Towards Development of a Novel Approach for Enhancement of TB Diagnostic Services during the Pandemic: A case of Primary Health Care Clinics in eThekwini District KwaZulu-Natal

by
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I would like to dedicate this degree to my parents, Innocent and Thembumusa Dlangalala. You have been there for me at every stage of my academic life. Without your sacrifices, this achievement would not be possible. Ma, I am grateful for your unwavering support and words of encouragement during difficult times. Baba, you are the one who inspired me to pursue my doctorate. After a challenging semester trying to get into the medical program, you told me to keep my head up and suggested that maybe I was meant to be a Ph.D. holder instead. Twelve years later, here I am.

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"Now to him who is able to do far more abundantly than all that we ask or think, according to the power at work within us, to him be glory in the church and in Christ Jesus throughout all generations, forever and ever. Amen." Ephesians 3:20-21

Declaration: Authorship

"I declare that the thesis, which I hereby submit for the degree of Doctor in Philosophy in Public Health at the University of Pretoria, is my work and has not previously been submitted by me for a degree at another university".

Signature ___________________________ Date: December 2023_________________

Declaration: Publications

Journal articles published

1. **Dlangalala T**, Musekiwa A, Brits A, Maluleke K, Jaya ZN, Kgarosi K, et al. Evidence of TB Services at Primary Healthcare Level during COVID-19: A Scoping Review. Diagnostics. 2021; 11(12):2221. doi:10.3390/diagnostics11122221

2. **Dlangalala T**, Musekiwa A, Mashamba-Thompson T. Towards development of a novel approach for enhancement of TB diagnostic services during the pandemic: A case of primary health care clinics in eThekwini district KwaZulu-Natal: A study protocol. PLOS ONE. 2022; 17(12):e0278305. doi:10.1371/journal.pone.0278305

3. **Dlangalala T**, Musekiwa A, Mashamba-Thompson T. Impact of COVID-19 on TB diagnostic services at primary healthcare clinics in eThekwini district, South Africa. Scientific Reports. 2023; 13(1):16645. doi:10.1038/s41598-023-43589-7

Journals under review

1. Geographical accessibility of TB diagnostic services at primary healthcare clinics in eThekwini District, South Africa. Submitted to *BMJ open*.
2. Quality of TB diagnostic services at Primary healthcare clinics in eThekwini District, South Africa Submitted to *PLOS ONE.*
3. Quality of TB services at primary healthcare clinics in eThekwini district, South Africa: Patient perspectives. Submitted to *BMC Infectious Diseases*.
4. Enhancing TB diagnostic services at primary healthcare clinics in the eThekwini district, South Africa, post-COVID-19: a nominal group technique. Submitted to *Discover Health Systems.*

Executive Summary

Introduction

Tuberculosis (TB) is an important public health issue in South Africa that has burdened health systems for decades. The past decade has seen progress in the management of this disease. However, the advent of the coronavirus disease 2019 (COVID-19) has disrupted the provision of essential TB services, resulting in TB detection dropping in the early phase of the pandemic. This has subsequently affected TB incidence and mortality. Therefore, in addition to recovery plans, TB services require strengthening to withstand future health crises. As such, this study aimed to generate evidence to inform a novel approach for improving TB diagnostic services in high-burden settings using the eThekwini district in KwaZulu Natal (KZN) Province, South Africa, as a study setting.

Methods

The study employed a multiphase mixed methods study design consisting of four phases. Initially, a scoping review was conducted to gather the available evidence on TB services during the COVID-19 pandemic. The findings were used to inform the objectives for the rest of the study. During the first phase, a geospatial analysis was conducted to calculate the geographic accessibility of TB diagnostic services at primary healthcare clinics in eThekwini district. The second phase consisted of a quasi-experimental study that determined the impact of COVID-19 on TB diagnostic services. The barriers and facilitators to providing quality diagnostic services were explored for the third phase through a facility audit and patient interviews. In the final phase, a Nominal Group Technique (NGT) was conducted with relevant TB stakeholders to develop an approach for enhancing TB diagnostic services during the pandemic. Together, the study's findings were synthesized and used to inform a framework to improve and strengthen the quality of TB diagnostic services.

Results

The scoping review revealed that the COVID-19 pandemic severely impacted TB detection due to various factors, including limited access to facilities. This prompted recommendations that could facilitate better service provision amid the pandemic. The study's geographic access evaluation determined that diagnostic services were highly accessible to most (92.6%) of the eThekwini population. The areas of poor accessibility mainly consisted of the rural population. Moreover, the analysis determined that many TB cases were in urban and sub-urban regions. The study also found that the impact of COVID-19 on TB detection was severe during the lockdown, showing 45% and 40% decreases in TB investigations and confirmed cases, respectively. These indicators recovered when lockdown measures were lifted. However, the peaks of SARS-CoV-2 variant-driven infection resulted in overall decreases in confirmed cases of TB. The assessment of the quality of TB diagnostic services revealed that many IPC aspects and continuous TB training were lacking at facilities, in addition to long turnaround times for GeneXpert results. Patients perceived long wait times, staff attitudes, and drug stockouts as barriers to quality services. Lastly, stakeholders identified key barriers to diagnostic services during the pandemic and developed an approach to overcome them. They suggested integrating TB/COVID-19 activities, continuous training among staff, strengthening IPC, decentralizing TB testing, using Point-of-Care tests (POC) and raising public awareness through social media platforms to enhance diagnostic services.

Conclusion

The present study has successfully developed a novel approach for enhancing tuberculosis (TB) diagnostic services at Primary Health Clinics (PHCs) in high-burden regions using the eThekwini district as a study setting. The approach involved devising a consolidated framework for providing high-quality diagnostic services, which is informed by the evidence generated in the thesis. The framework provides guidance on improving structural factors such as accessibility, infection prevention and control (IPC), and care processes, including continuous training and service integration. This comprehensive approach has the potential to improve service delivery and boost public confidence in the health system, ultimately leading to better health outcomes.

Keywords

Tuberculosis; Diagnostics; Health services; COVID-19; Primary Healthcare; Health equity; SARS-CoV-2; Quality of care

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Definition of Key Terms

Primary healthcare: As per the World Health Organization (WHO), primary healthcare is defined as the foremost point of contact that individuals, families, and communities have with the national healthcare system.[1]**TB diagnostic services:** The procedures for monitoring and confirming TB within individuals at a healthcare facility encompassing, screening, sputum, skin, and drug resistance testing**.**

Key stakeholders: For the purposes of this study, key stakeholders shall be defined as individuals who possess a comprehensive understanding of primary healthcare TB diagnostic services. This shall include TB nurses, TB researchers, and TB patients/survivors.

Pandemic: The Dictionary of Epidemiology defines a pandemic as, “an epidemic occurring worldwide, or over a very wide area, crossing international boundaries and usually affecting many people”.[2] For this study, the terms “COVID-19 pandemic” and “pandemic” will be used interchangeably.

List of Abbreviations

AIDS:	Acquires Immunodeficiency Disease Syndrome
COVID-19:	Coronavirus Disease 2019
DHIS:	District of Health and Information Systems
DOTS:	Directly observed treatment short-course
DR-TB:	Drug-Resistant Tuberculosis
GIS:	Geographic Information System
GPS:	Global Positioning System
GP:	General Practitioner
HCWs:	Healthcare workers
HIV:	Human Immunodeficiency Virus
HQHS:	High-Quality Health System
IPC:	Infection Prevention and Control
ITSA:	Interrupted time series analysis
KZN:	KwaZulu-Natal
LMIC:	Low- and Middle-Income Countries
LTFU:	Loss to follow-up
MMAT:	Mixed Methods Appraisal Tool
MDR-TB:	Multidrug-resistant TB
MERS-Cova:	Middle East respiratory syndrome coronavirus
MeSH:	Medical Subject Headings
NDPs:	National Development Plan
NGO:	Non-governmental Organization

NGT: Nominal Group Technique

PCC: Population, Concept and Context

PHCs: Primary Healthcare Clinics

POC: Point-of-care

PPE: Personal Protective Equipment

PRISMA-SR: Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews

SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2

SDGs: Sustainable Development Goals

SOPs: Standard Operating Procedures

TAT: Turnaround Time

TB: Tuberculosis

UN: United Nations

UNHLM: United Nations High Level Meeting

USA: United States of America

WHO: World Health Organization

XDR-TB: Extensively drug-resistant TB

Chapter 1 Introduction

Chapter 1 introduces the thesis; it provides a comprehensive rationale for the current study including the aims and objectives.

1. Thesis introduction

Tuberculosis (TB) is an infectious disease caused by the bacteria *Mycobacterium tuberculosis* although it is primarily a lung disease transmitted through the respiratory system, it can also infect all tissues in the body.[3] The disease has existed for centuries and has arguably been one of the biggest killers of humans throughout history and to date.[4] This is despite the availability of effective preventative and curative treatments and joint efforts by national and global agencies to combat the disease.[5]

In recent years, the global TB burden has remained relatively stable with approximately 10 million people falling sick annually and 1.2 million succumbing to the illness.[6] Moreover, an estimated 30% of those who fall sick are either not reported to health authorities or do not receive a formal diagnosis. These are the people who are at the heart of TB transmission.[6] The majority of the global burden is from countries in South East Asia, The West Pacific, and Africa.

To fight against the TB epidemic, global agencies convened to develop strategies to eliminate the disease. Most notably, the World Health Organization (WHO) adopted the end TB strategy in 2014 which aims to remove TB as a public health threat by 2035.[7] To do this, smaller milestones to reduce TB incidence and TB mortality were set for the years 2020 and 2030. In 2018, the United Nations High-Level Meeting (UNHLM) scaled up targets by aiming to diagnose and treat an additional 40 million people.[8] Despite progress, the UNHLM targets fell short with only 36 million people diagnosed.[6] Unfortunately, the advent of the coronavirus disease (COVID-19) pandemic abruptly impacted the gains achieved.[9]

The arrival of COVID-19 displaced TB as the leading cause of death by an infectious agent.[9] The virus rapidly spread throughout many countries with high TB burdens.[5] Given that both diseases are respiratory, many of these countries used their TB programmes to contain COVID-19 spread.[8, 10] This entailed diverting staff, facilities, and diagnostic resources toward COVID-19 response.[11] Additionally, the introduction of lockdown measures hindered access to health facilities; this, coupled with the fear and stigma associated with attending health facilities, resulted in massive reductions in TB detection.[12-14] After two years of sustained increases in TB case notifications, this number fell by 18% from 7.1 million to 5.8 million between 2019 and 2020.[9] Consequently, TB mortality rates immediately rose, followed by a 4.5% increase in TB incidence in 2021.[15] To prevent similar impacts in the future, strengthening TB services in high-burden regions is crucial.

2. Thesis background

South Africa has one of the highest global TB burdens, with 3.3% of global cases.[6] The epidemic is driven by the high number of people living with HIV.[16] Approximately 20% of the population is HIV infected of which 56% are TB/HIV coinfections.[15] Efforts from the national TB programme, such as introducing directly observed treatment short-course (DOTS) and GeneXpert for rapid TB detection, have assisted with managing the disease in the past two decades.[17] This has reflected in the TB mortality rate which has reduced from 224 per 100 000 population to 110 per 100 000 population between 2010 and 2018.[11] When the COVID-19 pandemic arrived, the country was already fighting and making strides toward managing TB.

By the time the first case of SARS-CoV-2 (the COVID-19 causal agent) was reported in March 2020, the well-developed infrastructure for TB and HIV was ready for a rapid response to the pandemic.[11, 14] GeneXpert machines were used for COVID-19 testing and community healthcare workers, trained for HIV and TB epidemics, were deployed for COVID-19 screening and testing referrals in susceptible communities.[14, 18] Additionally, the rise in SARS-CoV-2 infections prompted the government to implement a nationwide lockdown to curb transmission and prepare health systems for the inevitable influx of cases.[14]

The national lockdown, with varying degrees of restrictions, was implemented on the 27th of March 2020. This placed a series of limitations on people's movement between 2020 and 2022, with consequences for health services. TB testing was drastically reduced at the introduction of the lockdown and with each coinciding wave of COVID-19.[18] In May 2020, GeneXpert tests had declined by 48% compared to the previous year.[19] Although the move to less restrictive lockdown measures improved testing levels, there was still an overall decrease of 22% in nationwide testing and 15% in confirmed diagnoses by the end of 2020. Moreover, patient attendance at primary healthcare facilities had dropped by 18%.[18] These reductions should have manifested themselves in increased TB incidence; however, in 2021, TB incidence in South Africa had not deviated from pre-pandemic levels. It is possible that underreporting at the height of the pandemic may played a role in the incidence rate.

It's important to note that nationwide TB reports do not consider the diverse impacts of COVID-19 within regions of a country. In South Africa, the different provinces experienced different levels of the virus during its various waves.[14] A previous study indicated that primary healthcare services, including those for TB, were affected differently as a result of the pandemic.[20] Therefore, as the country establishes recovery plans to get TB progress back on track, the pandemic's impact in high TB burden settings should be considered. As such, the thesis aimed to develop an approach to enhance TB diagnostic services during pandemics in high TB burden settings.

3. Problem statement

One of the pillars of the WHO's end TB strategy is early diagnosis and treatment initiation.[7] This has been undermined by the COVID-19 pandemic, which greatly reduced access to healthcare services at its inception. This resulted from non-pharmaceutical measures such as lockdowns and reallocating health resources to manage the rising COVID-19 cases.[9] Additionally, fear and stigma were prevalent among both patients and healthcare providers around seeking help for and treating respiratory illnesses, respectively.[10, 21, 22] Together, these resulted in a reduction in TB detection (Figure 1). Several modeling studies predicted that reduced access to TB services during COVID-19 would increase incidence levels as a result of undetected TB cases.[23-25] Since then, the WHO has substantiated these models showing a 3.6% increase in TB incidence in 2021.[15]

South Africa has one of the highest global burdens of TB and also experienced the highest incidence of COVID-19.[15] Although, 2021, TB case notifications showed limited departure from pre-pandemic numbers,[15] TB detection can vary depending on the setting and thus warrants further investigation.[26] Therefore, the study aimed to propose a method to improve TB diagnostic services at PHCs during the pandemic using a high disease burden setting.

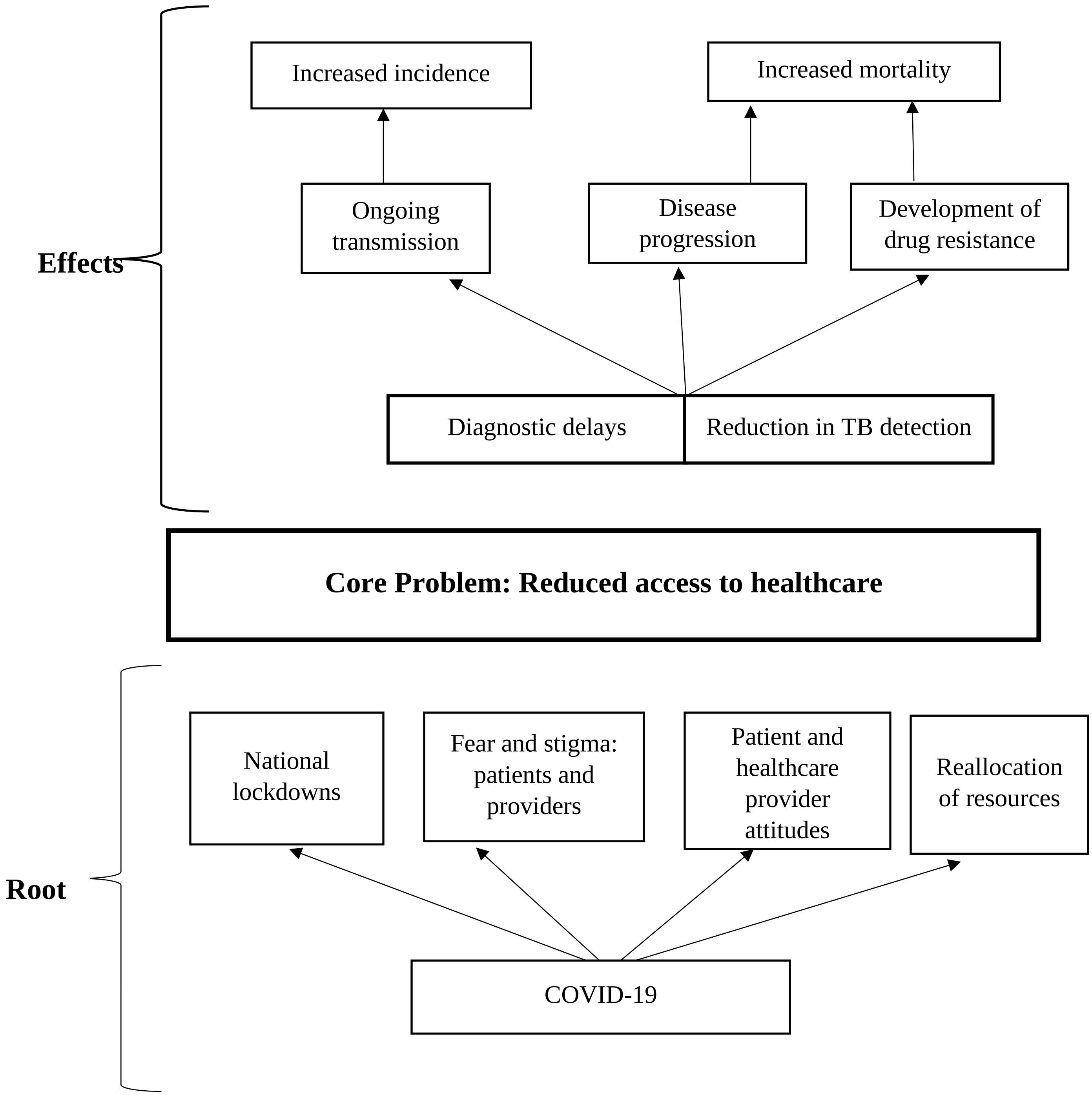

Figure 1 Problem analysis diagram depicting causes and effects of reduced access to healthcare due to COVID-19

4. Significance of the study

During the COVID-19 pandemic, it became evident that there were weaknesses in TB diagnostic services. This is unfortunate given the importance of prompt diagnosis in managing TB. This thesis proposes a method to improve these services based on lessons learned from the pandemic. By addressing these weaknesses, targeted policies can be generated to enhance TB services for regions with high TB burden and update existing pandemic preparedness models. Overall, this thesis provides valuable evidence to strengthen primary healthcare systems and improve TB diagnostic services.

5. Aim and Objectives

5.1 Aim

This study aimed to provide evidence to inform the development of a novel approach for enhancing TB diagnostic services during a pandemic at primary healthcare clinics for a high disease-burdened settings, using the eThekwini district as a study setting.

5.2 Objectives

1. To map the geographic accessibility of TB diagnostics services using geospatial analysis
2. To determine the impact of the COVID-19 pandemic on TB diagnostic services
3. To investigate the challenges and enablers of TB diagnostics services during the COVID-19 pandemic
4. To collaborate with local stakeholders in designing an approach for enhancing the current TB diagnostics services

Chapter 2 Literature Review

Chapter 2 presents the literature review that guided the development of the study objectives. It was conducted as a scoping review which allows the systematic mapping of evidence available on a given topic. This review synthesized the evidence on TB services during the COVID-19 pandemic. The literature search was conducted in June of 2021.

