use of appropriate statistical analyses. This has the advantage of reflecting a true picture of the situation of TB in study areas. However, these studies had several methodological shortcomings posing a danger of making premature conclusions.

Firstly, data collected was limited to the first months of 2020, hence not much analysis was conducted in the third and fourth quarters when services might have been restored. The use of aggregate data and lack of specifying the sample selection criteria limited the understanding of the TB care cascade. Data used in the analysis were captured during a period when resources were diverted to treating COVID-19 patients and may therefore have been subject to other inaccuracies such as missing or invalid data. Nevertheless, this study would mitigate the risk of data inaccuracy by querying outliers. Also, all variables were collected retrospectively, 1 year before and 1 year during the pandemic to get a large dataset that will truly represent the entire population. Furthermore, this research explicitly stated the inclusion and exclusion criteria to avoid overlapping sampling frames.

2.9 Conceptual framework

This study employed a conceptual model adapted and modified from (Heuschen, 2021). The framework considers the inter-relationships between the COVID-19 lockdown restriction measures, TB services delivery, and TB care outcomes.

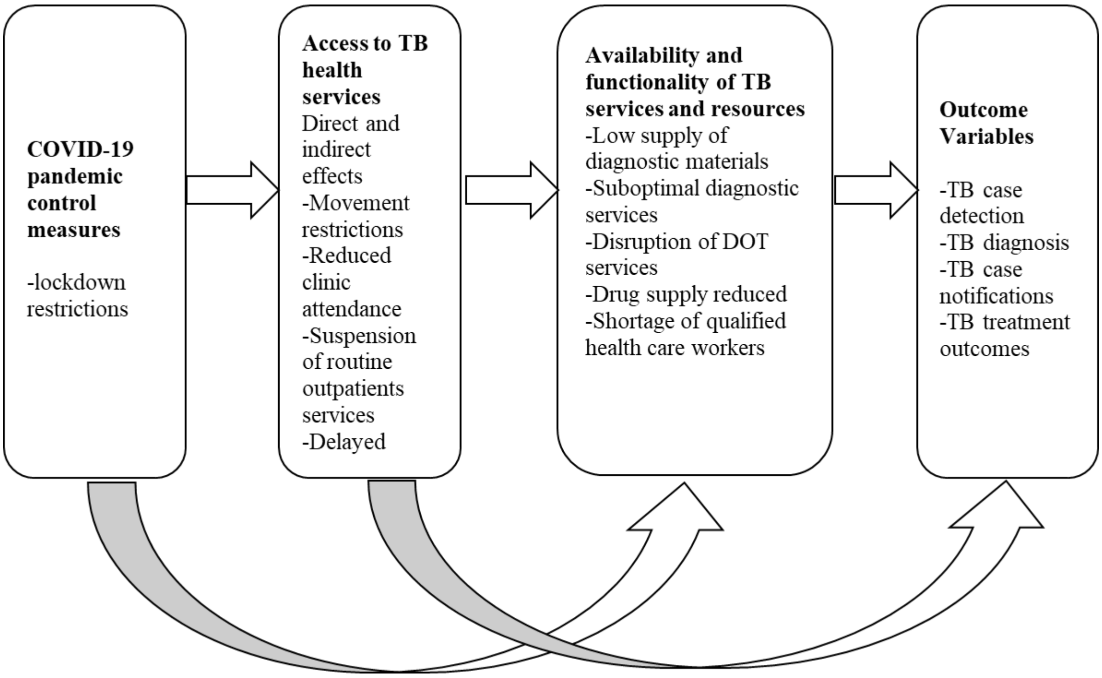


Figure 3 A conceptual framework adapted and modified from Heuschen (2021) representing the influence of COVID-19 lockdown restrictions on TB care.

2.10 Relevance of the conceptual framework

The primary focus of the TB program is to improve access to TB services at various levels of the healthcare system. The success of the program is measured by looking at case detection rates and treatment success. According to the conceptual framework in Fig 3, there are 3 key linking components likely to play a role in the effects of the COVID-19 pandemic on TB outcomes: access to TB health services, availability and functionality of services and resources, and the TB outcomes. The following section discusses these 3 thematic areas.

2.10.1 Access to TB health services

The model highlights that COVID-19, and its mitigation measures complicated access to TB health services. The health care system especially in high burdened TB countries came across several challenges in service provision largely attributed to the reallocation of resources to TB care, shortage of appropriate equipment, and movement restrictions affecting the commodities supply chain as well health care workers 19 (Khan et al., 2021).

At the same time, TB patients have had difficulties in accessing TB services due to restrictions to movement, fear of stigma and COVID-19 infection reduced TB clinic opening hours, transport costs, and inability to pay for care though in most contexts TB services are free (Stop TB Partnership, 2020). Consequently, there was a delay and reduction in clinic attendance in most of the countries with negative impacts on TB screening, diagnostic and treatment services. A cross-sectional study on COVID-19's impact on TB and HIV services conducted by Chen & Zhang, 2020 in low to middle-income countries confirmed these observations.

2.10.2 Availability and functionality of TB services and resources

The consequences of COVID-19 on TB case detection, diagnosis, and treatment outcome cannot be adequately assessed without understanding how TB services and resource needs have changed as well as the impact on available resources. There was a high likelihood that strategies in implementing TB interventions have changed by design considering the social distancing measures observed between the healthcare workers and patients, heightened demand for personal protective equipment, or constraints in the availability of resources such as human resources for health, diagnostic equipment capacity and commodities (WHO, 2020). It was predicted that due to the growing need for services, the cost of inputs for various TB interventions could substantially change. The current TB budget for supporting services may be smaller with a huge chunk diverted to the COVID-19 response.

According to (WHO, 2020), almost 50% of the TB burden countries reallocated their TB funds to COVID-19 care, with substantial decreases in their funding (Stop TB partnership). Although the Global Fund and the like funders have availed some funds to many countries except Tajikistan, Brazil, China, Russian Federation, Sierra Leone, Thailand, Tanzania, Guinea-Bissau, Cambodia, DPR Korea, and Indonesia, the funds were meant for malaria, HIV and TB programs (The Global Fund, 2020). There was no sufficient evidence to explain the changes to the available TB resources and services.

Available literature especially modelling studies have emphasized much on the consequences of the COVID-19 lockdowns on the availability and functionality of services and resources in the healthcare system. Early in the pandemic many countries had to reallocate human resources, diagnostic equipment, and other resources meant for TB programs to COVID-19 care (Hogan et al.,2020). The impact of reassigning these resources led to the suspension of routine outpatient activities, a shortage of qualified healthcare workers, and delayed diagnostic services among others. This was heightened by the disruptions in global supply chains leading to delays in the delivery of anti-TB medicines and commodities to health facilities (Zimmer et al., 2021).