The findings of the scoping review were published by MDPI's *Diagnostics* journal under the title: "*Evidence of TB Services at Primary Healthcare Level during COVID-19: A Scoping Review*" Link: Diagnostics | Free Full-Text | Evidence of TB Services at Primary Healthcare Level during COVID-19: A Scoping Review (mdpi.com)

diagnostics

Review

Evidence of TB Services at Primary Healthcare Level during COVID-19: A Scoping Review

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Abstract: Tuberculosis (TB) is still a major public health concern, despite the availability of preventative and curative therapies. Significant progress has been made in the past decade towards its control. However, the emergence of the novel coronavirus disease 2019 (COVID-19) has disrupted numerous essential health services, including those for TB. This scoping review maps the available evidence on TB services at the primary healthcare (PHC) level during the COVID-19 period. A comprehensive literature search was conducted in PubMed, Web of Science, Medline OVID, Medline EBSCO, and Scopus. A total of 820 articles were retrieved from the databases and 21 met the eligibility criteria and were used for data extraction. The emerging themes were the effect of the COVID-19 pandemic on TB services, patient and provider experiences, recommendations for TB services during the COVID-19 period, and the implementation of the recommendations. The review found that the mitigation strategies, as well as fear and stigma experienced at the start of the COVID-19 pandemic may have led to TB cases potentially going undetected, which may threaten TB treatment outcomes. Therefore, efforts must be directed at finding these missing cases and ensuring that PHC facilities are equipped to adequately diagnose and treat them.

Keywords: COVID-19; coronavirus; tuberculosis; health services; primary healthcare

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1. Introduction

Despite the availability of vaccinations and chemotherapy for prevention and treatment [1], 10 million new cases of tuberculosis (TB) were estimated to have occurred in 2019 [2]. However, only 7.1 million of these cases were found and reported to national TB programmes, leaving a third undetected [3]. In addition, considerably more were not started on an appropriate treatment [1]. These missed cases contribute to the ongoing transmission [4], while prolonged diagnosis and treatment initiation exacerbate disease severity and continued spread [5]. Interrupting transmission through early and accurate detection, rapid treatment initiation, and completion, preferably at the primary healthcare level (PHC), aids efforts in ending the TB epidemic [3,6]. In 2020, COVID-19 emerged, hindering global TB control efforts [7], and sidelining many routine TB services to accommodate the response to the COVID-19 pandemic [8,9]. TB services suffered a sharp decline due to lockdowns. Therefore, limiting access to healthcare and a rise in fear and stigma since the advent of COVID-19 [8,10,11].

Studies that predict the potential impact of the COVID-19 pandemic on TB services suggest that temporary disruptions in response to the pandemic will likely affect all aspects of the TB care cascade [12–14]. Even small disruptions to these services could have long-term consequences on TB control [12]. These will especially be felt in high burden countries where TB incidence and mortality have been predicted to increase by 6.3 and 1.4 million, respectively, between 2020 and 2025 [12]. Delays in timely diagnosis and treatment are listed as the potential drivers for these grim outcomes [12,14].

The World Health Organization's (WHO) End TB strategy and the sustainable development goal (SDG) 3.3 aim to end TB through timely diagnosis and treatment, treatment adherence, and preventative therapy [15,16]. The WHO aims to eliminate the TB epidemic by 2035 and has also set short-term milestones to reduce TB deaths and incidence rates by 2020 and 2025 [3,15]. Findings from the TB global health report showed that 2020 milestones were not achieved [3,17]. Similarly, interim targets were set by the United Nations (UN) to diagnose and treat 40 million additional people by 2022 [7]. Although progress towards these goals has been made, it is still below the threshold that would make TB elimination attainable [3,18]. Moreover, it is possible that the small gains made towards controlling TB were disrupted by the COVID-19 pandemic, pushing the global TB targets further into the future [7,19].

As the first point of contact with health services, PHC facilities can reach large proportions of the population. These facilities also promote equitable access to health services and continuity of care and are recognized as a powerful tool for achieving the health SDGs [16,20]. Moreover, the WHO has emphasized that progress towards containing the TB epidemic can accelerate when TB control has been integrated with PHC [21]. Furthermore, high-quality PHC services are an important predictor for whether TB control strategies will realize their promise [22].

Despite the emergence of other public health priorities, such as the COVID-19 pandemic, uninterrupted TB services at the PHC level are crucial for reaching TB targets. Given the novelty of the COVID-19 pandemic, its effects on TB services at the PHC level remain unclear and require further exploration. Therefore, this scoping review mapped evidence on TB services at the PHC level during the COVID-19 pandemic. This evidence will be used to develop the primary research in order to address and improve TB services at the PHC level during the COVID-19 pandemic.

2. Materials and Methods

2.1. Overview

Herein, we conducted a scoping review to map the available evidence on TB services during the COVID-19 era. This scoping review is conducted as part of a larger study that aims to develop a novel approach for improving TB diagnostic services during the pandemic in primary healthcare clinics in high disease burdened settings. A scoping review protocol was registered on the open science framework (OSF) under the title, "Evidence of TB services at primary healthcare level during COVID-19: A scoping review protocol", where it can be accessed via this link: https://osf.io/pq3ba, 15 October 2021. The scoping review was guided by the Arksey and O'Malley framework [23], Levac et al. [24], and the Joanna Briggs Institute 2020 guidelines [25]. The findings of the study were reported according to the Preferred Reporting Items for systematic reviews and meta-analyses extension for scoping reviews (PRISMA-ScR) checklist, Table A1 [26].

Step 1: Identifying the research question

The main research question was: What evidence exists on TB services at the PHC level during the COVID-19 pandemic?

We assessed the eligibility of the research question for a scoping review study by applying the population, concept, and context (PCC) framework, developed by the Joanna Briggs Institute [25], see Table 1.

Table 1. PCC framework to determine the eligibility of the research question and guide the selection of studies on TB services during the COVID-19 pandemic.

Determinants	Description
Population	Primary healthcare providers—healthcare practitioners providing TB services, which are the first point of contact between people in a community and the healthcare system.
Concept	TB services—the processes involved in finding, diagnosing, treating, and preventing TB, which leads to cases being notified to national health systems.
Context	COVID-19 era—the time since COVID-19 emerged, from January 2020 to date.

Step 2: Identifying relevant studies

We conducted an advanced search using the following five academic databases: PubMed, Web of Science, Medline OVID, Medline EBSCO, and Scopus. Studies were identified using the following keywords and Medical Subject Heading (MeSH) terms: "TB diagnostics", "Health Service" "TB testing" "COVID-19", "SARS-CoV-2", "COVID-19 Pandemic", "COVID-19 era", and "Primary healthcare". A combination of Medical Subject Headings (MeSH) and free word texts of the keywords were used when conducting the searches. WHO and Stop TB partnership websites were accessed for reports and the reference lists of all the included studies were consulted for additional literature. The comprehensive database search was conducted by an experienced librarian to ensure that the best search strategies were used for each database.

Publications that adhere to the following criteria were included:

- Studies reporting on TB services during COVID-19;
- Studies reporting on TB services at PHC;
- All of the publications reporting evidence on TB services during COVID-19 at PHC, regardless of study design;
- Studies from all countries around the world.

This review excluded studies based on the following:

- Studies reporting on TB services outside the PHC level;
- Studies reporting evidence on TB services and viral diseases other than COVID-19;
- Studies reporting evidence on health services other than TB during COVID-19;
- Publications from before 2020.

Step 3: Selecting studies

The studies were selected in three phases. First, the principal investigator screened the titles of each article using the eligibility criteria as a guide. Eligible articles were exported to an EndNote20 library where duplicates were identified and removed. In the second phase, two independent reviewers screened the abstracts of the included articles using a screening tool based on inclusion and exclusion criteria. The screening tool was piloted and adjusted using 10 articles before the screening process was conducted. The reviewers discussed any discrepancies that arose until they reached a consensus on the articles to select. In the third phase, the two reviewers screened the full texts of the relevant articles using a screening tool guided by the eligibility criteria. Before use, the screening tool was piloted by both screeners, and changes were made accordingly. Discrepancies during full-text screening were resolved by a third reviewer. The level of agreement between the two reviewers was calculated using the Kappa statistic.

Step 4: Charting the data

An electronic data charting form containing variables relevant to the research question was developed. Two independent reviewers then piloted the data extraction tool using 10 of the included studies. The necessary changes were applied according to the feedback given by the reviewers. Data were extracted from the included studies based on the following categories: Author, aim, type of publication, country, type of TB service, and primary healthcare provider.

2.2. *Quality Appraisal*

We determined the methodological quality of the included studies using the Mixed Methods Appraisal Tool (MMAT) V.2018 software [27]. The particular study design used in each article was appraised, following stipulations by the MMAT guidelines. Once the scores for each study were calculated as a percentage, they were given a specific rank. Studies equal to or below 50% were ranked as low quality, those between 51–75% were deemed average quality, and those ranging from 76–100% were given a high-quality score.

2.3. *Collating, Summarizing, and Reporting Results*

We employed the thematic analysis to extract relevant evidence to answer our research questions and presented a narrative summary that centered on the emerging themes. The themes that arose most from the included studies were as follows: The consequences of the COVID-19 pandemic on TB services, comparison of TB services before and after the COVID-19 pandemic, patient experiences of TB services during COVID-19, and recommendations for TB services at PHCs during COVID-19.

3. Results

3.1. *Screening Results*

The selection and exclusion of studies are depicted in the PRISMA-ScR flow chart (Figure 1). Initially, we retrieved 819 articles, 702 from database searches and 117 from Google. Following title screening, we excluded 594 ineligible articles. The 225 remaining articles were imported to Endnote 20. The results retrieved from each database are listed in Table 2. After removing 120 duplicates, 105 articles were eligible for abstract screening. A total of 54 articles were excluded after abstract screening and 51 were eligible for full-text screening. We excluded 30 articles after full-text screening. All of the articles reported findings from the pandemic and articles were excluded if they reported TB services outside of PHC (17), did not mention healthcare setting (9), and combined data on TB services from both PHC and higher healthcare settings (3). In total, 21 articles met the eligibility criteria and were used for data extraction. The responses of the reviewers had a 54.64% agreement versus a 73.77% expected agreement by chance, which equates to a moderate agreement (Kappa statistic = 0.4218, p-value < 0.05). The discrepancies from the full-text screening were resolved by a third screener.

3.2. *Characteristics of the Included Studies*

The characteristics of the included articles are detailed in Table 3. The studies presented evidence on TB services at the PHC level during the COVID-19 era. The findings were conveyed in a variety of formats including letters, editorials, expert opinion, reports, webinars, feature articles, news articles, and traditional research articles. In terms of countries, the included articles were from Portugal [28], Ethiopia [29], Japan [30], China [9], Malawi [31], the United States of America [32], Pakistan [33,34], Nigeria [35–37], India [38–40], South Africa [41–43], one provided recommendations for high burdened settings [44], one presented evidence from LMIC [45], and one study was addressed to all the countries [46]. The primary healthcare settings ranged from clinics, outpatient departments, general practitioner's practices, PHC centers, and pharmacies.

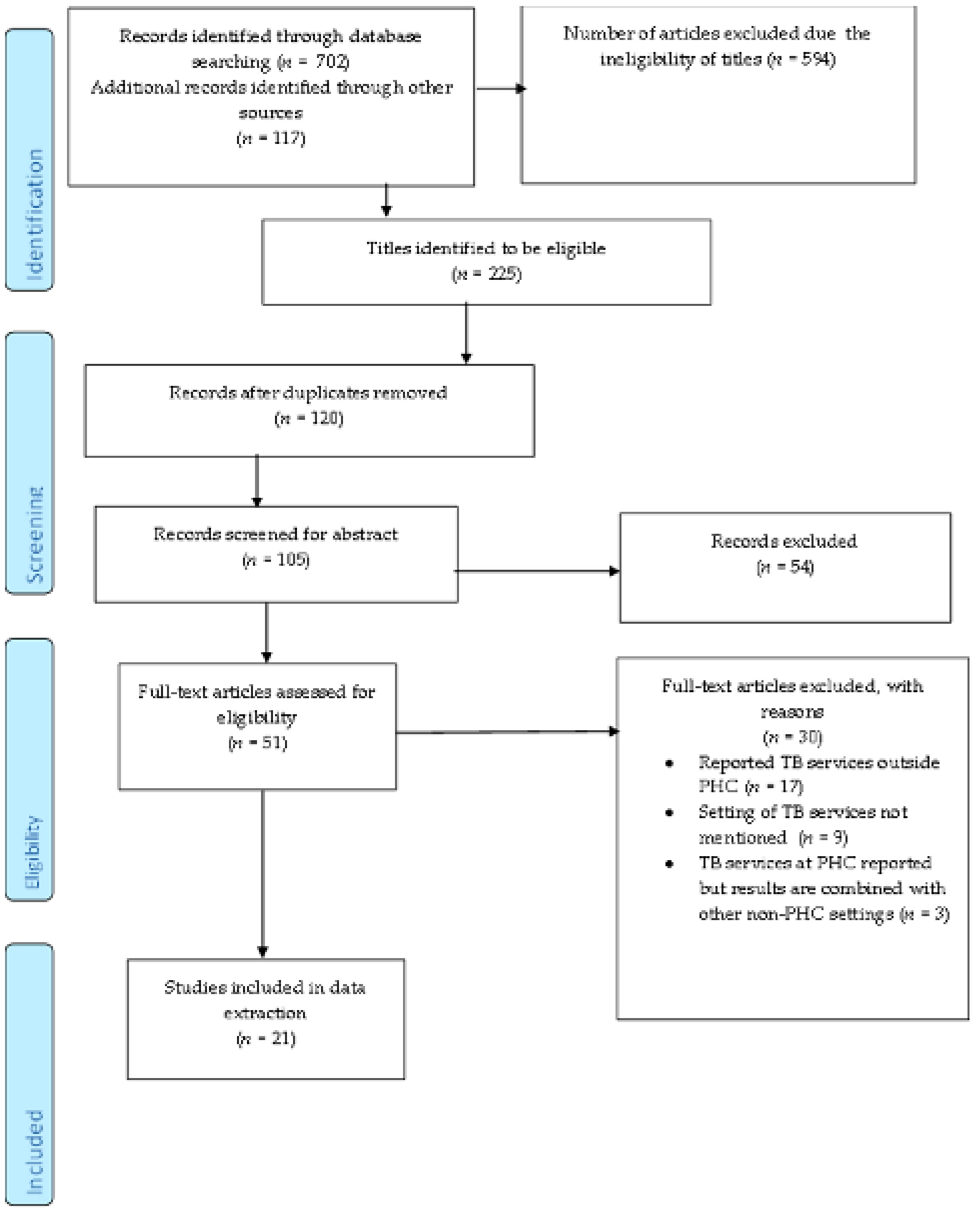

Figure 1. Prisma-flow diagram depicting the process of selecting and excluding studies.

Table 2. Results of the database search.

Date	Database	Keywords	Number of Results Retrieved
7 June 2021	PubMed	(("Health Services" [Mesh] OR "primary health care" [MeSH Terms] OR "Primary health care" [Text Word] OR "health care" [Text Word] OR "health service*" [Text Word] OR "Primary healthcare" [Text Word]) AND ("sars-cov-2" [MeSH Terms] OR "covid-19" [MeSH Terms] OR covid [Text Word] OR coronavirus OR "corona virus")) AND ("tuberculosis" [MeSH Terms] OR tuberculosis [Text Word])	191
7 June 2021	PubMed	(("primary health care" [MeSH Terms] OR "Primary health care" [Text Word] OR "Primary healthcare" [Text Word]) AND ("sars-cov-2" [MeSH Terms] OR "covid-19" [MeSH Terms] OR covid [Text Word] OR coronavirus OR "corona virus")) AND ("tuberculosis" [MeSH Terms] OR tuberculosis [Text Word])	13
11 June 2021	Web of Science	(TITLE-ABS-KEY (tuberculosis OR tb) AND TITLE-ABS-KEY (sars-cov-2 OR covid-19 OR covid OR coronavirus OR"corona AND virus") AND TITLE-ABS-KEY ("primary health care" OR "primary AND healthcare" OR "primary AND care" OR"Health Services"))	5
7 June 2021	Medline OVID	(((MH "COVID-19")) OR "covid-19" OR ((MH "SARS-CoV-2")) OR "sars-cov-2") AND (((MH "Tuberculosis+")) OR "tuberculosis") AND (((MH "Primary Health Care")) OR ("primary health care") OR ((MH "Health Services+")) OR ("health services") OR ("primary health"))	223
7 June 2021	Medline EBSCO	(((MH "COVID-19")) OR "covid-19" OR ((MH "SARS-CoV-2")) OR "sars-cov-2") AND (((MH "Tuberculosis+")) OR "tuberculosis") AND (((MH "Primary Health Care")) OR ("primary health care") OR ((MH "Health Services+")) OR ("health services") OR ("primary health"))	189
7 June 2021	Scopus	(TITLE-ABS-KEY (tuberculosis OR tb) AND TITLE-ABS-KEY (sars-cov-2 OR covid-19 OR covid OR coronavirus OR "corona AND virus") AND TITLE-ABS-KEY ("primary health care" OR "primary AND healthcare" OR "primary AND care" OR "Health Services"))	81

3.3. *Quality Appraisal*

Only four articles were primary studies presenting empirical evidence and were subject to a methodological quality assessment using the 2018 version of the MMAT tool [27]. The scores ranged from 40–75%. Two studies scored 60% [9,32] and another scored 40% [47] and 70% [35]. Results that scored lower than 51% were considered low quality, 51–75% were of average quality, and high quality if they fell between 76–100%.

3.4. *Summary of the Evidence*

The themes that emerged from the included studies were, consequences of COVID-19 pandemic on TB services, patient and provider experiences, recommendations and adaptations for TB services during the COVID-19 era, and implementing the recommendations for TB services, respectively.

Table 3. Characteristics of the included studies.

Author and Date	Aim of Study	Publication Type	Country	Primary Healthcare Provider	Type of TB Service(s) Reported
Fatima et al. 2021 [34]	To demonstrate how TB services were strengthened during COVID-19	Research article	Pakistan	PHC centers, private healthcare providers (PHCP)	General TB services and case notifications
Aguiar 2021 [28]	To show the changes made at a TB outpatient center as a result of COVID-19	Letter	Portugal	Outpatient center	TB case finding and treatment
Beyene et al. 2021 [29]	To assess the impact of COVID-19 on TB control programs at various clinics in Addis Ababa	Research article	Ethiopia	Public health clinics	TB screening and testing
Comella-del-Barrio et al. 2021 [45]	To give an overview of the effects of COVID-19 on TB control	Editorial	Low to middle-income countries (LMIC)	Primary healthcare in general	TB testing
Fei et al. 2020 [9]	To show how COVID-19 has affected TB control in China	Research article	China	Primary healthcare workers and clinics	General TB services
Adewole 2020 [35]	How COVID-19 has impacted TB care in Nigeria	Letter	Nigeria	TB clinic	TB case notification and detection
Burzynsky et al. 2020 [32]	To show how TB services have been adapted for COVID-19 during the closure of non-essential services in New York	Letter	United States of America	TB clinics	TB detection, testing, and treatment
Cox et al. 2021 [44]	To provide recommendations for TB care during COVID-19 in high burden settings	Letter	Countries with a high TB burden	Clinics	TB treatment
Keene et al. 2020 [42]	How TB and HIV services can leverage the COVID-19 pandemic	Expert Opinion	South Africa	Clinics	TB screening, testing, treatment, and detection
Rai and Kumar 2020 [38]	How TB patients were affected by the lockdown in India	Letter	India	Pharmacists, outpatient department, and general practitioners (GP)	TB treatment
World Health Organization 2020 [46]	To give guidance on how TB care should be conducted during COVID-19	Report	All countries	Outpatient centers and primary healthcare workers	TB treatment
Stop TB partnership 2020 [47]	To show how COVID-19 has impacted different TB stakeholders around the world	Report Survey	Global fund implementing countries	Clinics	General TB services
Soko et al. 2021 [31]	To estimate the impact of COVID-19 on TB case notifications	Research Article	Malawi	Primary healthcare centers	TB case notifications
Meneguim et al. 2020 [40]	How a TB center adapted its service for COVID-19 in India	Letter	India	Outpatient hospital department	TB diagnostics, treatment, follow-up, and adherence support
Pilane et al. 2020 [41]	Reporting disruption of TB and HIV services due to COVID-19	News Article	South Africa	PHC facilities	General TB services
Datta et al. 2020 [40]	To show how COVID-19 disrupted a TB free block model pilot study	Report	India	Mobile diagnostic services	Active case-finding and TB diagnostics
Debriche Health and Development Center 2020 [36]	To discuss how TB and PHC services have been impacted by COVID-19 and propose solutions	Webinar	Nigeria	PHC centers	General TB services

Table 3. *Cont.*

Author and Date	Aim of Study	Publication Type	Country	Primary Healthcare Provider	Type of TB Service(s) Reported
Adepoju 2020 [37]	To demonstrate how COVID-19 has affected TB care	Feature	Nigeria	PHC centers and clinics	TB screening and treatment
Jamal et al. 2020 [33]	To detail how TB services were maintained in the private sector during COVID-19	Letter	Pakistan	GPs	TB treatment and diagnostics
Ongole et al. 2020 [43]	To give insight into how TB care can be conducted during COVID-19 through strengthened PHC	Letter	South Africa	PHC centers	General TB services at PHC
Senoo et al. 2020 [30]	To report on the shortages of the BCG vaccine	Letter	Japan	Clinics	TB vaccinations

3.4.1. Consequences of the COVID-19 Pandemic on TB Services

Of the 21 included studies, 10 reported on the consequences of the COVID-19 pandemic at various PHC facilities. TB clinics in New York, USA temporarily halted the performance of any new TB tests [32]. A study from a LMIC reported that fewer TB cases were diagnosed due to the difficulty in accessing primary care [45], while a clinic in Nigeria reported that one person came to collect the TB medication during the lockdown [37]. South Africa experienced a 25% drop in access to primary healthcare following the lockdown, as well as a 9% drop in TB testing [41]. Another study in China reported that 75.3% of primary healthcare workers were reallocated from routine services to COVID-19 related work [9]. In a similar manner, clinics from Ethiopia were repurposed as COVID-19 centers [29] or in the case of TB clinics in New York, USA, closed altogether [32]. In Japan, the media reported a shortage of the BCG vaccine in order to claim that it was effective against COVID-19 [30].