2.10.3 TB outcomes

The TB treatment outcomes are measured by looking at the patient's health status. They are a consequence of services received such as proper diagnosis, correct treatment regimens, appropriate dosage ingested correctly in a specified period, and treatment support (WHO, 2020). TB services should be comprehensive and holistic, with a full package to support patients on anti-TB therapy to complete their treatments. Healthcare workers should identify factors that cause an interruption in treatment and make patients stop treatment. Evidence has shown that the quality of healthcare a patient receives is linked to health outcomes, therefore deficiencies in services provision can lead to poor TB outcomes (Subbaraman, 2016).

The analyses described in this study used the conceptual framework illustrated in Fig 2 to measure the impact of the COVID-19 pandemic on TB diagnosis and treatment outcomes in the Buhera district. The framework and the key findings from this study will inform decision-makers and policy makers about the status of TB outcomes and suggest ways in which program implementation could be revised.

2.11 Summary

This chapter has reviewed past studies and theoretical literature on the impact of the COVID-19 pandemic on healthcare specifically the provision of TB diagnostics and treatment services. Although many countries had successfully instituted lockdown measures to curb the transmission of COVID-19 infections there was a concern that these public health measures could adversely impact the utilization of TB services. The literature also highlighted that the LMCs were the most disadvantaged due to weak health systems, hence the need for governments to prioritize the health sector when it comes to resource allocation. This study on literature also provided a background for the current research to analyse and compare findings with existing empirical evidence. The next chapter outlines the methodology employed in the study so that the true effects of the pandemic in the Buhera district could be assessed.

CHAPTER 3 METHODOLOGY

3.1 Introduction

This chapter details the research methods followed in this study. It presents the following: research design, description of the study setting, the study population, sampling procedures, and inclusion and exclusion criteria of study participants. Lastly, the chapter looks at the plan for data collection, analysis, dissemination, and the ethical issues considered during the study process.

3.2 The Research Design

The study utilized a comparative retrospective analysis because the outcome of interest had already occurred. The researcher used aggregate data from TB patients extracted from the District Health Information System 2 (DHIS2) to evaluate the impact of COVID-19 on TB case detection, diagnosis, and treatment outcomes before and during the pandemic. The design was proper for this research because it allowed comparisons of variables to be made between the pre-COVID-19 pandemic period and the COVID-19 period. In addition, the research design was useful in finding significant associations between the COVID-19 pandemic restriction measures and TB outcomes.

3.3 Study setting

The study was conducted in the Buhera district in Manicaland province. The district has a population of 298 742 (Demographic data, 2022), 96% of which is rural. The population is predominantly young with children less than 5-14 years age group constituting 31.4% of the population. Buhera is characterized by low rains and dry spells such that most of the population rely on donor aid. There are 34 public health facilities in the district, of which 1 is a mission hospital, 2 are rural health hospitals, 7 are government rural health centers and 24 are council-owned clinics. All these health facilities were selected for the quantitative assessment as they provide TB case detection, diagnosis, and treatment services as per the national TB guidelines. Quarterly, these health facilities report TB data such as the number of cases detected, and notifications to the district (to be captured into DHIS2) using nationally standardized monitoring and evaluation tools. In addition, these health facilities offer HIV and TB services free of charge. Figure 4 is a district catchment area map depicting the distribution of health centers by wards.

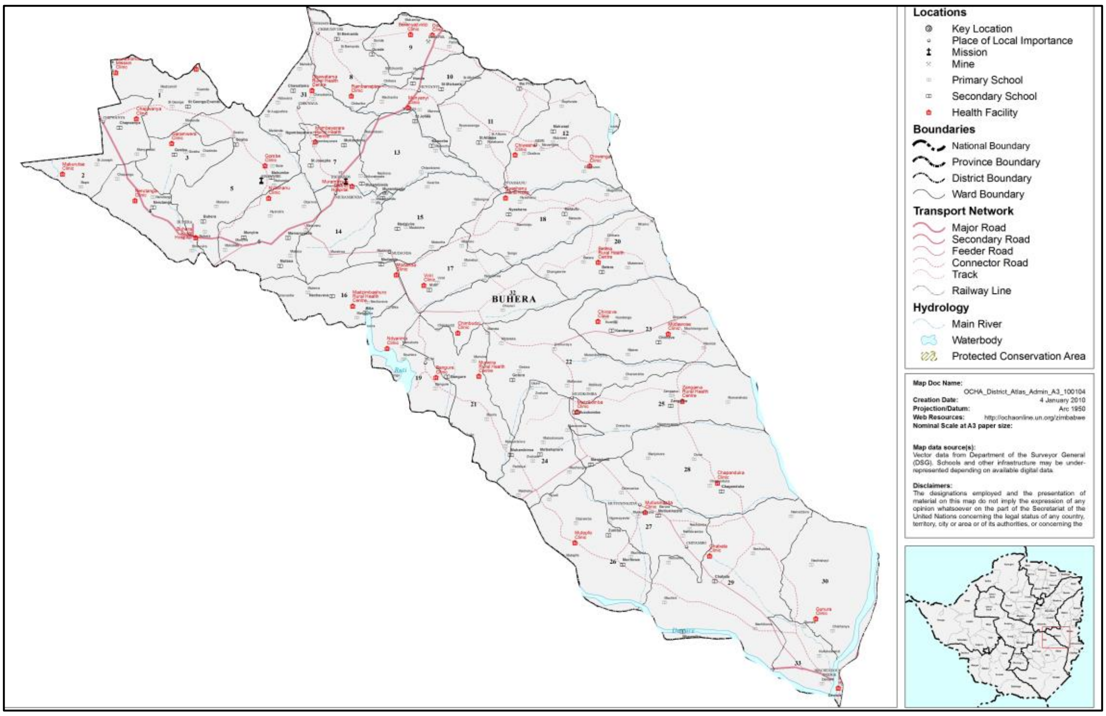


Figure 4 Buhera District Catchment Area Map

Source: Google maps

3.3.1 Study Population

The study population included patients who sought TB services in the Buhera district from April 2019 to March 2021. These were patients who presented with presumptive TB, diagnosed, and registered for anti-TB treatment in the district.

3.3.2 Inclusion Criteria

The study included presumptive and confirmed TB individuals as well as patients who were commenced on standard 6-month anti-TB treatment for two years (April 2019 to March 2021).

3.3.3 Exclusion Criteria

Patients with multi-drug-resistant TB (MDR TB) were excluded from this study as a plethora of studies have shown that MDR TB does not respond to the standard 6-month anti-TB regimens and the treatment often takes 2 or more years. As a result, the study would get inconclusive data on the treatment outcomes of MDR patients due to the strict timelines of the study.

3.3.4 Key Time Points and Periods

To understand better the impact of the pandemic on TB services, this study divided data into 2 study periods: the pre-COVID- 19 period (baseline) i.e., from April 2019 to March 2020, and the COVID-19 era i.e., from April 2020 to March 2021. To compare the outcomes of interest, the pre-COVID-19 period was further divided into quarters that are Q2 (April-June), Q3 July – September), Q4 (October – December), and Q1 (January – March) respectively, 2019; whereas the COVID-19 period was regarded as the corresponding quarters in 2020 to 2021as shown in Table 1. On March 30, 2020, the nationwide COVID-19 lockdown started, and the 1st wave intensified from June to September, followed by the 2nd wave that started from 21 December 2020 to 1 February, and lastly the 3rd wave from 29 June to 22 July 2021 (MoHCC, 2020). During the intensive phases, people were ordered to stay at home. Health facility attendance has been observed to be seasonal during the Christmas holiday such that there was likely to be some bias in October to December quarter.