A project that brought TB healthcare to the doorstep of a community was abruptly halted after the nationwide lockdown in India [39]. This project was aimed at rendering a neighborhood block TB-free and achieved it by actively finding TB cases and providing point-of-care mobile diagnostic services. The effects were seen by the abrupt drop in TB notifications during the 3 months of the national lockdown. In addition, direct comparisons with the same period from previous years showed a stark contrast. Another study in Nigeria that sought to directly compare TB case notifications and detection rates in the first few months of 2020 compared with the same period from 2019 showed similar results [35]. Another study from Ethiopia showed that patient flow had significantly decreased in the first months of the COVID-19 lockdowns compared with the same period from the previous year [29]. Moreover, TB case notifications at primary healthcare centers in Malawi were shown to be disproportionately lower than at a regional hospital in Malawi [31]. The current evidence shows that the COVID-19 pandemic has created a scenario where fewer TB cases were detected than usual. However, more evidence is required to determine the extent of the potentially missed cases.

3.4.2. Patient and Provider Experiences

Four of the included studies recorded the perspectives of healthcare workers and patients. All of the participants struggled to access healthcare facilities. Rumors on the closure of certain facilities meant that patients were not seeking care for a period of time in Malawi [31]. In India, 17.3% of patients defaulted on their TB treatment and others consulted general practitioners and private pharmacies for treatment due to the difficulty in accessing healthcare facilities [38]. A survey by the Stop TB partnership found that in several countries, fear of contracting COVID-19 kept patients away from visiting clinics [47]. Likewise, in Malawi, fear and ignorance of COVID-19 meant that many healthcare personnel refused to see or treat anyone displaying symptoms resembling COVID-19 [31]. Moreover, staff were increasingly reluctant to handle any sputum samples or observe sputum collection. Furthermore, this was the case in Nigeria [32,38]. A lack of personal protective equipment (PPE) discouraged staff from attending to patients in many countries [31,47]. A survey by the Stop TB partnership found that staff at TB clinics observed a need for patients to be given nutritional support, as well as have their transportation costs covered for visiting healthcare facilities [47].

3.4.3. Recommendations and Adaptations of TB Services

Five studies from multiple authors including the WHO have detailed recommendations on how TB services can be improved during a pandemic in high burden settings. All of the studies agreed that the use of telemedicine can be leveraged for TB care. Medical triage and counselling should be conducted by telephone. Where possible, sputum collection should be conducted in a well-ventilated area at home and staff must be adequately protected when collecting the samples from patients [46]. The switch to oral and shorter treatment regimens [42], as well as the video-supported treatment would reduce the number of patients visiting health facilities [46]. Integrating TB and COVD-19 care, such as testing and active case finding, could benefit the management of both diseases [42]. HIV care must also be integrated for countries with a high disease burden [42]. Patients with drug-susceptible TB should be provided with enough TB medication for the intensive phase and only return to the healthcare facility for an assessment. In addition, they need to switch to the continuation phase where sufficient medication is provided [43,45]. Patients with drug-resistant TB (DR-TB) must be switched to an oral treatment that lasts until the next scheduled visit, any patients exhibiting concerning iron levels or myelosuppression must be recalled by telephone [44,46]. Moreover, decentralizing the treatment collection has been encouraged [42,46]. Furthermore, there was an emphasis on strengthening primary care in order to help in managing the pandemic, by providing PHC workers with best practice training for COVID-19 [43,46]. This ensures that PHC facilities are equipped with enough staff who have access to PPE and provision of all chronic medication should be available for extended periods to reduce visits to health facilities [43]. Finally, all of the PHCs offering TB testing must follow the recommended infection prevention and control (IPC) measures, from the collection of samples until testing is conducted and the sample is disposed of in the laboratory [46]. It is not clear how many high burden countries have implemented these changes for their TB programs and how successful implementation has been. The following section explores examples of instances where TB services have been adapted.

3.4.4. Implementing the Recommendations for TB Services

Five of the included studies documented the changes made to the TB services in response to the COVID-19 pandemic. Outpatient departments in India and Portugal screened patients for COVID-19 before they were attended to. Crowd control was also maintained to ensure that social distance and IPC measures are upheld at all times [28,40]. The same center in Portugal did contact tracing by telephone and patients were only asked to come to the clinic if they had a positive screening after the phone call [28]. The oral treatment is now favored over injectables and treatment is administered in line with scheduled healthcare visits in India and the USA [32,40]. Those requiring intravenous treatments are administered by community nurses at home [40]. In several countries, treatment initiation is conducted in clinics, but all of the follow-ups are conducted by telephone, including any consultation with doctors, unless presenting with severe symptoms or treatment side effects [28,31,34,40]. TB clinics in New York, USA, have also begun giving patients daily reminders over the phone to ensure that they adhere to the treatments [28]. In cases where patients cannot utilize telehealth due to limitations in technology, then home visits are conducted on a case by case basis [32]. In Pakistan, general practitioners (GPs) who referred patients to TB centers were used to locate patients that could not be contacted during the pandemic. Moreover, their offices were used as a location where patients could fetch their medication [33]. Furthermore, certain provinces in Pakistan have mandated that private healthcare providers notify TB cases to national TB programs [34]. Healthcare workers are provided with the necessary PPE according to the risk of exposure and they work in shifts to avoid overcrowding [40]. In Pakistan, healthcare providers have been retrained in IPC and the correct use of PPE wherever necessary [34]. All of these adaptations are new and will need to be closely monitored throughout the pandemic to assess their sustainability and effectiveness. Furthermore, more data are needed on other high burden countries to see whether they have adapted TB services since the start of the pandemic.

4. Discussion

This scoping review mapped the existing evidence of TB services at the PHC level in the COVID-19 era. The evidence was from a wide range of documentary sources, and most came from high TB burden regions of Pakistan, India, Nigeria, and South Africa. The bulk of the literature found was from the start of the pandemic. The findings show evidence that the COVID-19 pandemic had a negative effect on TB services, how patients and healthcare providers were impacted, as well as recommendations for adapting these services and instances where recommendations had been implemented. Overall, the COVID-19 pandemic has negatively impacted TB services, users, and healthcare providers alike. The findings suggest that TB services were disrupted. In addition, the fear and stigma experienced by healthcare providers and patients likely led to a drop in TB case detection and the notifications seen during the first months of the pandemic. More evidence is needed on the steps taken to identify potentially undiagnosed and missed TB cases and how provider attitudes and patient experiences have improved, especially in high TB burden countries. Although the review has highlighted recommendations for enhancing TB services in high burden settings during the pandemic, only one TB endemic country had implemented these changes. Before COVID-19, countries were making strides towards achieving the SDG targets for TB; a record number of people had been treated including those with DR-TB; the annual number of missed TB cases had fallen below 3 million; and the TB preventative treatment had been prioritized in high burden settings [7]. However, this has likely changed since the start of the COVID-19 pandemic.

The findings of this scoping review show that the arrival of COVID-19 and the measures used to curb the spread drastically reduced the number of TB cases detected and notified, in sharp contrast to the numbers from the same period in previous years [29,32,36]. It further demonstrated how TB services were significantly disrupted and sidelined in response to a new public health emergency [9,32,37,45]. Moreover, the COVID-19 pandemic deterred health-seeking behaviors, hindered some patients from acquiring the TB treatment, and increased reluctance among healthcare workers to treat patients [31,37]. These results have created scenarios for TB cases to go undiagnosed. Furthermore, the fear of attending health facilities and the disruptions leading to their closure have likely interrupted TB treatment regimens, which could lead to treatment failure exacerbating disease transmission and development of drug resistance. These would be grim outcomes for global TB control efforts. The responses, uncovered by the review, mirror those experienced during the Ebola virus outbreak in West Africa, which increased preventable TB deaths over time [48]. Following the Ebola outbreak, TB, HIV, and malaria deaths exceeded those directly caused by the Ebola virus itself [49,50]. Similarly, the outbreak of the Middle East respiratory syndrome coronavirus (MERS-CoV) in Saudi Arabia harmed TB control efforts [51]. As a result of the Ebola outbreak [52], certain West African countries have implemented measures for epidemic response. However, it is unclear whether these have had any bearing on TB control during the COVID-19 era. The increase in TB mortality in the coming years due to the disruptions to health services has been foreshadowed by several studies [13,14,53]. These will be most evident in high burden settings unless swift action is taken to minimize the impact on health services, while simultaneously identifying, diagnosing, and treating any cases that are not from the start of the pandemic.

A study summarizing the effect of Ebola on TB services emphasized the importance of moving away from disease-specific national programmes to the holistic strengthening of health systems [48]. It further highlights how this kind of approach would not only assist with the management of infectious outbreaks, but ensure that disease control for other conditions is not compromised [48]. Two previous studies showed that China's and Saudi Arabia's prior coronavirus experience facilitated a better COVID-19 response than many other countries [54,55]. In contrast, this review did not find evidence of TB endemic countries adopting the lessons from previous epidemics. However, our findings present current recommendations for conducting TB services during the COVID-19 pandemic [42–44,46]. Although these are helpful, it would have been more beneficial if governments had adopted insights from past viral outbreaks. The review also demonstrates how the recent adaptations to TB services have been adopted in various countries [28,32–34,40]. However, only two of these were high TB burden countries [34,40]. Considering that many of these suggestions rely on the use of technology, their practicality for resource-limited settings remains to be seen. Therefore, high burden countries must continue to monitor the impact of COVID-19 on TB services and address these with evidence-based interventions.

4.1. Implication for Research

Many of the included studies documented the situation at the start of the COVID-19 pandemic. Consequently, geographic areas with a lower incidence at the start of the pandemic were not a focus of this study. Thus, an assessment of TB services in these regions is needed for better insight into the global effect of the COVID-19 pandemic. Research on how TB services have fared throughout the pandemic, including peaks in COVID-19 cases and subsequent vaccination strategies, are also needed. The same can be said for provider and health seeker attitudes. This will facilitate the measurement of the impact on TB and allow appropriate mitigation action. Undiagnosed TB cases and interruption to treatment were other issues likely to have been caused by the pandemic. Health systems must be ready to receive and appropriately treat and retain these cases until treatment completion. Therefore, assessing the quality of TB services in high burden settings and providing context-specific adaptations based on the findings could benefit TB control programmes. Moreover, only four empirical studies were found and even these scored low in terms of methodological quality. Therefore, robust primary studies are required to inform evidence-based decisions and recommendations for TB services during pandemics. These studies should focus on strengthening TB case findings, diagnostics, and treatment services for COVID-19 and future pandemics.

4.2. Strengths and Limitations

The scoping review employed a comprehensive database search that was not limited by language, publication or study design. In addition, the database search included a grey literature and repeated search in the database that retrieved the highest number of articles to maximize the number of studies found. The methodological quality of all the included primary studies was assessed and it was found that they ranged from a low to average quality. For this reason, the scoping review may not be appropriate to inform clinical practice, but does demonstrate a need for additional primary studies to be conducted with more methodological rigor. Moreover, the review retrieved evidence from the start of the COVID-19 pandemic. Therefore, certain geographic regions with initially low incidence rates were not covered. Furthermore, given the evolving nature of the pandemic, it is likely that latter phases including the emerging variants and vaccination control strategies have also impacted the TB service delivery.

5. Conclusions

In this review, the TB services at the PHC level were disrupted by the COVID-19 pandemic. The potential for undiagnosed TB cases and treatment failure are among the biggest concerns caused by the pandemic. For the TB elimination goals to be met, PHC must be strengthened and ready with effective solutions to address the issues caused by the COVID-19 pandemic and use these for pandemic preparedness in the future.

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Appendix A

Table A1. Preferred reporting items for systematic reviews and meta-analyses extensions for scoping reviews (PRISMA-ScR) checklist.

Section and Topic	Item No.	Checklist Item	Reported on Page
		ADMINISTRATIVE INFORMATION	
Title: Identification	1	Evidence of TB services at the primary healthcare level during COVID-19: A scoping review.	1
Registration	2	Open Science Framework: https://osf.io/pq3ba (accessed on 16 September 2021)	
		INTRODUCTION	
Rationale	3	Despite the availability of vaccinations and chemotherapy for prevention and treatment [1], 10 million new cases of tuberculosis (TB) were recorded in 2019 [2]. A third of these cases were missed by health systems [3], and considerably more were not started on an appropriate treatment [1]. These missed cases contribute to the ongoing transmission [4], while prolonged diagnosis and treatment initiation exacerbate disease severity and continued spread [5]. Interrupting transmission through early and accurate detection, rapid treatment initiation, and completion, preferably at the primary healthcare level (PHC), aids efforts in ending the TB epidemic [3,6]. In 2020, COVID-19 emerged, hindering global TB control efforts [7], many routine TB services were sidelined in response to the COVID-19 pandemic [8,9]. These services suffered a sharp decline due to lockdowns limiting access to healthcare and a rise in fear and stigma since the advent of COVID-19 [8,10,11]. Studies that predict the potential impact of COVID-19 on TB services suggest that temporary disruptions in response to COVID-19 will likely affect all aspects of the TB care cascade [12–14]. Even small disruptions to these services could have long-term consequences on TB control [12]. These will especially be felt by high burden countries where TB incidence and mortality have been predicted to increase by 6.3 and 1.4 million between 2020–2025, respectively [12]. Delays in patients seeking timely diagnosis and treatment are listed as the potential drivers for these grim outcomes [12,14]. The World Health Organization's (WHO) End TB strategy and the sustainable development goal (SDGs) 3.3 aim to end TB through timely diagnosis and treatment, treatment adherence, and preventative therapy [15,16]. The WHO aims to eliminate the TB epidemic by 2035 and has also set short-term milestones to reduce TB deaths and incidence rates by 2020 and 2025 [3,15]. Findings from the TB global health report showed that 2020 milestones were not achieved [3]. Similarly, interim targets were set by the United Nations (UN) to diagnose and treat 40 million additional people by 2022 [7]. Although progress towards these goals has been made, it is below the threshold that would make TB elimination attainable [3,18]. It is also possible that the small gains made towards controlling TB were disrupted by the COVID-19 pandemic, pushing the global TB targets further into the future [7,19]. As the first point of contact with health services, PHC can reach large proportions of the population. It also promotes equitable access to health services and continuity of care and is thereby recognized as a powerful way that health SDGs can be achieved [16,20]. The WHO has also emphasized that progress towards containing the TB epidemic can accelerate when TB control has been integrated with PHC [21]. Furthermore, high-quality PHC services are an important predictor for whether TB control strategies will realize their promise [22]. Despite the emergence of other public health priorities, such as the COVID-19 pandemic, uninterrupted TB services at PHC are crucial for TB targets to be reached. Given the novelty of the COVID-19 pandemic, its effects on TB services at the PHC level remain unclear and require further exploration. Therefore, this review aimed to systematically map evidence on TB services at the PHC level during the COVID-19 pandemic. The evidence obtained from the study will be used to develop primary research that is aimed at addressing and improving TB services at the PHC level during the COVID-19 pandemic to accelerate global efforts to end TB.	3–4
Objectives	4	This review aimed to systematically map evidence on TB services at the PHC level during the COVID-19 pandemic.	4

Table A1. *Cont.*

Section and Topic	Item No.	Checklist Item	Reported on Page
		METHODS	
Eligibility criteria	5	**Inclusion criteria** Publications that adhere to the following criteria were included: • Studies reporting on TB services during COVID-19; • Studies reporting on TB services at PHC. All of the publications reporting evidence on TB services during COVID-19 at PHC, regardless of study design. • Studies from all of the countries around the world. **Exclusion criteria** This review excluded studies based on the following: • Studies reporting on TB services outside the PHC level; • Studies reporting evidence on TB services and viral diseases other than COVID-19; • Studies reporting evidence on health services other than TB during COVID-19; • Publications from before 2020.	6
Information sources	6	We conducted an advanced search using the following five academic databases: PubMed, Web of Science, Medline OVID, Medline EBSCO, and Scopus.	5
Search strategy	7	Studies were identified using the following keywords and medical subject heading (MeSH) terms: "TB diagnostics", "Health Service" "TB testing" "COVID-19", "SARS-CoV-2", "COVID-19 Pandemic", "COVID-19 era" and "Primary healthcare". A combination of medical subject headings (MeSH) and free word texts of the keywords were used when conducting the searches. WHO and Stop TB partnership websites were accessed for reports and the reference lists of all the included studies were consulted for additional literature.	5–6
Study records: Data management	8a	Describe the mechanism(s) that will be used to manage records and data throughout the review.	
Selection process	8b	The studies were selected in three phases. First, the principal investigator screened the titles of each article using the eligibility criteria as a guide. Eligible articles were exported to an EndNote20 library where duplicates were identified and removed. In the second phase, two independent reviewers screened the abstracts of the included articles using a screening tool developed through the use of the inclusion and exclusion criteria. The screening tool was piloted and adjusted using 10 articles before the screening process was conducted. The reviewers discussed any discrepancies that arose until they reached a consensus on the articles to select. In the third phase, the two reviewers screened the full texts of the relevant articles using a screening tool guided by eligibility criteria. Before use, the screening tool was piloted by both screeners, and changes were made accordingly. Discrepancies during full-text screening were resolved by a third reviewer. The level of agreement between the two reviewers was calculated using McNemar's Chi-square statistic.	6
Data collection process	8c	An electronic data charting form containing variables relevant to the research question was developed. Two independent reviewers then piloted the data extraction tool using 10 of the included studies. The necessary changes were applied according to the feedback given by the reviewers.	7
Data items	9	Data were extracted from the included studies based on the following categories: Author, aim, type of publication, country, type of TB service, and primary healthcare provider.	7

Table A1. *Cont.*

Section and Topic	Item No.	Checklist Item	Reported on Page
Data synthesis	10	We employed thematic analysis to extract relevant evidence to answer our research questions and presented a narrative summary that centered around the emerging themes. The themes that arose most from the included studies were as follows: The unintended consequences of COVID-19 on TB services; comparison of TB services before and after COVID-19; patient experiences of TB services during COVID-19; and recommendations for TB services at PHC during COVID-19.	7
Confidence in cumulative evidence	11	To assess the risk of bias we determined the quality of the included studies using the mixed methods appraisal tool (MMAT) V.2018 software [27]. The tool assessed the methodological quality of the included primary studies. The particular study design guided how the article was appraised, following stipulations by the MMAT guidelines. Once the scores for each study were calculated as a percentage, they were given a specific rank. Studies equal to or below 50% were ranked as low quality, those between 51–75% were deemed average quality, and those ranging from 76–100% were given a high-quality score.	7