Table 1 depicts the two study periods used in this study. Data collection was limited to 1 year before the emergence of COVID-19 termed the pre-COVID-19 period and 1 year during the pandemic termed the COVID-19 period. The study periods were further disaggregated into quarters to obtain granular data.

Table 1 Data collection timeframe

Quarter 2	**Quarter 3**	**Quarter 4**	**Quarter 1**	
April - June 2020	July - September 2020	October - December 2020	January - March 2021	COVID-19 period
			20 March, MoHCC confirmed the first case	
April - June 2019	July - September 2019	October - December 2019	January - March 2020	Pre-COVID-19 period

3.3.5 Sampling procedure

A census sampling method was done using TB quarterly aggregate data from the DHIS2. The DHIS2 dataset for the Buhera district includes data from all 34 health facilities in the district from April 2019 to March 2021. The advantage of using a standardized dataset is that it would give a true reflection of the COVID-19 situation on TB trends in the district.

3.4 Data Collection Instruments

The quarterly aggregate TB data from DHIS2 was extracted and exported to a proforma developed using an Excel application for data cleaning.

3.4.1 Study Variables

The programmatic success of the TB control intervention is measured by looking at TB case detection, diagnosis, case notification, and treatment success. Patient health outcomes are a consequence of the services received for instance early and proper diagnosis, correct treatment regimens, adherence to anti-TB medicines, and treatment outcomes. The deficient provision and utilization of these services affect the quality of TB care. With the little evidence from the literature reviewed that the COVID-19 pandemic had negatively affected these TB outcomes in other settings. Henceforth, it was important to assess the extent to which these TB outcomes could have been impacted in Buhera district. Table 2 below describes the study variables and how they were assessed in this study.

Table 2 Description of variables

Variable	Description
TB detection rate	An aggregate number of patients with presumptive TB, stratified by age (children <15 years and adults ≥15 years) and sex (male and female).
TB diagnosis	An aggregate number of patients diagnosed with bacteriologically positive TB by either smear microscopy and/or Xpert MTB/RIF.
TB notifications	An aggregate number of patients with registered TB, stratified by bacteriologically confirmed TB, clinically diagnosed TB. Or the number of TB cases registered in the facility's TB treatment registers.
TB treatment outcomes	An aggregate number of TB patients registered 8 months before the reporting time to allow 6 months of monitoring and 2 months of tracking the patients for documentation of the final outcome. It's a binary variable. Unfavourable treatment outcomes included died, lost to follow-up (LTFU), failed treatment, or not evaluated whereas favourable outcomes included completed treatment and cured. These WHO TB treatment outcomes are fully described in Table 3 below.

Table 3 below displays descriptions of the recently revised and standardized WHO treatment outcomes definitions. These definitions apply to both adults and children to ensure consistent reporting to the NTPs. These treatment outcomes are crucial for monitoring and measuring the effectiveness of TB treatment strategies over time as well as across settings.

Table 3 Tuberculosis treatment outcome categories definitions

Treatment outcome categories	**Description**
Treatment success	A combination of cured and, treatment completed
Cured	A TB patient with a smear or culture-negative in the last month of treatment and on at least one previous occasion.
Completed treatment	A TB patient who completed treatment with no sputum smear examination
Died	A TB patient who dies for any reason before starting or during the TB treatment course.
Lost to follow-ups (LTFU)	TB patients who did not start treatment or interruption in treatment for two consecutive months or more.
Failed treatment	A TB patient whose sputum smear or culture is positive at month 5 or later during treatment
Not evaluated	A TB patient who transfers to another facility whose final treatment outcome is not recorded

Source: Zimbabwe National TB guidelines, 2016

3.5 Pretesting of instruments

A pilot study was conducted two weeks before the final data extraction. The researcher exported data for Murambinda Mission Hospital from DHIS2. This enabled the researcher to check for outliers, verify, and correct any extreme data variables using the DHIS2 export. Further to that it helped to make appropriate modifications as well as check if the data collected was useful in meeting the study objectives.

3.6 Data Collection Procedure

Sources of data

The study used aggregate secondary TB data on TB case detection, diagnosis, and treatment reported in the DHIS2 from April 2019 to March 2021. A DHIS2 is a nationwide database used to report health services delivery at the district level on a monthly and quarterly basis. The database generates high-quality data primarily abstracted from the standardized national TB monitoring and evaluation tools (presumptive TB register, Laboratory register, and TB register where treatment outcomes are recorded) at all public health facilities in the district. All data were collated on a data collection form and later exported to Stata version 13 for analysis.

3.7 Analysis and Organization of Data

Statistical analyses were performed using the Stata version 13. Categorical variables were recorded as frequencies and frequencies (percentages). The percentage differences in categorical variables were calculated using (COVID-19 value – pre-COVID-19 value) multiplied by 100% divided by the pre-COVID-19 value. The relative percentage changes observed between the two study periods were also calculated and the p-values were presented. Pearson's chi-square or Fisher's exact tests were used to test for associations between categorical variables. Study findings were presented using tables and graphs.

3.8 Dissemination of results

The findings obtained from this study shall be shared with Africa University, Buhera District Health Executive Team, health care workers, peer researchers, policy makers and other relevant stakeholders. They will be shared through presentations and papers even through journals and reports when opportunity arises.

3.9 Ethical Considerations

Permission to carry out the study was sought from the District Medical Officer (DMO) for Buhera. Ethical clearance was obtained from Africa University Research Ethics Committee (AUREC) (approval date 7 March 2023). Since it was a retrospective study, there was no participation of human subjects, therefore written informed consent was waived. A password-protected Excel spreadsheet was used for data entry. It was only accessible to the researcher, supervisors, and interested District Health Executive team members.

CHAPTER 4 DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter contains detailed analysis, presentation, and interpretation of the findings obtained from the quantitative assessment. The results are presented in relation to the study objectives defined in the study. A comprehensive method used to analyze the data has already been discussed under the research methodology.

4.2 Data Presentation and Analysis

4.2.1 TB case detection and Diagnosis

Table 4 Comparison of presumptive and confirmed TB cases during the pre-COVID-19 period COVID-19 period in Buhera district.

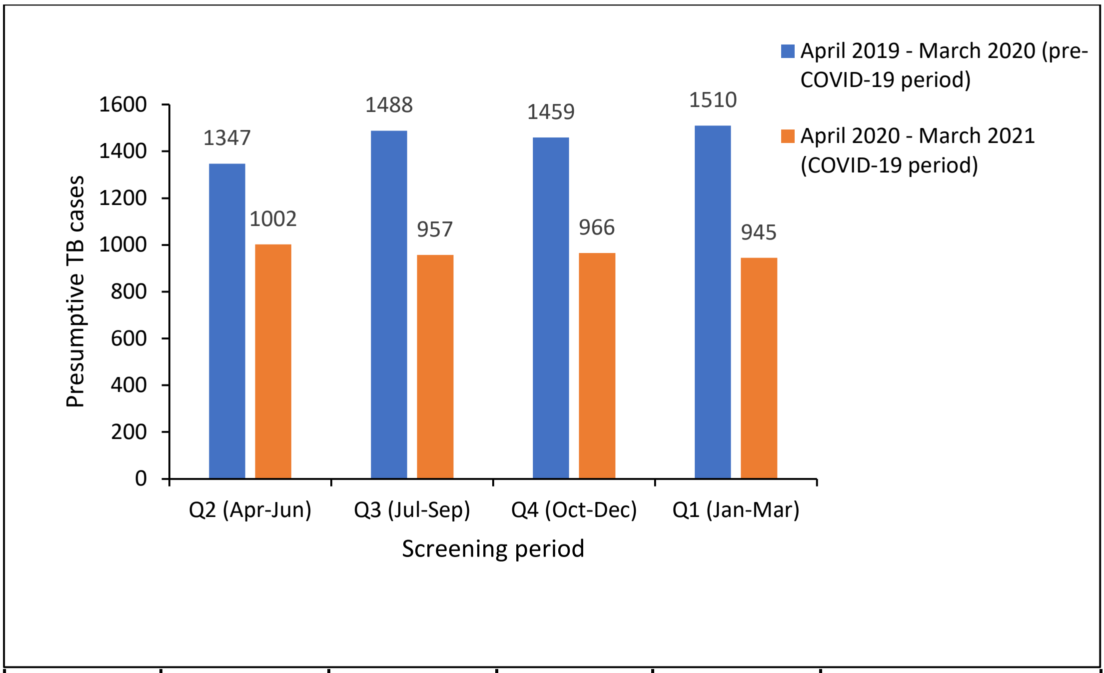
Variables	**pre-COVID-19 Apr 2019 to Mar 2020 N**	**COVID-19 Apr 2020 to Mar 2021 N**	**% change in totals**	**p-value**
Presumptive TB cases	5 804	3 870	-33.3	-
Sex				
Male	2 422	1 790	-18.7	<0.05*
Female	3 382	2 080	-38.6	
Age (years)				
Children (≤ 15)	809	690	-14.7	<0.05*
Adults (>15)	4 995	3 180	-36.3	
Mode of referral				
Contact tracing	506	527	4.2	
Community	696	455	-34.6	<0.001**
Health facility	4 602	2 888	-37.2	
Mode of Diagnosis				
Bacteriologically confirmed	250	289	13.5	<0.001**
Clinically diagnosed	149	88	-40.9	

P value <0.05*, <0.001** Pearson chi tests

Table 3 compares the characteristics of persons with presumptive TB and confirmed TB cases during the pre-COVID period and COVID-19 period, respectively. A total of 3 870 presumptive TB cases were reported throughout the COVID-19 period, compared with 5 804 in the pre-COVID-19 period, representing a 33.3% decrease in TB screening. The overall decrease was greater in females compared with males (38.6%, versus 18.7%; $p<0.05$) respectively, and among adults compared with children (36.3% versus 14.7%; $p<0.05$) respectively. The decline in presumptive TB cases was worse for those screened at health facilities and community (37.2% versus 34.6%, respectively), whereas contact tracing experienced a 4.2% increase in the COVID-19 period compared with the pre-COVID-19 period.

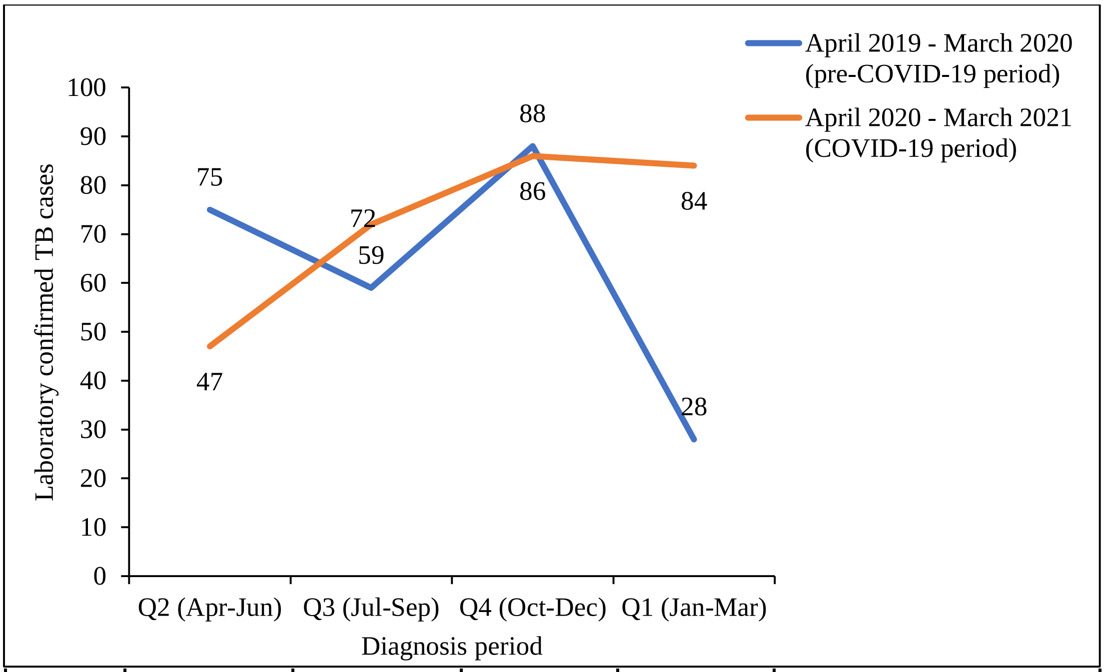
While there was a 13.5% increase in laboratory-confirmed cases during the period April 2020 – March 2021 compared with the period from April 2019 – March 2020, the absolute numbers of bacteriologically positive were almost similar between the two periods (250 versus 289) respectively. However, for clinically diagnosed cases the change was more pronounced representing a decrease of 40.9%.

The quarterly presumptive TB cases reported during the pre-COVID-19 and COVID-19 periods are displayed in Figure 5. The decline in presumptive TB cases during the second quarter of 2020 (April – June) was 26% and this became greater across all the quarters with 36%, 34%, and 37% in July – September, October – December, and January – March respectively. The 36% decrease corresponded to the immediate aftermath of the institution of lockdown measures whereas the 37% could be attributed to the intensification of the lockdowns following the 2nd wave of COVID-19 that started in December 2020 to February 2022.



% change	-26	-36	-34	-37	

Figure 5 Comparison of quarterly presumptive TB cases in the Buhera district during the pre-COVID-19 and COVID-19 periods.