References

1. Bloom, B.R.; Atun, R.; Cohen, T.; Dye, C.; Fraser, H.; Gomez, G.B.; Knight, G.; Murray, M.; Nardell, E.; Rubin, E.; et al. *Tuberculosis*; The World Bank: Washington, DC, USA, 2017; pp. 233–313.
2. Tuberculosis. Available online: https://www.who.int/news-room/fact-sheets/detail/tuberculosis (accessed on 8 March 2021).
3. Chakaya, J.; Khan, M.; Ntoumi, F.; Aklillu, E.; Fatima, R.; Mwaba, P.; Kapata, N.; Mfinanga, S.; Hasnain, S.E.; Katoto, P.D.M.C.; et al. Global Tuberculosis Report 2020—Reflections on the Global TB burden, treatment and prevention efforts. *Int. J. Infect. Dis.* **2021**. [CrossRef] [PubMed]
4. Pai, M.; Nicol, M.P.; Boehme, C.C. Tuberculosis Diagnostics: State of the Art and Future Directions. *Microbiol. Spectr.* **2016**, *4*, 1–15. [CrossRef]
5. Nathavitharana, R.R. Stamping out tuberculosis: The importance of diagnostic innovation and effective implementation. *Ann. Am. Thorac. Soc.* **2019**, *16*, 1112–1113. [CrossRef]
6. Dheda, K.; Ruhwald, M.; Theron, G.; Peter, J.; Yam, W.C. Point-of-care diagnosis of tuberculosis: Past, present and future. *Respirology* **2013**, *18*, 217–232. [CrossRef] [PubMed]
7. Sahu, S.; Ditiu, L.; Sachdeva, K.S.; Zumla, A. Recovering from the Impact of the Covid-19 Pandemic and Accelerating to Achieving the United Nations General Assembly Tuberculosis Targets. *Int. J. Infect. Dis.* **2021**. [CrossRef]
8. Alene, K.A.; Wangdi, K.; Clements, A.C.A. Impact of the COVID-19 Pandemic on Tuberculosis Control: An Overview. *Trop. Med. Infect. Dis.* **2020**, *5*, 123. [CrossRef] [PubMed]
9. Fei, H.; Yinyin, X.; Hui, C.; Ni, W.; Xin, D.; Wei, C.; Tao, L.; Shitong, H.; Miaomiao, S.; Mingting, C.; et al. The impact of the COVID-19 epidemic on tuberculosis control in China. *Lancet Reg. Health West. Pac.* **2020**, *3*, 100032. [CrossRef]
10. Karim, Q.A.; Karim, S.S.A. COVID-19 affects HIV and tuberculosis care. *Science* **2020**, *369*, 366–368. [CrossRef]
11. Jain, V.K.; Iyengar, K.P.; Samy, D.A.; Vaishya, R. Tuberculosis in the era of COVID-19 in India. *Diabetes Metab. Syndr. Clin. Res. Rev.* **2020**, *14*, 1439–1443. [CrossRef]
12. Cilloni, L.; Fu, H.; Vesga, J.F.; Dowdy, D.; Pretorius, C.; Ahmedov, S.; Nair, S.A.; Mosneaga, A.; Masini, E.; Sahu, S.; et al. The potential impact of the COVID-19 pandemic on the tuberculosis epidemic a modelling analysis. *EClinicalMedicine* **2020**, *28*, 100603. [CrossRef]
13. McQuaid, C.F.; McCreesh, N.; Read, J.M.; Sumner, T.; Houben, R.; White, R.G.; Harris, R.C. The potential impact of COVID-19-related disruption on tuberculosis burden. *Eur. Respir. J.* **2020**, *56*, 2001718. [CrossRef]
14. Hogan, A.B.; Jewell, B.L.; Sherrard-Smith, E.; Vesga, J.F.; Watson, O.J.; Whittaker, C.; Hamlet, A.; Smith, J.A.; Winskill, P.; Verity, R.; et al. Potential impact of the COVID-19 pandemic on HIV, tuberculosis, and malaria in low-income and middle-income countries: A modelling study. *Lancet Glob. Health* **2020**, *8*, e1132–e1141. [CrossRef]
15. Uplekar, M.; Weil, D.; Lonnroth, K.; Jaramillo, E.; Lienhardt, C.; Dias, H.M.; Falzon, D.; Floyd, K.; Gargioni, G.; Getahun, H.; et al. WHO's new end TB strategy. *Lancet* **2015**, *385*, 1799–1801. [CrossRef]
16. Hone, T.; Macinko, J.; Millett, C. Revisiting Alma-Ata: What is the role of primary health care in achieving the Sustainable Development Goals? *Lancet* **2018**, *392*, 1461–1472. [CrossRef]
17. World Health Organization. Global tuberculosis report 2020. Available online: https://www.who.int/publications/i/item/9789240013131 (accessed on 11 July 2021).
18. World Health Organization. End TB Strategy. Available online: https://www.who.int/tb/End_TB_brochure.pdf?ua=1 (accessed on 25 April 2021).
19. Zumla, A.; Chakaya, J.; Khan, M.; Fatima, R.; Wejse, C.; Al-Abri, S.; Fox, G.J.; Nachega, J.; Kapata, N.; Knipper, M.; et al. World Tuberculosis Day 2021 Theme-'THE CLOCK IS TICKING'- and the world is running out of time to deliver the United Nations General Assembly commitments to End TB due to the COVID-19 pandemic. *Int. J. Infect. Dis.* **2021**. [CrossRef]
20. Binagwaho, A.; Adhanom Ghebreyesus, T. Primary healthcare is cornerstone of universal health coverage. *BMJ* **2019**, *365*, 12391. [CrossRef]
21. World Health Organization. Brief Guide on Tuberculosis Control for Primary Health Care Providers for Countries in the WHO European Region with a High and Intermediate Burden of Tuberculosis. Available online: https://www.euro.who.int/__data/assets/pdf_file/0015/123162/E82858.pdf (accessed on 20 July 2021).
22. Davis, J.; Katamba, A.; Vasquez, J.; Crawford, E.; Sserwanga, A.; Kakeeto, S.; Kizito, F.; Dorsey, G.; Den Boon, S.; Vittinghoff, E.; et al. Evaluating Tuberculosis Case Detection via Real-Time Monitoring of Tuberculosis Diagnostic Services. *Am. J. Respir. Crit. Care Med.* **2011**, *184*, 362–367. [CrossRef] [PubMed]
23. Arksey, H.; O'Malley, L. Scoping studies: Towards a methodological framework. *Int. J. Soc. Res. Methodol. Theory Pract.* **2005**, *8*, 19–32. [CrossRef]
24. Levac, D.; Colquhoun, H.; O'Brien, K.K. Scoping studies: Advancing the methodology. *Implement. Sci.* **2010**, *5*, 69. [CrossRef]
25. Peters, M.D.J.; Marnie, C.; Tricco, A.C.; Pollock, D.; Munn, Z.; Alexander, L.; McInerney, P.; Godfrey, C.M.; Khalil, H. Updated methodological guidance for the conduct of scoping reviews. *JBI Evid. Synth.* **2020**, *18*, 2119. [CrossRef]
26. Tricco, A.C.; Lillie, E.; Zarin, W.; O'Brien, K.K.; Colquhoun, H.; Levac, D.; Moher, D.; Peters, M.D.J.; Horsley, T.; Weeks, L.; et al. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Ann. Intern. Med.* **2018**, *169*, 467–473. [CrossRef] [PubMed]

27. Hong, N.; Pluye, P.; Fabregues, S.; Bartlett, G.; Boardman, F.; Cargo, M.; Dagenais, P.; Gagnon, M.-P.; Griffiths, F.; Nicolau, B.; et al. *Mixed Methods Apprais. Tool (MMAT), Version 2018*; Registration of Copyright (#1148552); Canadian Intellectual Property Office: Ottawa, ON, Canada, 2018.
28. Aguiar, A.; Furtado, I.; Sousa, M.; Pinto, M.; Duarte, R. Changes to TB care in an outpatient centre during the COVID-19 pandemic. *Int. J. Tuberc. Lung Dis.* **2021**, *25*, 163b–166. [CrossRef] [PubMed]
29. Beyene, N.W.; Sitotaw, A.L.; Tegegn, B.; Bobosha, K. The impact of COVID-19 on the tuberculosis control activities in Addis Ababa. *Pan Afr. Med. J.* **2021**, *38*, 243. [CrossRef]
30. Senoo, Y.; Suzuki, Y.; Takahashi, K.; Tsuda, K.; Tanimoto, T. Prioritizing infants in a time of Bacille Calmette–Guérin vaccine shortage caused by premature expectations against COVID-19. *QJM Int. J. Med.* **2020**, *113*, 773–774. [CrossRef]
31. Soko, R.N.; Burke, R.M.; Feasey, H.R.A.; Sibande, W.; Nliwasa, M.; Henrion, M.Y.R.; Khundi, M.; Dodd, P.J.; Ku, C.C.; Kawalazira, G.; et al. Effects of Coronavirus Disease Pandemic on Tuberculosis Notifications, Malawi. *Emerg. Infect. Dis.* **2021**, *27*, 1831–1839. [CrossRef] [PubMed]
32. Burzynski, J.J.; Macaraig, M.; Nilsen, D.; Schluger, N.W. Transforming essential services for tuberculosis during the COVID-19 pandemic: Lessons from New York City. *Int. J. Tuberc. Lung Disease* **2020**, *24*, 735–736. [CrossRef]
33. Jamal, W.Z.; Habib, S.; Khowaja, S.; Safdar, N.; Zaidi, S.M.A. COVID-19: Ensuring continuity of TB services in the private sector. *Int. J. Tuberc. Lung Dis.* **2020**, *24*, 870–872. [CrossRef]
34. Fatima, R.; Akhtar, N.; Yaqoob, A.; Harries, A.D.; Khan, M.S. Building better tuberculosis control systems in a post-COVID world: Learning from Pakistan during the COVID-19 pandemic. *Int. J. Infect. Dis.* **2021**, in press. [CrossRef] [PubMed]
35. Adewole, O.O. Impact of COVID-19 on TB care: Experiences of a treatment centre in Nigeria. *Int. J. Tuberc. Lung Dis.* **2020**, *24*, 981–982. [CrossRef]
36. Debriche Health Development Centre. Webinar on the Impact of COVID-19 on TB and PHC Services in Nigeria. Available online: https://stoptb-strategicinitiative.org/index.php/2020/07/12/webinar-on-the-impact-of-covid-19-on-tb-and-phc-services-in-nigeria/ (accessed on 18 August 2021).
37. Adepoju, P. Tuberculosis and HIV responses threatened by COVID-19. *Lancet HIV* **2020**, *7*, e319–e320. [CrossRef]
38. Rai, D.K.; Kumar, R. Problems faced by tuberculosis patients during COVID-19 pandemic: Urgent need to intervene. *Indian J. Tuberc.* **2020**, *67*, S173–S174. [CrossRef] [PubMed]
39. Datta, B.; Jaiswal, A.; Goyal, J.; Prakash, A.; Tripathy, J.; Trehan, N. The untimely demise of the TB Free block model in the wake of coronavirus disease 2019 in India. *Trans. R. Soc. Trop. Med. Hyg.* **2020**, *114*, 789–791. [CrossRef] [PubMed]
40. Meneguim, A.C.; Rebello, L.; Das, M.; Ravi, S.; Mathur, T.; Mankar, S.; Kharate, S.; Tipre, P.; Oswal, V.; Iyer, A.; et al. Adapting TB services during the COVID-19 pandemic in Mumbai, India. *Int. J. Tuberc. Lung Dis. Off. J. Int. Union Against Tuberc. Lung Dis.* **2020**, *24*, 1119–1121. [CrossRef]
41. Pilane, P. Covid-19 disrupts HIV and TB services. Mail Guardian 2020. Available online: https://mg.co.za/coronavirus-essentials/2020-09-04-covid-19-sets-hiv-treatment-and-testing-back/ (accessed on 21 September 2021).
42. Keene, C.; Mohr-Holland, E.; Cassidy, T.; Scott, V.; Nelson, A.; Furin, J.; Triviño-Duran, L. How COVID-19 could benefit tuberculosis and HIV services in South Africa. *Lancet Respir. Med.* **2020**, *8*, 844–846. [CrossRef]
43. Ongole, J.J.; Rossouw, T.M.; Fourie, P.B.; Stoltz, A.C.; Hugo, J.; Marcus, T.S. Sustaining essential healthcare in Africa during the COVID-19 pandemic. *Int. J. Tuberc. Lung Dis.* **2020**, *24*, 643–645. [CrossRef] [PubMed]
44. Cox, V.V.; Wilkinson, L.; Grimsrud, A.; Hughes, J.; Reuter, A.; Conradie, F.; Nel, J.; Boyles, T. Critical changes to services for TB patients during the COVID-19 pandemic. *Int. J. Tuberc. Lung Dis.* **2020**, *24*, 542–544. [CrossRef]
45. Comella-Del-Barrio, P.; De Souza-Galvão, M.L.; Prat-Aymerich, C.; Domínguez, J. Impact of COVID-19 on Tuberculosis Control. *Arch. Bronconeumol.* **2021**, *57* (Suppl. 2), 5–6. [CrossRef]
46. World Health Organization. World Health Organization (WHO) Information Note: Tuberculosis and COVID-19. Available online: https://www.who.int/docs/default-source/documents/tuberculosis/infonote-tb-covid-19.pdf (accessed on 15 August 2021).
47. Stop TB Partnership. The Impact of COVID-19 on the TB Epidemic: A Community Perspective. Available online: http://www.stoptb.org/assets/documents/resources/publications/acsm/Civil%20Society%20Report%20on%20TB%20and%20COVID.pdf (accessed on 15 August 2021).
48. Ansumana, R.; Keitell, S.; Roberts, G.M.T.; Ntoumi, F.; Petersen, E.; Ippolito, G.; Zumla, A. Impact of infectious disease epidemics on tuberculosis diagnostic, management, and prevention services: Experiences and lessons from the 2014–2015 Ebola virus disease outbreak in West Africa. *Int. J. Infect. Dis.* **2017**, *56*, 101–104. [CrossRef]
49. Hoffman, S.J.; Silverberg, S.L. Delays in Global Disease Outbreak Responses: Lessons from H1N1, Ebola, and Zika. *Am. J. Public Health* **2018**, *108*, 329–333. [CrossRef]
50. Zumla, A.; Hui, D.S.C. Emerging and Reemerging Infectious Diseases: Global Overview. *Infect. Dis. Clin. North Am.* **2019**, *33*, xiii–xix. [CrossRef]
51. Alfaraj, S.H.; Al-Tawfiq, J.A.; Altuwaijri, T.A.; Memish, Z.A. Middle East Respiratory Syndrome Coronavirus and Pulmonary Tuberculosis Coinfection: Implications for Infection Control. *Intervirology* **2017**, *60*, 53–55. [CrossRef]
52. Martinez-Alvarez, M.; Jarde, A.; Usuf, E.; Brotherton, H.; Bittaye, M.; Samateh, A.L.; Antonio, M.; Vives-Tomas, J.; D'Alessandro, U.; Roca, A. COVID-19 pandemic in west Africa. *Lancet Glob. Health* **2020**, *8*, e631–e632. [CrossRef]

53. Stop TB Partnership. The potential impact of the COVID-19 response on tuberculosis in high-burden countries: A modelling analysis. Available online: http://www.stoptb.org/assets/documents/news/Modeling%20Report_1%20May%202020_FINAL.pdf (accessed on 5 July 2021).
54. Obied, D.A.; Alhamlan, F.S.; Al-Qahtani, A.A.; Al-Ahdal, M.N. Containment of COVID-19: The unprecedented response of Saudi Arabia. *J. Infect. Dev. Ctries.* **2020**, *14*, 699–706. [CrossRef] [PubMed]
55. Algaissi, A.A.; Alharbi, N.K.; Hassanain, M.; Hashem, A.M. Preparedness and response to COVID-19 in Saudi Arabia: Building on MERS experience. *J. Infect. Public Health* **2020**, *13*, 834–838. [CrossRef] [PubMed]

Chapter 3 Methodology & Conceptual Framework

Chapter 3 presents the methodology used for each of the study objectives and the conceptual framework that guided the thesis's design and analysis. Briefly, a mixed methods approach was used encompassing both quantitative and qualitative research techniques to gain a comprehensive understanding of TB diagnostic services during COVID-19. This study design would guide the development of a novel approach to improve these services. For this purpose, two frameworks were consolidated, the first was Donabedian's framework for assessing quality of care and the second was the Lancet's Commission's high-quality health system framework.

The methodology and underlying framework have been presented in detail as a study protocol which was published by the journal PLOS ONE under the title: "*Towards development of a novel approach for enhancement of TB diagnostic services during the pandemic: A case of primary health care clinics in eThekwini district KwaZulu-Natal: A study protocol*". Link: Towards development of a novel approach for enhancement of TB diagnostic services during the pandemic: A case of primary health care clinics in eThekwini district KwaZulu-Natal: A study protocol | PLOS ONE

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STUDY PROTOCOL

Towards development of a novel approach for enhancement of TB diagnostic services during the pandemic: A case of primary health care clinics in eThekwini district KwaZulu-Natal: A study protocol

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Abstract

Introduction

The COVID-19 pandemic has greatly impacted TB diagnostic services in high TB burden settings. This has caused cases to go undetected and increased the number of TB deaths in 2020. Renewed efforts to improve the resilience of TB services during pandemics are required. Therefore, the current study aims to propose a novel approach for conducting TB diagnostic services in high burden settings during the pandemic.

Methods/Design

The proposed study will be conducted in three phases. During the first phase, a geospatial analysis to assess the geographic accessibility of TB diagnostic services will be conducted. In the second phase, the effect of COVID-19 on TB diagnostic services will be determined using an interrupted time series analysis. During the third phase, the barriers and enablers of TB diagnostic services will be explored using patient interviews and a vertical audit. The fourth phase of the study will be guided by the outcomes of the previous three phases where a nominal group technique with key stakeholders will be conducted to propose a novel means for conducting TB diagnostic services during the pandemic. The data of the study will be analyzed using the latest version of ArcGIS, Stata software.

Discussion

The study has received full ethical approval from ethics committees. The results together with input from relevant TB stakeholders will be used to develop a new approach to conducting TB diagnostic services at Primary healthcare clinics.

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Introduction

Tuberculosis (TB) is a communicable disease that up until recently was the leading cause of death by an infectious agent [1]. COVID-19 now occupies the top spot in this regard and its emergence has resulted in devastating consequences for TB control efforts globally. The year 2020 saw newly diagnosed TB cases drop by 18%, from 7.1 million to 5.8 million compared to the previous year [1]. This was due to several reasons including, governments around the globe imposing strict lockdowns to curb the spread of the virus [2, 3]. Furthermore, the emergence of SARS_CoV-2 prompted the diversion of health resources from other diseases to COVID-19 care [4]. Simultaneously, healthcare-seeking behaviors and access to TB services were greatly reduced [4, 5]. Together these factors have led to fewer cases being diagnosed and initiated on treatment which has increased the number of TB deaths for 2020 [1].