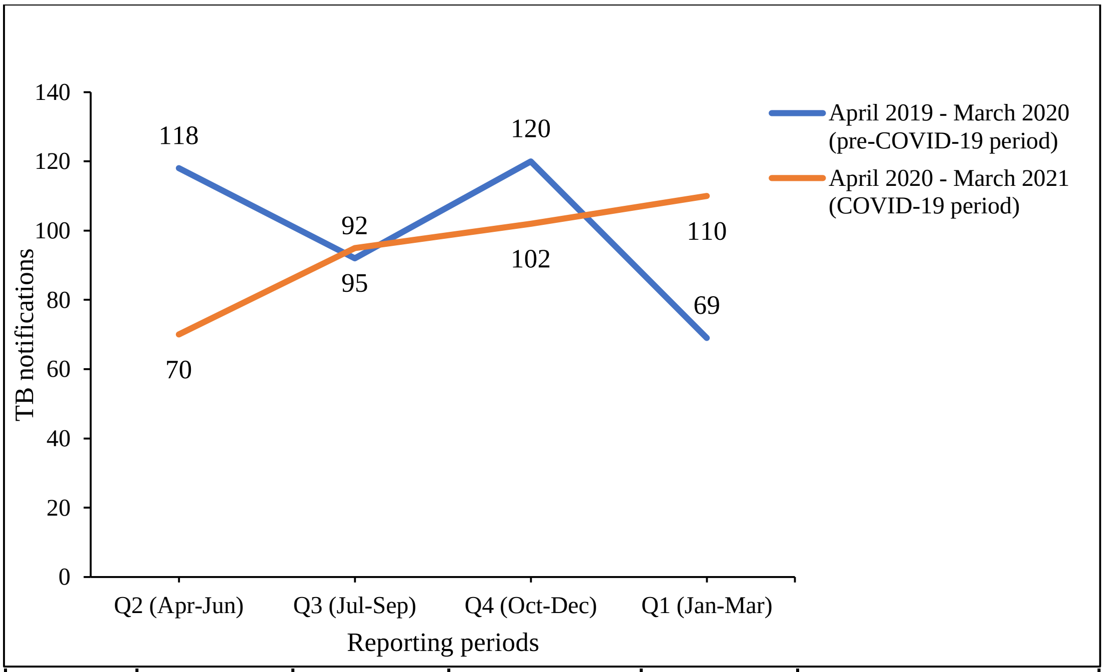


% change	-37	-22	-2	+200	

Figure 6 Trends in quarterly laboratory-confirmed TB cases during the pre-COVID-19 and COVID-19 periods.

Despite having more numbers diagnosed bacteriologically positive during the COVID-19 period compared with the baseline period, representing an increase of 13.5%, the lockdowns saw major decreases of 37.3%, and 22% in laboratory-confirmed TB cases during the periods April to June and July to September illustrated in Figure 6. To counteract this downward trend, laboratory operations returned to normalcy with support from interested partners which saw laboratory cases increasing dramatically by 200% in quarter 1 of 2021.

4.2.2 TB notifications



% change	-41	+3	-15	+59	

Figure 7 Comparison of TB notifications during the pre-COVID-19 and COVID-19 periods in the Buhera district.

TB case notifications dropped by 5.5%. between the two study periods. Figure 7 shows trends in quarterly TB notifications during quarters 2 to quarter 4 of 2019 and quarter 1 of 2020 and corresponding quarters of 2020-2021. There was a precipitous drop of

41% from April to June 2020 compared with the same quarter in 2019. This was mainly attributed to the immediate implementation of COVID-19 lockdown measures. However, there was a sharp increase in the TB registered cases in the first quarter of 2021 compared to 2020 following the strict application of infection, prevention and control measures at health facilities creating an enabling environment where symptomatic patients feel safe to access health care services.

4.2.3 TB treatment outcomes

Table 5 Comparison of TB treatment outcomes between the pre-COVID-19 and COVID-19 periods

Characteristics	**Pre-COVID-19 Notified TB cases N=399 n (%)**	**COVID-19 Notified TB cases N=377 n (%)**	**% Change between pre and COVID-19 period**	**p-value**
Sex				
Male	224 (56.1)	220 (58.4)	-1.8	0.562
Female	175 (43.8)	157 (41.6)	-10.2	
Age (years)				
Children (≤ 15)	8 (2)	10 (2.6)	25	0.637
Adults (>15)	391 (97.9)	367 (97.3)	-6.1	
Mode of diagnosis				
Bacteriologically confirmed	250 (62.7)	289 (76.7)	15.6	<0.05*
Clinically diagnosed	149 (37.3)	88 (23.3)	-40.9	
HIV status				
Positive	233 (58.4)	210 (55.7)	-9.8	
Negative	164 (41.1)	161 (4.2)	-1.8	0.273
Unknown	2 (0.5)	6 (1.6)	200	
Type of DOT				
Health facility	32 (8.0)	5 (1.3)	-84.4	<0.001**
Community	367 (92.0)	372 (98.7)	1.4	
Treatment success				
Yes	361 (90.5)	334 (88.6)	-7.5	0.391
No	38 (9.5)	43 (11.4)	13.2	

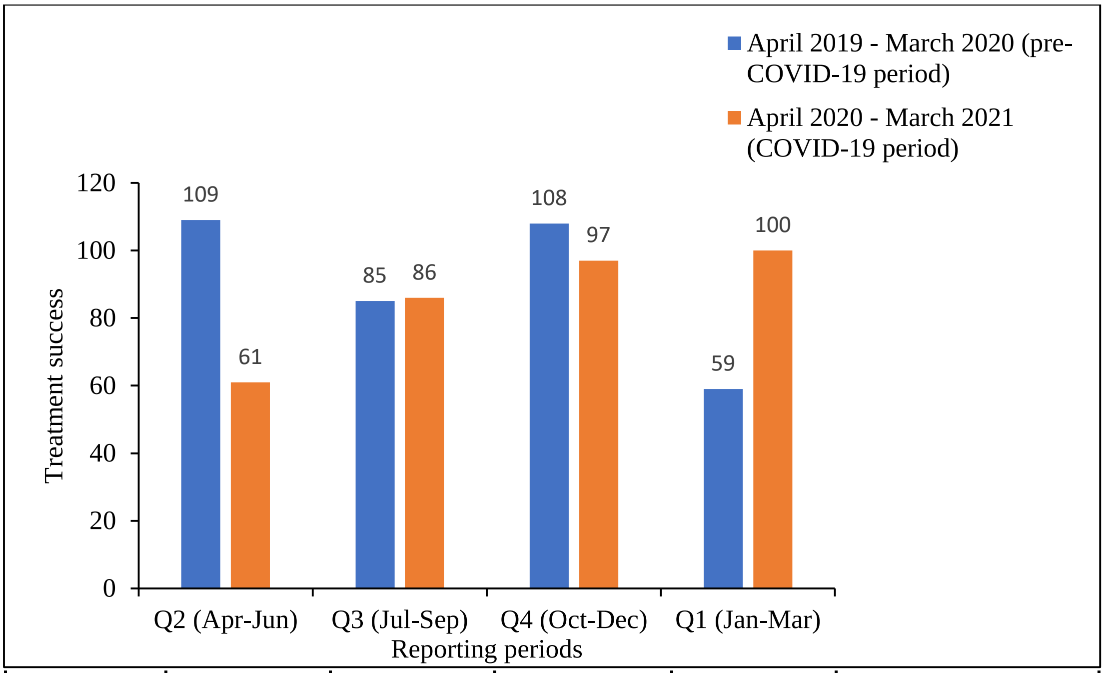
P value <0.05*, <0.001** Pearson chi tests