South Africa (SA) has one of the highest TB burdens and accounted for 3.3% of the global cases in 2020 [1]. Before COVID-19, the country had made significant strides toward TB control. This was due to the introduction of universal testing and the use of new and repurposed TB drugs [6]. These have allowed the country to meet some key milestones of the end TB strategy set for the year 2020, specifically, reaching a 20% reduction in TB incidence between 2015–2020 [1]. However, due to COVID-19, SA has experienced a similar fate to the rest of the world, reporting a reduction in the number of TB cases notified in 2020 compared to the previous year [1, 7]. A few studies have investigated the impact of COVID-19 on the South African healthcare system with a focus on HIV-related indicators [8, 9]. Some have looked at the impact of COVID-19 on TB services [10, 11]. A study from a district in the Limpopo province showed no significant changes to TB indicators during the first wave of COVID-19 [11]. However, Pillay and colleagues found that TB testing across the country drastically reduced during the national lockdown and has slowly improved after restrictions were lifted, however, as of February 2021 TB testing is still lower than the expected levels [10]. The results imply that COVID-19 has had varying effects on TB services across the country and an investigation into specific regions especially those with a higher TB burden is warranted.

A look at previous epidemics like Ebola and Mers-CoV shows a similar pattern to what is being experienced with COVID-19, where resources and efforts were geared toward fighting the emerging health threat at the expense of existing diseases of importance [12, 13]. This approach has resulted in the indirect cost of such epidemics being greater than the epidemic itself [14]. Modelling studies have predicted a similar outcome for COVID-19 control efforts in light of other health issues like TB [15, 16]. The consequences thereof have already become manifest in high TB burden countries like SA and will likely continue unless effective action is taken [10, 11, 17]. It is important therefore that recovery efforts are not only aimed at restoring TB case detection and treatment levels to those recorded before the COVID-19 pandemic but ensuring that healthcare systems are strengthened so that they remain operational during the current pandemic and other global health crises that may emerge in future. Therefore, our study aims to propose a method for improving TB diagnostic services during COVID-19 at PHC clinics in high burden settings, using eThekwini, SA as a study setting.

A study of this nature is crucial for several reasons, firstly TB is listed among the top ten killers in SA and the leading cause of death among those living with HIV [18]. The main hurdle in eradicating TB in SA is the number of people that become infected that never receive a diagnosis [10]. The reduction in testing experienced at the start of the pandemic suggests that these "missed" people have likely increased [17, 18]. Difficulty in accessing healthcare and reluctance to seek care at the start of COVID-19 are some of the reasons for this [5, 17, 19]. Therefore, it is of the utmost importance that essential services like TB testing are trusted by users and remain in place despite other health challenges arising. Failure to do this will not only undo the strides taken toward TB control in SA but increase the TB burden in coming years. The outcomes of this research can assist in the creation of resilient and robust healthcare systems capable of sustaining essential TB care throughout the different phases of the current pandemic and other health crises that may arise in the future.

Methods/Design

Study design

This study will employ an implementation science research approach, which seeks to understand implementation problems for efficacious methods and comes up with evidence-based solutions to improve their uptake and integration into healthcare practice [20]. In implementation research, a variety of study designs are used to address a research question. A scoping review to gain insight into the state of TB services at PHC during COVID-19 has already been conducted and published elsewhere [2]. The findings of the scoping review helped to refine the subsequent objectives. In the first phase of the study, a geospatial analysis will be conducted to determine the accessibility of TB diagnostic services in eThekwini. During the second phase, the impact of COVID-19 on TB diagnostic services in eThekwini will be determined using a quasi-experimental research design. The barriers and facilitators of TB diagnostic services will also be explored through a cross-sectional and a qualitative study design. Once data from the other two phases are analysed, they will be used to guide the nominal group technique (NGT) in the final phase, where key stakeholders will co-create a novel approach for the current TB diagnostic services during COVID-19.

Conceptual framework

Fig 1 presents the conceptual framework of this study, two frameworks will be combined, Donabedian's model for assessing the quality of care [21] and the high-quality health system (HQHS) framework by the Lancet commission [22]. Both frameworks assert that high-quality care can improve health outcomes at an individual and population level. Donabedian's framework states that the quality of healthcare can be measured by looking at the structure, process, and outcome [21]. Structure refers to the physical attributes of the healthcare system such as infrastructure, equipment, number of trained professionals, and the organizational structures in place. The process refers to how care is administered by healthcare personnel and how the users interact with the healthcare system. Lastly, the outcome is the influence of care received on the health status of the patient or population [21]. Each component of the model influences the next, so that good structure will result in good processes which in turn results in good outcomes.

This conceptual framework will be used to guide the first three phases of the study, Fig 1. The quality of care will be assessed using Donabedian's components of structure, process, and outcome and the quality indicators from the HQHS framework (shaded grey) which have been contextualized for TB care; indicators unique to the HQHS framework have been asterisked. The structure will refer to the included primary healthcare facilities. The study will investigate the accessibility of these facilities and their proximity to the nearest testing laboratory compared to the TB burden in the area. Other structural components assessed will include staff as well as facility characteristics. Processes of care, which according to the HQHS can be divided into competent care, competent systems, and user experience will be measured using the latest evidence-based guidelines [23] and additional measures included by the HQHS framework. The framework also states that high-quality systems should not only improve the health of people but also provide them economic benefits along with increased trust and confidence in health systems [22]. As such, outcome measures for the study will be the confidence

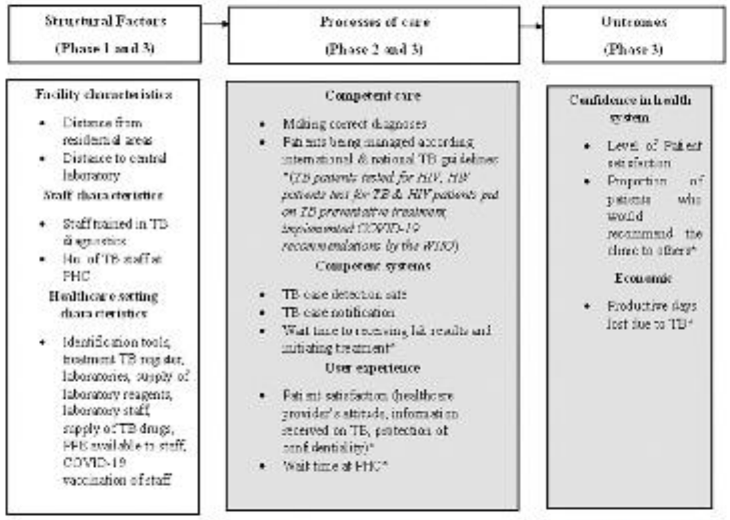

Fig 1. Conceptual framework for measuring quality of TB care for the study: Towards development of a novel approach for enhancement of TB diagnostic services during the pandemic: A case of primary health care clinics in eThekwini district KwaZulu-Natal.

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in the health system and the economic consequences faced by TB patients. The information derived from this part of the study will then be used to inform the final phase in which a new approach for TB diagnostic services for high-burden settings will be designed by key stakeholders.

Study setting

The study will be undertaken in the eThekwini district in the province of KwaZulu-Natal (KZN), South Africa. The district is the most densely populated within the province with a population of approximately 3 199 944 [24]. It is a high TB burden district and also has one of the highest cases of COVID-19 in the country. In 2015, it had the highest incidence of TB, totaling 24 588 cases [25]. The district also carries approximately half the country's burden of extensively drug-resistant TB [26]. A total of 114 public sector clinics provide primary health-care services in the district comprising 108 fixed clinics and 6 community health centers. The study will be conducted at fixed primary health care clinics; therefore no mobile clinics will be included.

Phase 1: Geospatial analysis

Objective 1: To map the geographic accessibility of TB diagnostics services using geospatial analysis. *Design.* Cross-sectional study.

Sampling. All clinics that offer TB testing in the eThekwini district.

Data source. Geospatial data of all clinics offering TB diagnostic services and the surrounding residential areas in eThekwini will be obtained from the Department of Health and Geographic positioning system. For the results of the spatial processes to be in "meters" the

Universal Transverse Mercator (UTM) zone, 36˚S, was applied to all spatial data. Data on the TB prevalence and clinic characteristics will be obtained from the National TB prevalence survey [27] and the DHIS.

Analysis and mapping. The coordinates of PHC clinics and residential areas within the eThekwini will be linked to a base map using ArcGIS software. The spatial data of the clinics will be used as inputs to measure proximity to the nearest residential areas. The average speed of 80km/h for the most available and used mode of transport, the minibus taxi, will be applied to estimate the travel time. The detailed model that will be used for this study to determine travel time has been described in a paper by Kuupiel and colleagues [28]. An Autocorrelation tool/Morons index will be used to determine the spatial distribution of PHC clinics in ArcMap. The resulting travel times and distances will be exported into Stata statistical software, where the means and standard deviations will be calculated and recorded. The z scores and p values will also be reported. The results will be used to assess the travel time and distances of TB services compared to the TB prevalence in the surrounding residential areas.

Outcome measures. Geographical accessibility in terms of distance and time traveled to PHC clinics that offers TB testing services in eThekwini. The Council for Scientific and Industrial Research (CSIR) has stipulated that social facilities offering public services in South Africa should have a travel distance of 5km to clinics and 30km to hospitals [29]. We will use a travel distance of ≤5km as geographically accessible.

Phase 2: Quasi-experimental, vertical audit, and qualitative study

Objective 2: To determine the effect of the COVID-19 pandemic on TB diagnostic services. *Design*. Regression-based quasi-experimental.

Sampling. All PHC clinics providing TB diagnostic services in the eThekwini district will be included.

Data sources. Aggregated monthly data from the District of Health Information Systems (DHIS). The time points used will be between January 2018 to January 2022. Any outliers will be identified and corroborated with data from February 2022.

Analysis. A segmented linear regression of an interrupted time series analysis will be used to determine the impact of COVID-19 on TB services before and after the start of the pandemic. The outcome variables to be assessed are TB samples sent for testing as well as TB case notifications from PHC clinics in the eThekwini district. The following regression model will be used for the assessment:

$$Y_{t=}\beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \varepsilon_t$$

Y_t: the outcome variable at each time point, number of samples being sent for TB testing, or TB cases notified

β_0: is the baseline level of the outcome (number of samples being sent to the lab and TB cases notified) at the start of the series

T_t: the time passed since the beginning of the study, measured in months.

X_t: is a dummy variable that represents a time before the exposure, COVID-19, and is coded (0). The post-exposure period will be coded (1)

β_1: measures the base trend, how the outcomes change per quarter before COVID-19

β_2: measures the number of samples or cases at the point where (COVID-19) is introduced

β_3: estimates the change in trend following COVID-19

An unchanging slope in the trendline before and after COVID-19 means that the trend in TB samples tested and cases notified were the same despite the emergence of COVID-19. If the slope increases then the outcome variables would have increased after COVID-19 conversely a decreasing slope would indicate a downward trend in the outcome variables. We hypothesize that the trend and the levels will change following the emergence of COVID-19. If β_2 and β_3 produce significant p-values then this would indicate the immediate effect of COVID-19 and its effect over time, respectively. Stata statistical software will be used to conduct this analysis.

Outcome measures. The number of TB tests samples sent for testing and the number of TB cases notified.

Objective 3: To explore challenges and enablers of TB diagnostics services during the COVID-19 pandemic. *Design.* A clinical audit and a qualitative data gathering technique.

Sampling. Two clinics from each of the five sub-districts of eThekwini will be purposively selected. Selection will be purposively determined by the clinic size and the TB burden in the area.

To ascertain user experience and trust in the health system, two patients from each audited facility will be interviewed (S1 File). Only those patients that are 18 years and older and have received a TB service on the day of the audit will be invited for an interview. The interviews will be audio-recorded and conducted using an interview guide. If conceptual saturation is reached before participants at every facility are interviewed then data collection will end. Data saturation will be determined through an iterative process of collecting and analyzing the findings.

Data sources. Data will be gathered through an adapted audit checklist developed by the United States Agency for International Development (USAID) for assessing the quality of TB services (S1 File). The responses on the tool will be coded with 1 = yes and 0 = no responses. The final number of yes responses will be divided by the sum of the audit items on the checklist, this will be used to determine the facility score for diagnostic services. The quality of TB diagnostic services will be assessed using three cutoffs, a score of ≥85% will be considered excellent, an average score will be between 50%-84%, and a score of <50% will be considered poor.

For user experience and confidence in the health system, data will be collected through in-depth interviews (S1 File). Before data collection begins both tools will be piloted at two facilities that fall outside of the inclusion criteria. Based on the inputs received from the piloting phase, appropriate changes will be made to the data collection tools.

Analysis. The results of the audit will be analyzed to explain the general performance of the PHC facilities and service quality. Descriptive analysis in the form of percentages and counts will be used to describe the outcome variables, and Stata statistical software will be used in this regard.

The results of the interviews will be transcribed and analyzed using thematic content analysis by extracting and grouping similar themes from the patient responses. Direct quotations will also be included if they are found to summarize the main findings of the theme.

Outcome measures. Quality of TB diagnostic services.

Phase 3: Mixed methods—nominal group technique

Objective 4: To collaborate with local stakeholders in designing an approach for enhancing the current TB diagnostic services. *Design.* Nominal group technique.

Sampling. Key stakeholders will be chosen using criterion-based purposive and a snowballing sampling technique, in the case where a participant cannot take part, snowball sampling will be used to recruit a replacement. For this study, key stakeholders will be defined as individuals that demonstrate knowledge and experience in PHC TB diagnostic services, as well as the TB patients/survivors who use these services. A maximum number of 12 participants are anticipated for the study, this allows for optimal idea generation among group members [30].

Recruitment strategy. The eThekwini district health office will be approached to recommend two TB health service researchers or public health specialists who will be able to participate in the nominal group technique, they will be contacted and informed about the purpose of the study. In the case where there are unavailable, they will be asked to recommend someone else who may be suitable to replace them. Similarly, two TB nurses, two TB advocates, and two TB patients will be recruited from a PHC in which the facility audits took place.

Data source. Data will be obtained from audio transcripts from the NGT. The workshop will be guided by the findings from the previous objectives. The session will start with the group members introducing themselves and sharing their experience with TB diagnostic services. The PI will then provide context for the workshop and outline the process for the rest of the day. In the first phase of the workshop, the participants will be asked to independently respond to a series of questions posed by the PI regarding the biggest hindrances to TB diagnostics due to COVID-19. Following this, each participant will be allowed to present their answers to the rest of the group. After this stage, the group will clarify and discuss responses after which the ideas will be grouped according to themes. Once data saturation has been reached the ideas will be prioritized from least to most important. A score of one will be given to ideas deemed least important and five will be given to the ideas of most importance. In the second phase of the workshop, all stakeholders will use ranked ideas to come up with improvements to the current TB diagnostic services. The stakeholders with expert knowledge on the workings of TB diagnostic services will suggest ways in which services can be improved while TB patients and survivors will give users insight into the suggestions.

Analysis. For the NGT, total scores allocated to each idea during the ranking step will be calculated by adding scores from each participant and assigning the idea an overall score. The proceedings of the NGT will be audio-recorded and transcribed. Qualitative analysis of the five highest-ranking priority themes will be conducted using thematic content analysis. Quality data will be elicited from stakeholders' presentations which will include motivation for selected themes. During the discussion and clarifying of the priority list, additional data will be collected. This time will also be used to elaborate on the existing themes.

Outcome measure. An improved approach to conducting TB diagnostic services at PHC during COVID-19.

Ethical consideration and data sharing

The study will be conducted following the Protection of Personal Information Act [31]. The participants will be notified about the purposes of the study and allowed to ask questions or withdraw their participation should they choose. Before the start of data collection, eligible participants will be asked to give written consent which will be administered by the primary investigator or a trained research assistant (S1 File). No identifying characteristics or personal information of the participants will be made available at any stage of reporting the results, participants will only be identified by a code or a number. COVID-19 regulations will be closely adhered to according to South Africa's most recent guidelines. Throughout the study, stakeholders from the PHC clinics, the Department of Health, and members of the community will be engaged to ensure that the cultural dimensions of the community are understood and respected by the research team. Full ethical approval has been received from the University of Pretoria, the Faculty of Health Sciences Research Ethics committee (Reference Number 652/2021), and the KwaZulu-Natal Department of Health (Reference number KZ_202112_012). Once an objective has been completed, the findings will be submitted for publication in a peer-reviewed journal. The results of this study will also be presented at local and international conferences. Upon completion of the study, the findings will also be disseminated among various stakeholders including the department of health and the included primary healthcare clinics.

Strengths and limitations

To determine the impact of COVID-19 on TB diagnostic services and geographic accessibility the study will use data from all PHC clinics in eThekwini. This gives an accurate depiction of the outcome measures than using a representative sample. Moreover, the power of an interrupted time series analysis, which will be used to determine the impact of COVID-19 on TB diagnostic services, is increased with the use of more data points [32]. Our study will use all the available monthly data since the start of the pandemic to conduct this analysis. Since routine data is used for an interrupted time series analysis, its collection may have been compromised at the start of the COVID-19 pandemic but we will ensure that only reliable data is used. We aim to use all the data collected in the first three objectives of the study to come up with an innovative way of conducting TB diagnostic services. This process will involve TB stakeholders to ensure that the approach is relevant and beneficial for service providers and users alike. This study can offer a foundation for policies aimed at strengthening TB services, which can ultimately help primary healthcare clinics be better prepared for future public health crises. Since the study will only use data from one district, the findings may only be generalizable to settings with a similar TB burden and COVID-19 infection rate as eThekwini.

Study timeline

The study has not yet begun data collection and participant recruitment. It is anticipated that data cleaning and analysis for the geospatial analysis will commence in September 2022. The interrupted time series analysis will be conducted in October and data collection for the audit and in-depth interviews will be conducted in November and analysed in December of 2022. Following analysis of audit and interview data, the NGT will take place in February of 2022. Participant recruitment for the in-depth interviews will occur on the days that facility audits are conducted. For the Nominal Group Technique, participant recruitment will begin after the completion of the third objective. It is anticipated that data collection will be completed within one year.

Supporting information

S1 File. Informed consent form; audit tool; interview questions.
(DOCX)

Author Contributions

Conceptualization: Thobeka Dlangalala, Tivani Mashamba-Thompson.

Methodology: Alfred Musekiwa.

Project administration: Thobeka Dlangalala.

Supervision: Alfred Musekiwa, Tivani Mashamba-Thompson.

Validation: Tivani Mashamba-Thompson.

Writing – original draft: Thobeka Dlangalala.

Writing – review & editing: Thobeka Dlangalala, Alfred Musekiwa, Tivani Mashamba-Thompson.