Table 5 shows the characteristics of TB treatment outcomes between the pre-COVID-19 and COVID-19 periods. There was no statistically significant difference in the distribution of sex (p=0.562), age (p = 0.637), HIV status (p=0.273) between the two groups. However, there were significantly bacteriologically confirmed TB cases ($p < 0.05$) during the pandemic period compared with the baseline figures. Treatment success slightly decreased by 7.5% with a 13.2% increase in treatment failure during the COVID-19 period compared with the pre-COVID-19.

Table 6 Treatment outcomes of patients enrolled on TB treatment during the pre-COVID-19 and COVID-19 periods.

WHO Treatment outcomes	**Pre-COVID-19 (Apr 2019-Mar 2020)**	**COVID-19 (Apr 2020-Mar 2021**	**Difference between pre-COVID-19 and COVID-19 (%)**	**p-value**
Enrolled for treatment	399	377		
Cured	190 (47.6)	162 (42.9)	28 (-4.7)	
Completed	171 (42.8)	172 (45.6)	1 (2.8)	
Lost to follow up	10 (2.5)	4 (1.1)	6 (-1.4)	0.144
Failed treatment	1 (0.25)	1 (0.25)	0	
Died	25 (6.2)	30 (7.9)	5 (1.7)	
Transferred out/ not evaluated	2 (0.5)	8 (2.1)	6 (1.6)	

There were small but insignificant differences observed in adverse treatment outcomes during the COVID-19 period with lower rates of LTFU (2.5% versus 1.1%), and slightly increased rates of death (6.2% versus 7.9%), and not evaluated (0.5% versus 2.1%) (p=0.144) compared with patients completing treatment during pre-COVID-19) shown by Table 6.



Percentage change	-44	+1	-10	+69	

Figure 8 Comparison of treatment success between the pre-COVID-19 period and COVID-19 in the Buhera district.

Figure 8 displays treatment success amongst those enrolled each quarter in the Buhera district, during pre-COVID-19 and COVID-19 periods. Enrolment occurred 8 months before reporting period to give an allowance of 6 months for treatment completion and 2 months for follow-up and documentation of final outcome. The treatment success rate sharply decreased in the second quarter of 2021 compared to 2019. However, during the January to March 2021 quarter, health facilities were now dispensing medication that last for longer periods, and the treatment success rate increased by 69%.

4.3 Summary

This chapter included a thorough analysis of all the findings. The results showed that the COVID-19 pandemic adversely impacted TB service delivery in the Buhera district, with declining trends in TB case detection, diagnosis, and treatment outcomes. The next chapter provides a comprehensive discussion that relates these findings to the reviewed literature and conceptual framework.

CHAPTER 5 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

This chapter highlights and discusses the major study findings in line with the research objectives, available literature, and the framework to identify similarities and dissimilarities between this study and previous studies. The next part concludes the research by discussing the implications of the current study and the resultant recommendations. Lastly, the chapter ends with suggestions for further research.

5.2 Discussion

This study assessed the impact of the COVID-19 pandemic on TB case detection, diagnosis, and treatment outcomes in the Buhera district. In summary, the study found that the pandemic adversely impacted almost all aspects of the TB service delivery system. The next section discusses how COVID-19 impacted the study outcomes in Buhera district.

5.2.1 TB case detection

Presumptive TB cases considerably declined over the 12 months COVID-19 period compared with the pre-COVID-2019 period. In contrast to findings from other studies conducted in Zimbabwe by Thekkur et al. (2021), Sierra Leone by Lakoh (2021), and Nigeria by Adewole (2020) that found that the health-seeking behaviour of presumptive TB among children and women was greatly influenced during the COVID-19 period, this study found that adults and women were particularly affected compared with their counterparts. Both health facility-initiated referrals and community-initiated referrals dramatically dropped by 34.6% and 37.2% respectively.

The decline in presumptive TB cases was similar to what was observed during the COVID-19 period in health facilities in Zimbabwe by Thekkur et al. (2021), Zambia by Mwamba et al. (2020), Ethiopia by Arega et al. (2022), Sierra Leone by Lakoh (2021), and Nigeria by Adewole (2020) where fear of contracting COVID-19 disease and the consequences of COVID-19 diagnosis such as isolation at health facilities and transportation difficulties were thought to deter patients from seeking TB services. Besides the lack of access and fear stated earlier, the other possible explanation is that the presumptive referral system was stopped due to the temporal closure of TB outpatient clinics and the reallocation of staff to COVID-19 care during the intensive period. While these findings are largely attributed to the direct consequences of lockdown restrictions, there are other barriers to access and utilization of TB services such as low health literacy levels, poor health-seeking behaviours, transportation constraints direct treatment, and non-treatment costs (Thekkur et al., 2021).

5.2.2 TB diagnosis

Despite having fewer presumptive TB cases that were tested during the COVID-19 pandemic study period, there was a 13.5% increase in laboratory-confirmed TB cases compared with the baseline period. Similar research findings have been reported in Sierra Leone by Lakoh (2021) and Malawi by Thekkuret al. (2021), and Zimbabwe by Thekkuret al. (2021). Since 2016, Buhera district has been scaling up Xpert MTB RIF (gene expert) testing to improve TB diagnostic capacity and address issues around drug-resistant TB. These efforts could partly explain the increase in laboratory-confirmed tests. Other contributory factors may be that the laboratory operations returned to normalcy with support from interested partners and the use of selective referral.

Although the overall finding showed an increase in bacteriological positivity over the 12 months of the COVID-19 pandemic compared with the pre-COVID-19 period, the district experienced a sharp decline in laboratory-confirmed TB cases during the first 6 months of the pandemic following the expiring of Xpert MTB/RIF assays cartridges and shortage of laboratory reagents. It is also possible that due to the temporal closure of TB clinics and shortened TB clinic hours, sputum was not being collected for investigations and patients and there was limited access to health facilities.

5.2.3 TB notifications

The current study found that TB case notifications declined throughout the COVID-19 period representing a decrease of 5.5%. These findings were consistent with other studies conducted in Sierra Leone by Lakoh (2021), Malawi by Thekkur et al. (2021), Zimbabwe by Thekkur et al. (2021), China by Wu et al. (2020), India by Golandaj (2021) where TB notifications decreased by 3%, 19%, 38%, 48%, and 56% respectively in 2020 compared with 2019. These statistics do not necessarily show a decrease in TB incidence but may translate to a significant number of undiagnosed cases in the communities due to lockdown restrictions. Initial concerns were that the COVID-19 pandemic would lead to poor TB treatment outcomes since lockdown restrictions would hinder patients from collecting anti-TB refills. The decline in TB case notifications in the Buhera district could also be indicative of a dysfunction of the primary healthcare system in general despite the concerted efforts from the National TB Program.