References

1. World Health Organization. Global tuberculosis report Geneva2021 [cited 2021 12-16-2021]. Available from: https://www.who.int/teams/global-tuberculosis-programme/tb-reports.
2. Dlangalala T, Musekiwa A, Brits A, Maluleke K, Jaya ZN, Kgarosi K, et al. Evidence of TB Services at Primary Healthcare Level during COVID-19: A Scoping Review. Diagnostics. 2021; 11(12):2221. https://doi.org/10.3390/diagnostics11122221 PMID: 34943458
3. Global Fund. The Impact of COVID-19 on HIV, TB and Malaria services systems for health: A Snapshot from 502 Health facilities across Africa and Asia 2020 [cited 2021 15-08-2021]. Available from: https://www.theglobalfund.org/media/10776/covid-19_2020-disruption-impact_report_en.pdf.
4. Alene KA, Wangdi K, Clements ACA. Impact of the COVID-19 Pandemic on Tuberculosis Control: An Overview. Tropical Medicine and Infectious Disease. 2020; 5:123. https://doi.org/10.3390/tropicalmed5030123 PMID: 32722014
5. Rai DK, Kumar R. Problems faced by tuberculosis patients during COVID-19 pandemic: Urgent need to intervene. Indian Journal of Tuberculosis. 2020; 67(4):S173–S4. https://doi.org/10.1016/j.ijtb.2020.07.013 PMID: 33308666
6. National Institute for Communicable Diseases. Impact of COVID-19 intervention on TB testing in South Africa South Africa: National Institute for Communicable Diseases; 2020 [cited 2021 12-19-2021]. Available from: https://www.nicd.ac.za/wp-content/uploads/2020/05/Impact-of-Covid-19-interventions-on-TB-testing-in-South-Africa-10-May-2020.pdf.
7. World Health Organization. COVID-19 pandemic slows progress against tuberculosis 2021 [cited 2022 01-18-2022]. Available from: https://www.afro.who.int/news/covid-19-pandemic-slows-progress-against-tuberculosis.
8. Siedner MJ, Kraemer JD, Meyer MJ, Harling G, Mngomezulu T, Gabela P, et al. Access to primary healthcare during lockdown measures for COVID-19 in rural South Africa: a longitudinal cohort study. medRxiv. 2020. https://doi.org/10.1101/2020.05.15.20103226 PMID: 32511504
9. Dorward J, Khubone T, Gate K, Ngobese H, Sookrajh Y, Mkhize S, et al. The impact of the COVID-19 lockdown on HIV care in 65 South African primary care clinics: an interrupted time series analysis. The Lancet HIV. 2021; 8:e158–e65. https://doi.org/10.1016/S2352-3018(20)30359-3 PMID: 33549166.
10. Pillay Y, Pienaar S, Barron P, Zondi T. Impact of COVID-19 on routine primary healthcare services in South Africa. South African Medical Journal. 2021; 111(8):714. https://doi.org/10.7196/SAMJ.2021.v111i8.15786 PMID: 35227349
11. Mutyambizi C, Dunlop J, Maluleka C, Ranoto L, Chetty T, Ndou R, et al. Effect of COVID-19 on HIV, tuberculosis, and prevention of mother-to-child transmission of HIV indicators in Mopani district, South Africa. South African Medical Journal. 2021; 111(12):1181. https://doi.org/10.7196/SAMJ.2021.v111i12.15822 PMID: 34949305
12. Hoffman SJ, Silverberg SL. Delays in Global Disease Outbreak Responses: Lessons from H1N1, Ebola, and Zika. American Journal of Public Health. 2018; 108(3):329–33. https://doi.org/10.2105/AJPH.2017.304245 PMID: 29345996
13. Algaissi AA, Alharbi NK, Hassanain M, Hashem AM. Preparedness and response to COVID-19 in Saudi Arabia: Building on MERS experience. Journal of Infection and Public Health. 2020; 13(6):834–8. https://doi.org/10.1016/j.jiph.2020.04.016 PMID: 32451260
14. Alene KA, Wangdi K, Clements ACA. Impact of the COVID-19 Pandemic on Tuberculosis Control: An Overview. Tropical Medicine and Infectious Disease. 2020; 5(3):123. https://doi.org/10.3390/tropicalmed5030123 PMID: 32722014
15. Hogan AB, Jewell BL, Sherrard-Smith E, Vesga JF, Watson OJ, Whittaker C, et al. Potential impact of the COVID-19 pandemic on HIV, tuberculosis, and malaria in low-income and middle-income countries: a modelling study. The Lancet Global Health. 2020; 8(9):e1132–e41. https://doi.org/10.1016/S2214-109X(20)30288-6 PMID: 32673577
16. McQuaid CF, Vassall A, Cohen T, Fiekert K, White RG. The impact of COVID-19 on TB: a review of the data. Int J Tuberc Lung Dis. 2021; 25(6):436–46. Epub 2021/05/30. https://doi.org/10.5588/ijtld.21.0148 PMID: 34049605; PubMed Central PMCID: PMC8171247.
17. Karim QA, Karim SSA. COVID-19 affects HIV and tuberculosis care. Science. 2020; 369:366–8. https://doi.org/10.1126/science.abd1072 PMID: 32703860.
18. Burger RD, C Deghaye NNkonki L Rensburg R Smith A Van Schalkwyk C. Examining the unintended consequences of the COVID-19 pandemic on public sector health facility visits: The first 150 days. National Income Dynamic Study (NIDS), 2020.
19. Adepoju P. Tuberculosis and HIV responses threatened by COVID-19. The Lancet HIV. 2020; 7(5):e319–e20. https://doi.org/10.1016/S2352-3018(20)30109-0 PMID: 32277870

20. Peters DH, Adam T, Alonge O, Agyepong IA, Tran N. Implementation research: what it is and how to do it. BMJ. 2013; 347:f6753. Epub 2013/11/22. https://doi.org/10.1136/bmj.f6753 PMID: 24259324.
21. Donabedian A. The quality of care. How can it be assessed? JAMA: The Journal of the American Medical Association. 1988; 260(12):1743. https://doi.org/10.1001/jama.260.12.1743 PMID: 3045356
22. Arsenault C, Roder-DeWan S, Kruk ME. Measuring and improving the quality of tuberculosis care: A framework and implications from the Lancet Global Health Commission. Journal of Clinical Tuberculosis and Other Mycobacterial Diseases. 2019; 16:100112. https://doi.org/10.1016/j.jctube.2019.100112 PMID: 31497655
23. World Health Organization. World Health Organization (WHO) Information Note: Tuberculosis and COVID-19 2020 [cited 2021 15-08-2021]. Available from: https://www.who.int/docs/default-source/documents/tuberculosis/infonote-tb-covid-19.pdf.
24. KwaZulu Natal Department of Health. KZN Provincial Health Statistics 2018. Available from: http://www.kznhealth.gov.za/gis/prov.pdf.
25. Vanleeuw L, Loveday M. Tuberculosis: Health Systems Trust; 2015. Available from: https://www.hst.org.za/publications/District%20Health%20Barometers/9%20(Section%20A)%20Tuberculosis.pdf.
26. Kapwata T, Morris N, Campbell A, Mthiyane T, Mpangase P, Nelson KN, et al. Spatial distribution of extensively drug-resistant tuberculosis (XDR TB) patients in KwaZulu-Natal, South Africa. PLOS ONE. 2017; 12:e0181797. https://doi.org/10.1371/journal.pone.0181797 PMID: 29028800
27. National Institute for Communicable Diseases. The first national TB prevalence survey. South Africa: 2018.
28. Kuupiel D, Adu KM, Apiribu F, Bawontuo V, Adogboba DA, Ali KT, et al. Geographic accessibility to public health facilities providing tuberculosis testing services at point-of-care in the upper east region, Ghana. BMC Public Health. 2019; 19(1). https://doi.org/10.1186/s12889-019-7052-2 PMID: 31182068
29. Greene C. Council for Scientific and Industrial Research (CSIR) guidelines for the provision of social facil-ities in South African settlements. Pretoria: 2012.
30. Allen J, Dyas J, Jones M. Building consensus in health care: a guide to using the nominal group technique. British journal of community nursing. 2004; 9:110–4. https://doi.org/10.12968/bjcn.2004.9.3.12432 PMID: 15028996.
31. POPIA, (2021).
32. Bernal JL, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: A tutorial. International Journal of Epidemiology. 2017; 46:348–55. https://doi.org/10.1093/ije/dyw098 PMID: 27283160.

Chapter 4 Manuscript addressing Objective 1

One of the gaps revealed by the scoping review in chapter 2 was the need for more primary studies. In chapter four, there is an attempt to address this gap by investigating the geographic accessibility of TB diagnostic services in eThekwini district.

The chapter has been presented in a manuscript format reflecting the journal guidelines to which it was submitted. The manuscript is currently under consideration in the journal BMJ Open under the title "*Geographical accessibility of TB diagnostic services at primary healthcare clinics in eThekwini District, South Africa*"

Geographical accessibility of TB diagnostic services at primary healthcare clinics in eThekwini District, South Africa

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Abstract

Background

Improving geographic access can aid in managing Tuberculosis (TB) by enabling early diagnosis and treatment initiation. Although geospatial techniques have been utilized to map the transmission patterns of drug-resistant TB in South Africa, fewer studies have investigated the accessibility of TB services. This study evaluated the accessibility of TB diagnostic services and disease distribution in eThekwini district, South Africa.

Methods

In this cross-sectional study, population data for the year 2021 were disaggregated into smaller analysis units and then re-aggregated through the dasymetric mapping technique. Data on confirmed TB cases, including GPS coordinates of clinics, were obtained from the District of Health Information System (DHIS), exported to ArcGIS 10.8.2, and used to calculate distances to the nearest clinics and hospitals.

Results

Ninety-two percent of the population (3 730 494 people) in eThekwini could access TB diagnostic services within 5km. Patients travelled an average distance of 4.7km (range; 0.1-26.9km). TB diagnostic services were highly accessible in the north and central regions and moderately accessible in the predominately rural west and south regions, respectively. The smallest population of eThekwini resides in rural areas, however, 40.7% of its residents live >5km from a diagnosing facility, with patients in the south having to travel up to 44.5km. TB cases were higher in urban, sub-urban areas and along the prime corridor; however, fewer were in the rural areas. Our findings also showed that 98.4% of the clinics in eThekwini were located within 30km of a hospital at an average distance of 9.6km within the district. However, the distribution of these hospitals does not demonstrate equitable access as the majority are located within the central region and fewer are found in the other three regions of eThekwini.

Conclusions

Access to diagnostic services is poor in rural areas and solutions are needed to address these inequities in healthcare access.

Strengths and limitations

- The study used dasymetric mapping to determine the geographic access of TB diagnostic services. This method allows for a more accurate measurement of geographic access by accounting for unhabitable regions such as bodies of water or mountains.
- The study assumes that patients will use the nearest health facility when they can use any facility of their choosing, including those outside their residential areas.
- We also assumed that all members of the district utilized public healthcare services and did not consider the subset of the population with medical insurance who can afford private healthcare.
- The study only considered potential accessibility which measures the availability and distance to facilities and did not consider revealed accessibility, which measures the availability and distance to facilities, and did not consider revealed accessibility, which is determined by utilization.

Background

Tuberculosis (TB) is the leading cause of death by an infectious agent in low- and middle-income countries (LMICs). [1] This is concerning given that TB is preventable and treatable, with an 85% treatment success rate following a 6-month drug regimen. [2] A major driver of the epidemic is the number of people who become infected but are never diagnosed. [3] Typically, 3 million are “missed” annually by national TB programs; [1] this number is largely from LMICs where underdiagnosis is partly due to financial and geographic barriers impeding access to healthcare. [4] These barriers became more pronounced during the coronavirus disease-2019 (COVID-19) period. [5-7] This has further widened the TB diagnostic gap and increased the number of TB deaths for the first time in over a decade. [2] These knock-on effects of COVID-19 will likely continue in the years to come. [8 9] Strengthening TB services in a post-COVID-19 world should evaluate and address barriers to access.

Improving geographic access to healthcare can alleviate the TB burden through early diagnosis and treatment initiation. [4] Studies have linked geographic accessibility to TB outcomes, [10] showing that geographical barriers are associated with delays in seeking care, loss to follow-up, and a lack of adherence during TB diagnostic and treatment processes. [11 12] These can prolong periods of infectiousness, leading to ongoing transmission within communities, an increased likelihood of poor clinical prognosis, and the development of drug resistance among patients. [13] This is especially true for settings with a high HIV co-infection rate like South Africa. [13] Therefore, it is important to investigate access to TB services while also recognizing the spatial heterogeneity of the disease to inform effective interventions where they are most needed. [14] This can be established using epidemiological data and geospatial technologies.

In South Africa, spatial analysis has been used to determine the risk factors associated with recurring drug-susceptible TB. [15] However, the bulk of the geospatial research as it relates to TB has been used to understand the occurrence and transmission patterns of extensively drug-resistant (XDR) TB. [13 16-18] Although this is important work, similar studies are also required for drug-susceptible TB which is still pervasive and has increased because of COVID-19-related disruptions to health services. [19] To our knowledge, no studies in South Africa have examined the access to TB services in relation to the population and disease distribution within a high-burden region. Therefore, we aimed to analyze the accessibility of TB diagnostic services at primary healthcare clinics (PHCs) in the eThekwini district in relation to the population and disease distribution. Specifically, we assessed the travel distances from residential areas to PHCs and from PHCs to district hospitals, respectively. Additionally, we mapped the spatial distribution of TB within the district. It is anticipated that the results of this study will reveal the level of accessibility of TB services which can guide governance and provision of equitable TB service delivery where they are most needed.

Methods

Study setting

The study setting was in South Africa's Kwa-Zulu Natal (KZN) province (Figure 1). The province constitutes 11 districts and has the second-largest population in South Africa. [16] eThekwini is the largest district in terms of population and the only metropolitan municipality in KZN. [20] It has, however, the smallest area size of all the districts in the province at a total of 263 952 hectares. [21] The district comprises four municipal planning regions: the North, South, Central, and Outer West. [20] The regions are further divided into wards which amount to 111 in total. As of the year 2021, its population was estimated at 4 027 660 with the majority residing in the north region and the smallest group residing in the outer west region. The district has a high TB burden, and in the year 2015, it recorded the highest incidence rates in South Africa, at 24 588 cases. [22] TB testing can be accessed free of charge through the public health sector mainly through PHCs. [23]

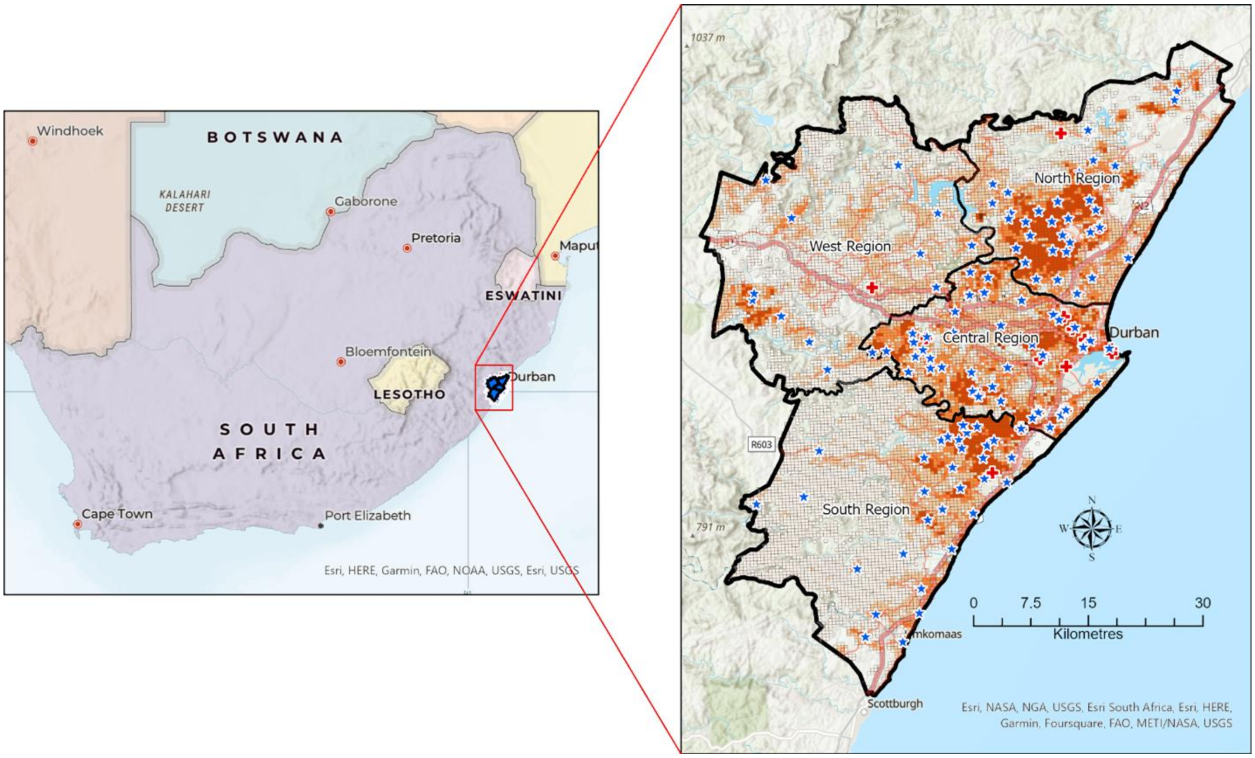

Figure 1 Geographic location of eThekwini district Kwa-Zulu Natal (KZN) Province, South Africa

Study design

Descriptive cross-sectional study which assessed the geographic accessibility of TB diagnostics services for the year 2021. The study was useful for revealing the size of the problem (access to TB diagnostic services) at a given point in time.

Data sources and manipulation

Global Positioning System (GPS) coordinates for all the health facilities were provided by the KZN Department of Health and any missing coordinates were obtained from Google Maps. Population data for the eThekwini district was provided by Stats SA using a community survey from 2021. The spatial road network and the municipal boundaries of the eThekwini district were obtained from the Council for Scientific and Industrial Research (CSIR). To get more precise analysis outputs, the municipal boundaries were divided into smaller analysis units of 20-hectare hexagons, which give more precise analysis outputs and better distance estimates. [24] Each hexagon was populated with the year 2021 population data by calculating the population-weighted centroid based on the population distribution using dasymetric mapping. TB confirmation data for the year 2021 was obtained from the District of Health Information System (DHIS2). This data is collected monthly from primary healthcare facilities by designated data capturers and reported to the district. These data were used to calculate the number of TB cases per ward (the smallest administrative unit).

Mapping and Analysis Techniques

The analysis was conducted in ArcGIS 10.8.2 software. The distances were measured using road network distance which gives a more accurate measurement than Euclidean distance. The distance is measured from the centroid of each hexagon to the closest health facility using the origin-destination matrix.[25] For distance measurements, the implicit mode of travel was assumed which states that the shortest physical distance is a function of the mode of travel. It was also assumed that people are likely to travel from their place of residence to the nearest health facility. To visualize the distribution of TB, the aggregated TB cases were linked to a base map in ArcGIS using the spatial join function. All distances computed were exported onto Excel to calculate means and standard deviations.

Outcome measures

The primary outcome was the travel distance to PHCs offering TB testing services in the eThekwini district. The secondary outcome was the travel distances from PHCs to nearest hospital. The CSIR has stipulated that social facilities offering public services in South Africa should have a travel distance of 5km to clinics. [24] Therefore, clinics that were < 5km from patients were deemed highly accessible; PHCs with distances between 5-10km were moderately accessible, and > 10km were deemed poorly accessible. The CSIR guidelines further state that PHCs should ideally be situated within 30km of district hospitals, therefore, distances greater than this were classified as inaccessible.

Patient and Public Involvement

No patients/public were involved in any aspect of this study.

Results

Travel distance analysis of PHCs in the eThekwini district

A total of 123 clinics were included in the analysis of geographic accessibility. The distances that people traveled to the closest diagnostic facility within the different regions of the eThekwini district are depicted in Figure 2. The map shows that much of the population had good access to TB diagnostic services with only a few areas exhibiting poor accessibility. The mean distances traveled by patients to diagnostic facilities for each of the planning districts in eThekwini are found in Table 1. On average, patients visiting eThekwini PHCs had to travel 4.7km (range; 0.1-26.9km). The Central and North regions were highly accessible, with average distances of 2.6km (range; 0-13.9km) and 4.5km (range; 0.1-26.2km), respectively. The South and West regions were considered moderately accessible, with mean distances of 5.2km (range; 0-44.5km) and 6.2km (range; 0-23.2km), respectively. However, it's worth noting that patients from all four regions could travel maximum distances that were beyond the recommended 5km to access diagnostic facilities. Patients from the South region residing furthest from PHCs could travel up to 44.5km.