These findings are also consistent with a study done by Soko et al. (2021) in Blantyre, Malawi on the effects of the COVID-19 pandemic on TB notifications where it was found that TB case notifications substantially declined during the COVID-19 period. However, TB case notification rates increased in the first quarter of 2021 reaching near pre-pandemic levels. Missed cases or delayed diagnoses normally result in severe TB complications ultimately hindering progress toward TB end due to treatment failures. In the context of Buhera, the 5% drop in TB case notifications during the pandemic was a result of missed diagnosis or at least delayed diagnosis. The findings are similar to qualitative findings obtained by Soko et al. (2021) that access to health facilities was extremely challenging after the aftermath implementation of lockdown measures in Malawi. In the current study, alternative explanations could be issues of reporting whereby TB cases would be started on treatment yet not notified to the national TB program. At one point in time in the district, due to the closure of TB clinics, patients would go straight to the pharmacies to collect their TB medicines. Therefore, data triangulation using the pharmacy register, pharmacy modules in electronic Patient Management Systems (ePMS), laboratory registers, and TB registers is critical in generating credible findings that would allow for evidence-based decisions.

To conclude that the true TB incidence has declined is unlikely due to the reasons mentioned earlier. In addition to general health services restrictions, qualitative findings obtained by Soko et al. (2021) in Malawi demonstrated that TB diagnosis and notifications trends were particularly impacted because both COVID-19 and TB patients present with similar symptoms such as cough, fever, and difficulty breathing. Because of similarities in clinical presentations, patients with TB symptoms were less likely to seek healthcare services because of fear of being infected with COVID-19 and the possible consequences of diagnosis such as isolation. Further to that, it is plausible that some people with presumptive TB symptoms were turned away and directed to COVID-19 specific services when they visited health facilities. This reduced their chances of being diagnosed.

5.2.4 TB treatment outcomes

Treatment success is core to achieving the End TB goal because it helps to reduce disease transmission, mitigate the development of drug-resistant TB and protect the public from TB infection. However, the current study found that there was a 7.5% decline in TB treatment success rates during the pandemic. A higher number of patients were not evaluated probably due to services disruptions when health workers were on strike amidst the pandemic and EHTs who are responsible for TB case follow-ups were assigned to COVID-19 duties. However, during the first quarter of 2021, there was some improvement as health facilities were now dispensing medication that last for longer periods.

These results are consistent with studies done in Ethiopia by Arega et al. (2022) and in Korea by Youn (2020) with drops in treatment success rates by 4.8% and 4.9% respectively. The plausible reasons included delayed diagnosis, increased number of patients with treatment interruption, poor patient monitoring and tracking, and underreporting of treatment success. However, findings obtained from China by Fei (2020) and real-time monthly surveillance of TB activities set in cities of Malawi Thekkur et al. (2021) and Sierra Leone Lakoh (2021) did not show strong evidence of a significant decline in treatment success. These findings are largely attributed to the use of hybrid approaches in treatment support that are a combination of self-administration of anti-TB therapy and DOT.

Multi-month dispensing of anti-TB medicines will be ideal, especially in the context of the public health crisis that requires social distancing. However, this approach requires strict supervision of treatment to promptly detect treatment interruptions and monitor adherence to treatment regimens.

The district received support from partners in the form of human resources and treatment success considerably improved during the first quarter of 2021. Zimbabwe has been using the Directly observed therapy model in delivering TB treatment. According to WHO (2017) and WHO (2018), the DOT approach has been endorsed as the standard of care for both drug-susceptible and drug-resistant TB with high treatment adherence and treatment success (>80%). However, this study found that the health facility DOT decreased by 84% whereas community DOT increased by 1.4% possibly due to financial cost and logistic implications.

5.3 Conclusions

In summary, the COVID-19 pandemic has severely disrupted TB care and service delivery in the Buhera district, with fewer presumptive cases referred for diagnosis in 2020 compared to 2019. TB case notifications and TB treatment success rates declined considerably over the 12 months of COVID-19 setting back progress towards the end TB goal of eliminating TB by 2035. Unfortunately, the declining trends in TB diagnosis and treatment success could not be reversed. Therefore, in addition to the recommendations made, there is a need to mobilize resources to strengthen and restore essential TB program activities in the Buhera district.

5.4 Implications

The study shows the importance of building resilient healthcare systems and having an emergency preparedness and response plan in place to enable access to continued care in the context of the public health crisis. Given that COVID-19 is likely to be endemic, the study findings suggest the urgent exploration of the use of other innovative service delivery approaches such as the person-centered model to minimize interruption of service delivery now and in future pandemics. Suggestions on how to do this have been made.

5.5 Recommendations

Following the major findings observed and discussed above, the researcher recommends the following strategies presented in Table 7 to be considered and effected in planning and implementation of the TB control program.

Table 7 Recommendations

Finding	Recommendation	Timeline	Responsible authority
Low TB case detection	Provide correct and consistent health education to patients about COVID-19 and TB so they continue seeking TB services	Continuous	Health Promotions Officer
	Integrate TB and COVID-19 screening services	Immediately	The District Health Executive Team, TB coordinator
	Strengthen community linkages to improve active case finding, adherence, and treatment support (promoting home-based and community-based care)	30 March 2023	The District Health Executive Team, TB coordinator
	Ensure effective infection, prevention, and control measures in health facilities to provide safe working spaces for healthcare workers and patients	Continuous	The District Health Executive Team, TB coordinator
Delayed TB diagnosis	Put in place a robust procurement system to avoid stockouts	30 June 2023	District Pharmacist
	Sharing of the gene expert machine in the laboratory / multiple usage of the machine	Continuos	Laboratory Scientist
Poor TB treatment outcomes	Multi-month dispensing of TB medicines	Immediately	The District Health Executive Team
	Use of virtual care and digital platforms for adherence support and remote monitoring of patients	30 April 2023	The District Health Executive Team

5.6 Suggestions for Further Research

A mixed methods research design with both quantitative and qualitative analysis amongst TB patients themselves is needed to obtain in-depth information on why patient access to health services and health service delivery was badly influenced. Further to that there is a need to extend this study to establish the long-term impact of the pandemic on TB incidence and mortality.