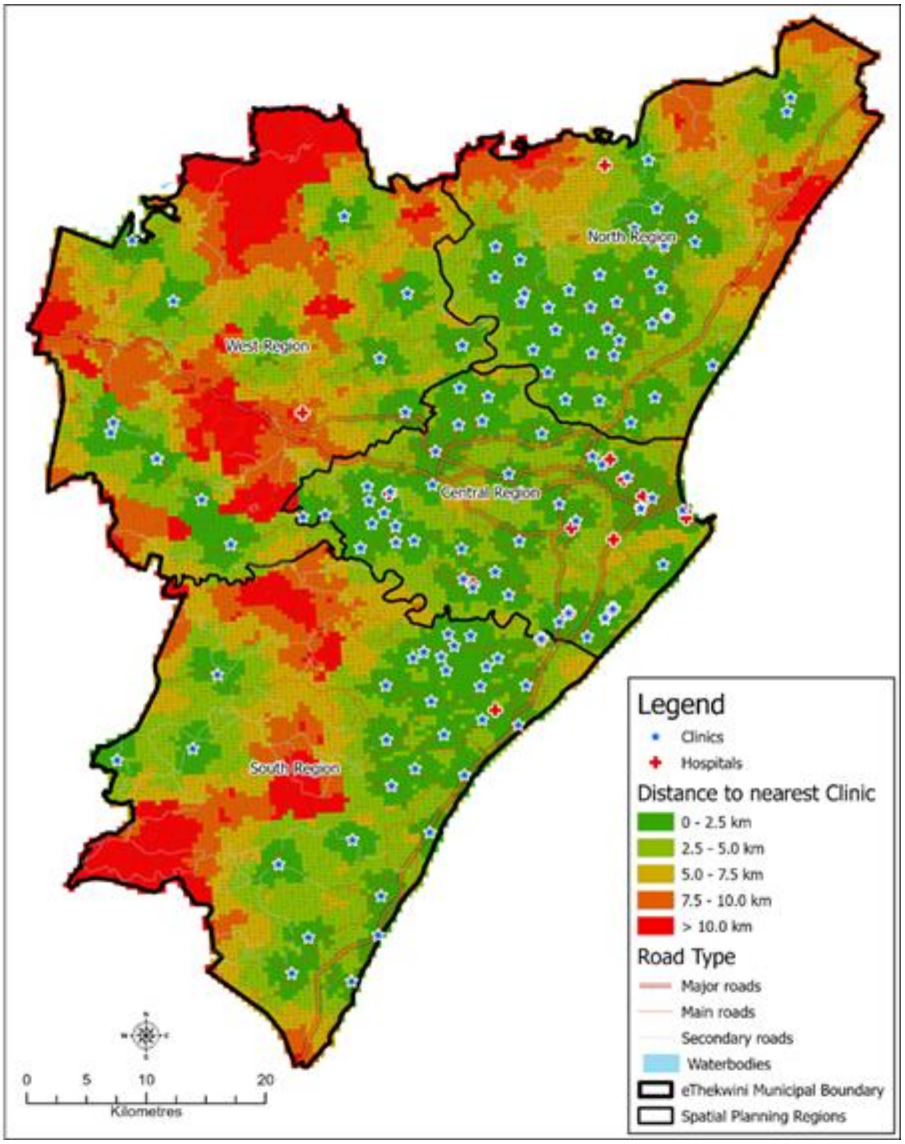

Figure 2 Travel Distance to TB Diagnostic Services Facilities in eThekwini District

Table 1 Travel Distance Statistics per Planning District of eThekwini District

Spatial Planning Region	Average distance (km) to Clinic	MIN distance (km) to Clinic	MAX distance (km) to Clinic
Central	2.6	0.0	13.9
North	4.5	0.1	26.2
South	5.3	0.0	44.5
West	6.7	0.0	23.2

eThekwini	4.8	0.1	26.9

Table 2 describes the accessibility to TB diagnostic services per planning region and level of urbanization, respectively while the visual representation of these data is found in figure 3. Approximately 92.6% (3 730 494 people) of the population could access a TB diagnostic service within the required travel distance standard of 5km and thus were considered well served. The remaining 7.4% (294 572 people) could access a TB diagnostic services facility beyond 5km (Table 2). The Central, North, and South Regions had ≥98% of the population residing within 5km of a PHC (Figure 3A; Table 2A). These regions also constitute the built-up areas of the district which include the prime corridor, and urban and sub-urban areas are where most of the population resides (Figure 3B). The rural areas which make up the largest geographic area of eThekwini (48.5%) had the smallest number of the district's population (10.7%) (Supplementary file 1). This is also where most of the underserved population resides, which constitutes 4.4% of the total population and 59.5% of the underserved population (Figure 3B; Table 2B).

Table 2 Accessibility of diagnostic services per region and density corridor within eThekwini

A. Accessibility and population data per planning region					
Planning Regions	**Population per planning region (2021)**	**Population ≤ 5km from clinic**	**%Population ≤ 5km from a clinic**	**Population ≥ 5km from a clinic**	**%Population ≥ 5km from a clinic**
Central	1 246 322	1 214 392	30.2	31 930	0.8
North	1 340 765	1 269 623	31.5	71 148	1.8
South	992 601	935 849	23.2	56 752	1.4
West	447 973	310 631	7.6	137 342	3.4
Total	4 027 660	3 730 494	92.6	294 572	7.4
B. Accessibility and population data per level of urbanization					

Level of urbanization	Population density (2021)	Population ≤ 5km from clinic	%Population ≤ 5km from a clinic	Population ≥ 5km from a clinic	%Population ≥ 5km from a clinic
Prime corridor	902 728	889 913	22.10	12 815	1.4
Rural	431 689	255 701	6.3	175 988	40.7
Sub-urban	1 550 235	1 454 265	36.1	95 970	6.1
Urban	1 143 006	1 130 612	28.0	12 394	1.1
Total	4 027 660	3 730 494	92.6	297 165	7.4

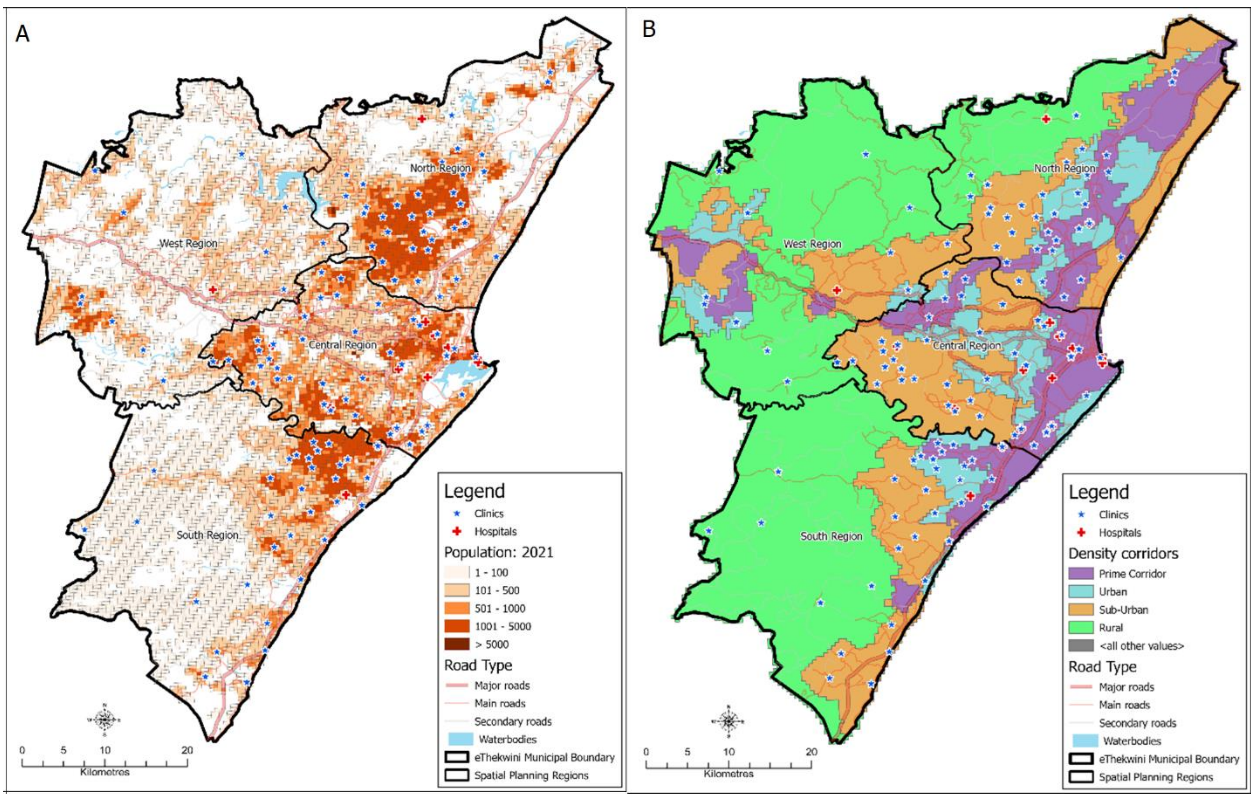

Figure 3 Population distribution and level of urbanization within the eThekwini district in 2021

Distribution of TB cases in eThekwini District

The confirmed TB cases within the eThekwini district in the year 2021 have been depicted in Figure 4. A total of 9,953 TB cases were recorded in 2021. The densely populated central region had the lowest number of TB cases with a total of 1,739. The sparsely populated western region followed closely with 1,976 cases. Conversely, the northern region, which had the highest population density in the district, had the highest number of TB cases totaling 3,398. Despite the north region having a high proportion of TB cases, patients in this area had good access to TB diagnostic services. On the other hand, the central region had a relatively low number of cases and high accessibility to PHCs. The west region had a moderate level of accessibility but also had a relatively low amount of cases. The south region had a moderate level of accessibility and a relatively high number of TB cases, however, these were concentrated in the urban and sub-urban areas and fewer cases were located in the rural areas. Furthermore, Table 1 shows that patients in the south could travel up to 44.5km to reach a facility with diagnostic services.

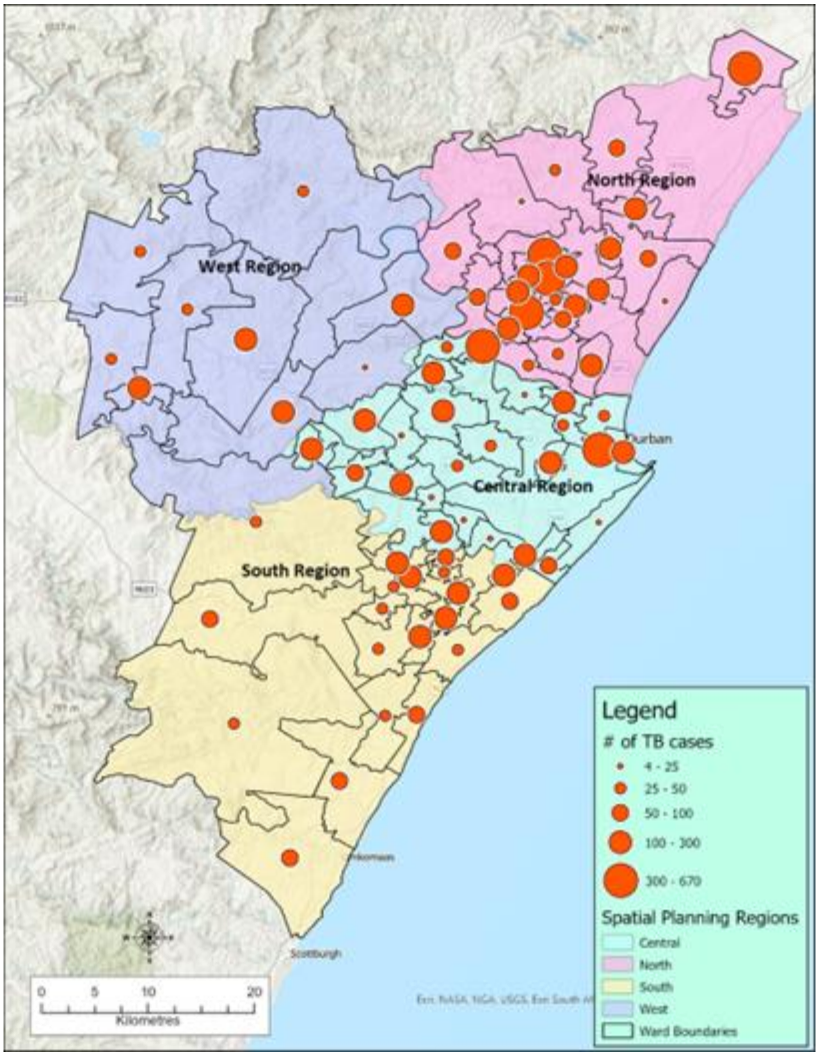

Figure 4 Confirmed TB cases within eThekwini per planning region in 2021

Analysis of distances from PHCs to the nearest hospital

Travel distances from clinics to the nearest hospitals are depicted in Figure 5. The average distance from PHCs to hospitals within eThekwini was 9.6km (SD±7.6km). A total of 121 clinics (98.4%) were within 30km of a hospital. Eighty clinics (65%) were situated within 10km of hospitals, 28 (22.7%) were situated within 10.1-20 km, 12 (9.6%) were located between 20.1-30 km and only two (1.6%) were outside a 30km radius from a local hospital Most hospitals are concentrated in the central region and fewer are found in the three regions of eThekwini.

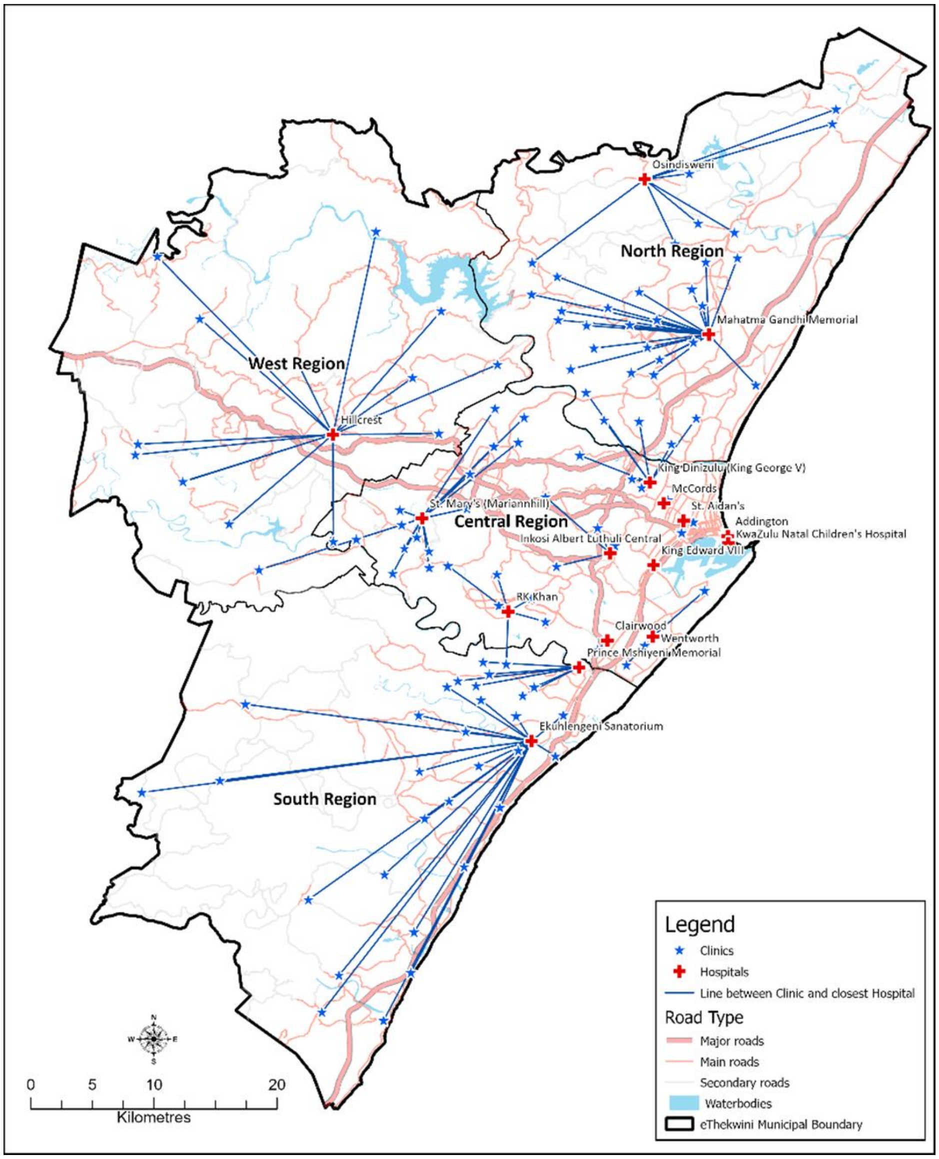

Figure 5 Travel distances between PHCs and hospitals in eThekwini

Discussion

Our research evaluated the accessibility of TB diagnostic services at PHCs in the eThekwini district. The results showed that TB diagnostic services were accessible to a majority (92.6%) of the population. Of the 7.4% of the population that fell outside a 5km radius of a clinic, 59.5% resided in rural areas. On average the population in eThekwini had to travel 4.8km to access diagnostic services. Moreover, the central and north regions were highly accessible while the south and west regions experienced moderate accessibility, respectively. However, patients from all regions could travel distances longer than 5km to reach a diagnostic facility with distances in the south region reaching up to 44.5km. Many of the TB cases were in the densely populated urban and suburban regions and fewer in the sparsely populated rural areas. Our analysis also revealed that 98.4% of clinics were <30km from a hospital at an average distance of 9.6km (SD±7.6km). However, these hospitals are not spatially distributed, with many being in the central region of the eThekwini district.

Geographic accessibility to healthcare services can significantly impact the health outcomes of a population. For TB, limited access to diagnostic facilities can worsen disease progression and increase community transmission. [13] Our findings showed that 92.6% of the eThekwini population had good access to TB diagnostic services, enabling them to reach a facility within 5km. Nevertheless, access remains a challenge in rural areas. Patients from the predominately rural west and south regions had moderate access (5-10km) to TB diagnostic services, however, these patients could travel up 23.2 and 44.5km to reach a PHC, respectively. A Ghanaian study reported similar findings, showing that 81.4% of its population lived within 5km of a PHC, traveling an average of 4.7km to reach these facilities. However, access remained a challenge for rural populations. [26] Authors from Ghana and India have demonstrated that longer travel distances are often associated with higher costs which deters health-seeking behaviors in rural communities. [12 27 28] Consequently, limited accessibility to health services is often accompanied by lower TB case notifications, leading to the underreporting of disease from these areas. [29]

Our study investigated the distribution of TB cases throughout the eThekwini district. The results depicted urban and sub-urban areas having higher TB cases than rural areas. The evidence suggests that higher TB case notification rates in urban areas are due to better health services utilization than in rural regions. [30 31 28] While the lower population density in rural regions may have played a role in the lower number of TB cases observed by our findings, it is important to note that most of the underserved population resides in this region; therefore, the longer distances these patients travel cannot be ignored. MacPherson et al, [32] showed a decrease in TB case notifications in Blantyre, Malawi, as the distance to the nearest clinic grew. These authors further highlighted that low TB cases in areas with risk factors for TB, such as poverty, could reveal an access issue rather than a low TB burden. [32] In South Africa, the poorest live furthest from the closest PHCs. Therefore, patients from these regions are at particular risk for developing TB. Moreover, Mee et al. [33] found that in rural South Africa, distances longer than 5km from health facilities were associated with a higher risk of death for people with TB/HIV co-infection. Therefore, access to diagnostic services should be prioritized in remote areas of eThekwini.

The eThekwini district already has four and five mobile clinics in the predominately rural regions of the south and west, respectively. Based on our findings this is an adequate number of clinics as 3.4% of the underserved population reside in the west and 1.4% reside in the south. However, regarding the distribution of the mobile units, consideration must be given to areas in the south where the population can travel up to 44.5km to reach a facility. Moreover, given the vulnerabilities that rural populations face, it is paramount that TB services are always available at these mobile health units. The COVID-19 pandemic disrupted the provision of these services as many mobile units were repurposed for COVID-19 response. [34]

Our findings also showed that 98.4% of clinics in eThekwini were within the recommended 30km of a district hospital. However, many of the hospitals in the district are concentrated in the central region. The post-apartheid South African government has worked hard to ensure equitable access to healthcare by providing healthcare free of charge and expanding PHCs. [35] [36] The placement of district hospitals in eThekwini reveals the enduring effects of apartheid. Hospitals are mainly situated in areas where privileged individuals reside, while fewer are present in remote regions where the poor still live. This distribution does not reflect the current population needs. Although PHCs play a vital role, district hospitals act as their referral points, which offer more comprehensive services, including but not limited to emergency care. Current studies on access to emergency care primarily focus on obstetrics and maternal health. [37-39] However, it is important to note that patients with tuberculosis, particularly those in remote settings, are also likely to require emergency services. [40] This is because they tend to present later to healthcare clinics when the disease has already progressed to a severe stage, which may require immediate and urgent interventions. Moreover, patients with drug-resistant forms of TB receive their treatment at district hospitals, and TB samples from PHCs are sent to district hospitals for testing so distances could affect turnaround times. Therefore, hospitals within eThekwini should be better distributed.