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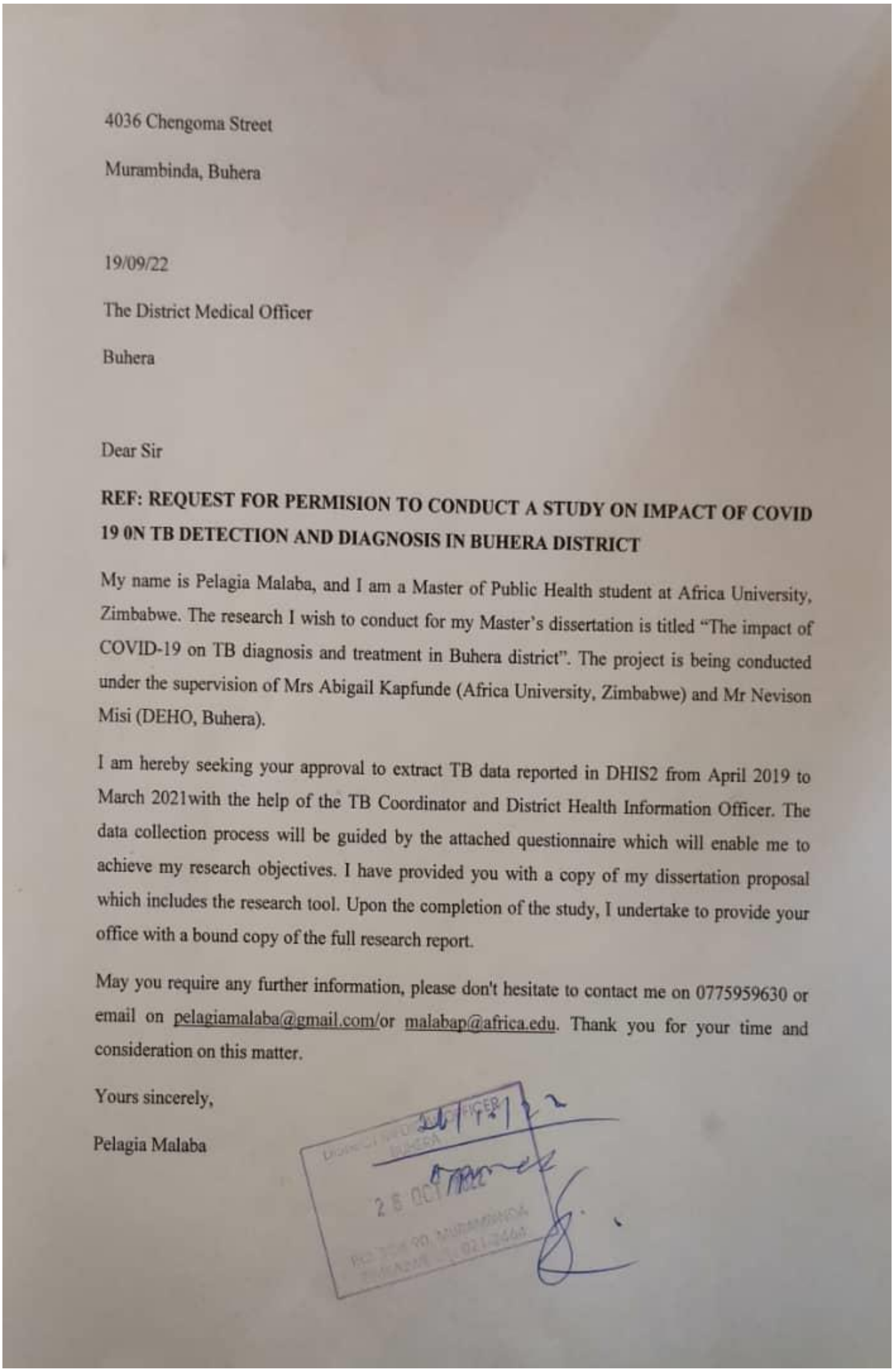
APPENDICES

Appendix 1: Data collection tool

Variables	**pre-COVID- 19 period (April 2019 to March 2020)**					**COVID-19 period (April 2020 to March 2021)**				
	Q 2	Q 3	Q 4	Q 1		Q 2	Q 3	Q 4	Q 1	
	April - June	July - September	October - December	January - March	Total	April - June	Jul - September	October - December	January - March	Total
Presumptive TB cases										
Sex										
Male										
Female										
Age category										
Children (≤ 15)										
Adults (>15)										
Mode of referal										
Contact tracing										
Community										
Health facility										
Bacteriologically positive										
Positivity rate (%)										
Notified TB cases										
Mode of diagnosis										

Bacteriologically confirmed											
Clinical diagnosis											
Enrolled for treatment											
HIV status											
Positive											
Negative											
Unknown											
Treatment outcomes											
Cured											
Completed											
Lost to follow up											
Failed treatment											
Died											
Transferred out/ not evaluated											
Treatment success											
Yes											
No											

Appendix 2: Approval from the District Medical Officer



4036 Chengoma Street

Murambinda, Buhera

19/09/22

The District Medical Officer

Buhera

Dear Sir

REF: REQUEST FOR PERMISION TO CONDUCT A STUDY ON IMPACT OF COVID 19 0N TB DETECTION AND DIAGNOSIS IN BUHERA DISTRICT

My name is Pelagia Malaba, and I am a Master of Public Health student at Africa University, Zimbabwe. The research I wish to conduct for my Master's dissertation is titled "The impact of COVID-19 on TB diagnosis and treatment in Buhera district". The project is being conducted under the supervision of Mrs Abigail Kapfunde (Africa University, Zimbabwe) and Mr Nevison Misi (DEHO, Buhera).

I am hereby seeking your approval to extract TB data reported in DHIS2 from April 2019 to March 2021with the help of the TB Coordinator and District Health Information Officer. The data collection process will be guided by the attached questionnaire which will enable me to achieve my research objectives. I have provided you with a copy of my dissertation proposal which includes the research tool. Upon the completion of the study, I undertake to provide your office with a bound copy of the full research report.

May you require any further information, please don't hesitate to contact me on 0775959630 or email on pelagiamalaba@gmail.com/or malabap@africa.edu. Thank you for your time and consideration on this matter.

Yours sincerely,

Pelagia Malaba

Appendix 3: AUREC Approval Letter

AFRICA UNIVERSITY

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: AU2596/23 7 March 2023

PELAGIA MALABA
C/O Africa University
Box 1320
MUTARE

RE: IMPACT OF COVID-19 ON TUBERCULOSIS DIAGNOSIS AND TREATMENT OUTCOMES IN BUHERA DISTRICT, 2022

Thank you for the above-titled proposal that 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 2596/23
  This number should be used on all correspondences, consent forms, and appropriate documents.
- **AUREC MEETING DATE** NA
- **APPROVAL DATE** March 7, 2023
- **EXPIRATION DATE** March 7, 2024
- **TYPE OF MEETING** Expedited
  After the expiration date, this research may only continue upon renewal. For purposes of renewal, a progress report on a standard AUREC form should be submitted a month before the expiration date.
- **SERIOUS ADVERSE EVENTS** All serious problems having to do with subject safety must be reported to AUREC within 3 working days on 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

MARY CHINZOU
ASSISTANT RESEARCH OFFICER: FOR CHAIRPERSON
AFRICA UNIVERSITY RESEARCH ETHICS COMMITTEE