Based on our findings, we recommend that eThekwini deploy its mobile clinics at rural locations according to the population distribution and the travel distance guidelines provided by the CSIR. Furthermore, the quality of care of mobile health units and PHCs should be continuously assessed and improved because improving geographic access and utilization of services would be futile without ensuring high-quality care. eThekwini has started active case finding for asymptomatic high-risk groups. These should include the vulnerable poorer populations in rural and urban areas where high population density facilitates transmission. This is especially important in light of the COVID-19 pandemic which has not only increased the risk factors for developing TB but also the number of undiagnosed cases. Lastly, where feasible, in remote areas with poor access to health facilities, the government should consider upgrading existing PHCs to hospitals and introducing more clinics. This could assist with increasing emergency care in these regions for all health conditions including TB.

Conclusion

GIS technology is a powerful tool that can reveal healthcare access and thereby inform the development of equitable solutions. In our study, the eThekwini district had high accessibility to TB diagnostic services at PHCs. However, access remains a problem in some remote regions. This also was true for the location of hospitals within the region. The evidence shows higher cases of TB in urban and sub-urban regions compared to rural regions suggesting that there is better utilization in areas with better access. To keep making progress towards the elimination of TB, these access issues will need to be addressed. Active case-finding and mobile clinics can be used in the interim, however, permanent solutions like expanding clinics and district hospitals should also be considered.

Contributors

TD and TM-T conceptualized the study. DM conducted the mapping and analysis. TD under the guidance of EB wrote the first draft. AM and TM-T critically reviewed the manuscript. All authors have read and approved the final manuscript.

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Data availability statement

Data that were analyzed in the study are available from the corresponding author upon reasonable request.

Ethics statements

Patient consent for publication

Not applicable.

This research was reviewed and approved by the University of Pretoria's Faculty of Health Sciences Research Ethics Committee, reference number 652/2021, and the Health Research and Management unit of the KZN Department of Health (Ref No. KZ_202112_012).

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References

1. World Health Organization. Global tuberculosis report Geneva: World Health Organization; 2020 [cited 2023 02-28-2023]. Available from: https://www.who.int/publications/i/item/9789240013131 accessed 02-28-2023 2023.
2. World Health Organization. Global tuberculosis report Geneva2021 [cited 2021 02-28-2023]. Available from: https://www.who.int/teams/global-tuberculosis-programme/tb-reports accessed 02-28-2023 2023.

3. Pillay Y, Pienaar S, Barron P, et al. Impact of COVID-19 on routine primary healthcare services in South Africa. *South African Medical Journal* 2021;111(8):714. doi: 10.7196/samj.2021.v111i8.15786
4. Lönnroth K, Jaramillo E, Williams BG, et al. Drivers of tuberculosis epidemics: The role of risk factors and social determinants. *Social Science & Medicine* 2009;68(12):2240-46. doi: https://doi.org/10.1016/j.socscimed.2009.03.041
5. Togun T, Kampmann B, Stoker NG, et al. Anticipating the impact of the COVID-19 pandemic on TB patients and TB control programmes. *Annals of Clinical Microbiology and Antimicrobials* 2020;19(1) doi: 10.1186/s12941-020-00363-1
6. Alene KA, Wangdi K, Clements ACA. Impact of the COVID-19 Pandemic on Tuberculosis Control: An Overview. *Tropical Medicine and Infectious Disease* 2020;5:123. doi: 10.3390/tropicalmed5030123
7. Karim QA, Karim SSA. COVID-19 affects HIV and tuberculosis care. *Science* 2020;369:366-68. doi: 10.1126/science.abd1072
8. Cilloni L, Fu H, Vesga JF, et al. The potential impact of the COVID-19 pandemic on the tuberculosis epidemic a modelling analysis. *EClinicalMedicine* 2020;28:100603. doi: 10.1016/j.eclinm.2020.100603
9. Hogan AB, Jewell BL, Sherrard-Smith E, et al. Potential impact of the COVID-19 pandemic on HIV, tuberculosis, and malaria in low-income and middle-income countries: a modelling study. *The Lancet Global Health* 2020;8(9):e1132-e41. doi: 10.1016/s2214-109x(20)30288-6
10. Robsky KO, Hughes S, Kityamuwesi A, et al. Is distance associated with tuberculosis treatment outcomes? A retrospective cohort study in Kampala, Uganda. *BMC Infectious Diseases* 2020;20(1) doi: 10.1186/s12879-020-05099-z
11. Tadesse T, Demissie M, Berhane Y, et al. Long distance travelling and financial burdens discourage tuberculosis DOTs treatment initiation and compliance in Ethiopia: a qualitative study. *BMC public health* 2013;13:424-24. doi: 10.1186/1471-2458-13-424
12. Tripathy JP, Srinath S, Naidoo P, et al. Is physical access an impediment to tuberculosis diagnosis and treatment? A study from a rural district in North India. *Public Health Action* 2013;3(3):235-39. doi: 10.5588/pha.13.0044
13. Kapwata T, Morris N, Campbell A, et al. Spatial distribution of extensively drug-resistant tuberculosis (XDR TB) patients in KwaZulu-Natal, South Africa. *PLOS ONE* 2017;12:e0181797. doi: 10.1371/journal.pone.0181797
14. Gwitira I, Karumazondo N, Shekede MD, et al. Spatial patterns of pulmonary tuberculosis (TB) cases in Zimbabwe from 2015 to 2018. *PLOS ONE* 2021;16(4):e0249523. doi: 10.1371/journal.pone.0249523
15. Marjan M, Frank van L, David Henry M, et al. Neighbourhood risk factors of recurrent tuberculosis in Cape Town: a cohort study using geocoded notification data. *Journal of Epidemiology and Community Health* 2023;77(1):56. doi: 10.1136/jech-2022-219622
16. Lim JR, Gandhi NR, Mthiyane T, et al. Incidence and Geographic Distribution of Extensively Drug-Resistant Tuberculosis in KwaZulu-Natal Province, South Africa. *PLOS ONE* 2015;10(7):e0132076. doi: 10.1371/journal.pone.0132076
17. Nelson KN, Shah NS, Mathema B, et al. Spatial Patterns of Extensively Drug-Resistant Tuberculosis Transmission in KwaZulu-Natal, South Africa. *J Infect Dis* 2018;218(12):1964-73. doi: 10.1093/infdis/jiy394 [published Online First: 2018/07/03]
18. Sy KTL, Leavitt SV, De Vos M, et al. Spatial heterogeneity of extensively drug resistant-tuberculosis in Western Cape Province, South Africa. *Scientific Reports* 2022;12(1) doi: 10.1038/s41598-022-14581-4
19. World Health Organization. Global Tuberculosis Report Geneva2022 [Available from: https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2022 accessed 02-28-2023 2023.
20. District Development Model. About EThekwini South Africa2020 [Available from: https://www.durban.gov.za/pages/government/about-ethekwini accessed 02-03-2023 2023.

21. KwaZulu Natal Department of Health. KZN Provincial Health Statistics 2018 [Available from: http://www.kznhealth.gov.za/gis/prov.pdf.
22. Vanleeuw L, Loveday M. Tuberculosis: Health Systems Trust; 2015 [Available from: https://www.hst.org.za/publications/District%20Health%20Barometers/9%20(Section%20A)%20Tuberculosis.pdf.
23. Karim SSA, Churchyard GJ, Karim QA, et al. HIV infection and tuberculosis in South Africa: an urgent need to escalate the public health response. *The Lancet* 2009;374(9693):921-33. doi: 10.1016/s0140-6736(09)60916-8
24. Greene C. Council for Scientific and Industrial Research (CSIR) guidelines for the provision of social facil-ities in South African settlements. Pretoria, 2012.
25. Johnston K. Calculating the distance between locations: Esri; 2021 [cited 2023 06-19-2023]. Available from: https://www.esri.com/arcgis-blog/products/spatial-analyst/analytics/calculating-the-distance-between-locations/#:~:text=The%20shortest%20physical%20distance%20for,is%20flying%20above%20the%20surface. accessed 06-19-2023 2023.
26. Ashiagbor G, Ofori-Asenso R, Forkuo EK, et al. Measures of geographic accessibility to health care in the Ashanti Region of Ghana. *Scientific African* 2020;9:e00453. doi: https://doi.org/10.1016/j.sciaf.2020.e00453
27. Buor D. Analysing the primacy of distance in the utilization of health services in the Ahafo-Ano South district, Ghana. *Int J Health Plann Manage* 2003;18(4):293-311. doi: 10.1002/hpm.729
28. McLaren Z, Ardington C, Leibbrandt M. Distance as a barrier to health care access in South Africa. Cape Town: Southern Africa Labour and Development Research Unit, 2013.
29. Hierink F, Okiro EA, Flahault A, et al. The winding road to health: A systematic scoping review on the effect of geographical accessibility to health care on infectious diseases in low- and middle-income countries. *PLOS ONE* 2021;16(1):e0244921. doi: 10.1371/journal.pone.0244921
30. Dangisso MH, Datiko DG, Lindtjørn B. Accessibility to tuberculosis control services and tuberculosis programme performance in southern Ethiopia. *Global Health Action* 2015;8(1):29443. doi: 10.3402/gha.v8.29443
31. Areru HA, Dangisso MH, Lindtjørn B. Large local variations in the use of health services in rural southern Ethiopia: An ecological study. *PLOS Global Public Health* 2022;2(5):e0000087. doi: 10.1371/journal.pgph.0000087
32. Macpherson P, Khundi M, Nliwasa M, et al. Disparities in access to diagnosis and care in Blantyre, Malawi, identified through enhanced tuberculosis surveillance and spatial analysis. *BMC Medicine* 2019;17(1) doi: 10.1186/s12916-019-1260-6
33. Mee P, Collinson MA, Madhavan S, et al. Determinants of the risk of dying of HIV/AIDS in a rural South African community over the period of the decentralised roll-out of antiretroviral therapy: a longitudinal study. *Global Health Action* 2014;7(1):24826. doi: 10.3402/gha.v7.24826
34. National Department of Health. The National Strategic Plan for HIV, TB, and STIs 2023-2028 South Africa: National Department of Health; 2023 [cited 2023 08-22-2023]. Available from: https://knowledgehub.health.gov.za/elibrary/national-strategic-plan-hiv-tb-and-stis-2023-2028 accessed 08-22-2023 2023.
35. Harris B, Goudge J, Ataguba JE, et al. Inequities in access to health care in South Africa. *J Public Health Policy* 2011;32 Suppl 1:S102-23. doi: 10.1057/jphp.2011.35
36. Gilson L, McIntyre D. Post-apartheid challenges: household access and use of health care in South Africa. *Int J Health Serv* 2007;37(4):673-91. doi: 10.2190/HS.37.4.f
37. Ouma PO, Maina J, Thuranira PN, et al. Access to emergency hospital care provided by the public sector in sub-Saharan Africa in 2015: a geocoded inventory and spatial analysis. *The Lancet Global Health* 2018;6(3):e342-e50. doi: 10.1016/s2214-109x(17)30488-6
38. Geduld H, Hynes EJC, Wallis LA, et al. Hospital proximity does not guarantee access to emergency care. *The Lancet Global Health* 2018;6(7):e731. doi: 10.1016/s2214-109x(18)30235-3

39. Schmitz MM, Serbanescu F, Kamara V, et al. Did Saving Mothers, Giving Life Expand Timely Access to Lifesaving Care in Uganda? A Spatial District-Level Analysis of Travel Time to Emergency Obstetric and Newborn Care. *Global Health: Science and Practice* 2019;7(Supplement 1):S151-S67. doi: 10.9745/ghsp-d-18-00366
40. Sikalengo G, Hella J, Mhimbira F, et al. Distinct clinical characteristics and helminth co-infections in adult tuberculosis patients from urban compared to rural Tanzania. *Infectious Diseases of Poverty* 2018;7(1) doi: 10.1186/s40249-018-0404-9

Abbreviations

CSIR:	Council for Scientific and Industrial Research
DHIS:	District of Health Information System
KZN:	KwaZulu Natal
NHLS:	National Health Laboratory services
PHCs:	Primary Healthcare Clinics
TB:	Tuberculosis
WHO:	World Health Organization
XDR	Extensively drug resistant Tuberculosis.

Chapter 5 Manuscript addressing Objective 2

The results from Chapter 4 revealed that TB diagnostic services were highly accessible with the exceptions of a few remote regions. Once geographic accessibility had been established, the impact of the COVID-19 pandemic on TB diagnostic services was evaluated.

Chapter 5 presents the results of the analysis that assessed the impact of COVID-19 on TB diagnostic services during the pandemic. The chapter has been presented as an article with the title: "*Impact of COVID-19 on TB diagnostic services at primary healthcare clinics in eThekwini district, South Africa"* which was published by the journal *Scientific Reports*. Link: Impact of COVID-19 on TB diagnostic services at primary healthcare clinics in eThekwini district, South Africa | Scientific Reports (nature.com)

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Impact of COVID-19 on TB diagnostic services at primary healthcare clinics in eThekwini district, South Africa

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We assessed the impact of the pandemic on TB diagnostics at primary healthcare clinics (PHCs) during the different stages of COVID-19 in eThekwini district, South Africa. Data from the District Health Information System (DHIS) were used to conduct an interrupted time series analysis that assessed the changes in TB investigations and confirmed TB cases during four pandemic periods: lockdown and the subsequent three peaks of infection compared to the two years prior (2018–2022). The initial lockdown resulted in − 45% (95% CI − 55 to − 31) and − 40% (95% CI − 59 to − 28) immediate declines in TB investigations and confirmed cases, respectively. Both indicators showed substantial recovery in the months after the first wave ($p < 0.05$). However, while TB investigations sustained smaller declines throughout the pandemic, they rebounded and surpassed pre-COVID-19 levels by the end of the investigation period. On the other hand, confirmed cases experienced reductions that persisted until the end of the investigation period. TB diagnostic services at PHCs were considerably disrupted by COVID-19, with the confirmation of cases being the most adversely affected throughout the pandemic. The reasons for these persistent declines in TB detection must be determined to inform the development of sustainable diagnostic systems that are capable of withstanding future pandemics.

Abbreviations

DHIS	District of health information system
ITS	Interrupted time series
KZN	KwaZulu-Natal
PHCs	Primary healthcare clinics
SSA	Sub-Saharan Africa
TB	Tuberculosis

The outbreak of SARS-CoV-2 brought the world to a standstill in early 2020 due to a lack of effective pharmaceutical interventions which prompted world leaders to implement non-pharmaceutical measures to manage transmission[1]. These actions profoundly impacted the utilization and provision of healthcare services around the globe[2–7]. In addition to population-wide lockdowns, countries repurposed many of their health facilities and human resources to tackle COVID-19[8–10]. This has had a devastating impact on managing other diseases of importance, particularly Tuberculosis (TB) which was disproportionately affected[11].

TB prevention and care were severely impacted by the wake of the COVID-19 pandemic[3,12]. This comes after achieving significant milestones in reducing the global burden[12]. The TB area most affected by the pandemic was detection, specifically the number of newly diagnosed cases which fell by 18% in 2020 and have only slightly recovered in the year 2021[12]. Though, not ideal these outcomes are not surprising since many diagnostic platforms were repurposed for COVID-19[13], testing facilities shut down[14,15], and given the similarities in the clinical presentations of COVID-19 and TB[16], fear and stigma prevented patients from seeking care[3]. All these resulted in patients presenting later to health facilities thus reducing TB testing in 2020[17]. Consequently, this reduction in TB detection particularly in high-burden countries has increased TB incidence by 3.6% between 2020 and 2021[12].

South Africa, faces a dual burden of TB and HIV with an estimated 60% of new cases coming from those living with HIV[18]. Given the deadly nature of opportunistic TB infection among people living with HIV, a reduction

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in TB detection will have dire consequences for the country. Nevertheless, South African TB diagnostic services suffered a similar fate to the rest of the world as a consequence of COVID-19[13,19,20]. During the first lockdown, TB tests conducted using the Xpert MTB/RIF Ultra assay, the primary diagnostic tool in South Africa, decreased by 33%[21]. Between January 2020 and February 2021 the number of people screened for TB and positive TB tests decreased by 19.2% and 18%, respectively, compared to pre-pandemic years[19]. A study from the Limpopo province recorded a 33% reduction in the number of positive TB tests during the initial lockdown[20]. Therefore, finding the missed TB cases and rebuilding stronger TB diagnostic services should be a top priority for the country.

Much of the published literature on TB detection in South Africa is from the start of the pandemic[13,19,22]. Little is known about the state of TB detection in the country's high-burden settings, particularly, during the different waves of COVID-19 infection. Therefore, this study aimed to estimate the impact of COVID-19 on TB detection at different stages of the pandemic (March 2020–June 2022) compared to two pre-pandemic years (2018–2019) using TB investigations and confirmation of TB cases as indicators. This was done using data from Primary Healthcare Clinics (PHCs) in eThekwini a high TB burden region in South Africa. To our knowledge, a study of this nature has not been conducted in South Africa and the findings can be used to implement targeted interventions for building stronger health systems.

Methods

This study was conducted as part of a larger research project assessing the effects of COVID-19 on TB diagnostics services at PHCs with the aim of optimizing these services for health crises such as COVID-19[23].

Study setting

The study was conducted in the eThekwini district of the KwaZulu-Natal (KZN) province. The district boasts a population of approximately 3.9 million people making it the most populated region in KZN[24]. TB and HIV account for the highest number of deaths by communicable infection within eThekwini, especially among men[24]. Healthcare is provided through a mixture of PHCs, regional hospitals, and one provincial and central hospital[24]. However, TB diagnosis is mainly achieved through passive case finding at PHCs[24,25]. eThekwini has been the epicenter of the COVID-19 pandemic within the province and has recorded 358 222 active cases and 5 707 deaths as of 1 February 2023, respectively[26].

In South Africa, the first case of COVID-19 was diagnosed on the 5th of March 2020[27]. By the 15th of March 2020, the government declared a national state of disaster in response to the COVID-19 pandemic[28]. With the increasing number of cases, the first lockdown was implemented at midnight on the 26th of March 2020[19]. The peak of infection for the first wave of COVID-19 was reached in July 2020, and the peaks for the second, third, and fourth waves were reached in January 2021, July 2021, and December 2021, respectively[29]. Following the decrease in COVID-19 cases and the increase in population immunity, the South African government terminated the national state of disaster on 5 April 2022[28].

Data sources

South Africa collects and records routine data from primary healthcare facilities in the District of Health Information System (DHIS)[30]. Aggregated monthly data on TB investigations and confirmed TB cases from PHCs in eThekwini were extracted from the DHIS. TB investigations entail all inquiries into TB symptoms while the confirmation of TB represents a positive diagnosis following a TB investigation (new cases and relapses). Clinics with missing data points were excluded from the analysis.

Outcomes

The outcomes of interest were expressed as the total number of TB investigations and the confirmed number of TB cases at PHCs, taken in monthly intervals. After excluding clinics with incomplete data sets and those with outlier values, 94 and 76 facilities were used to analyze TB investigations and confirmation of TB, respectively. The predictions of the outcome variables will be represented by a line graph against a scatterplot of the actual values over time.

Study design

A single group interrupted time series (ITS) analysis was conducted[31] using the STATA statistical software version 15.1. The analysis determined whether the exposure (COVID-19) had an immediate or long-term impact on TB investigations and confirmations of TB at PHCs. A times series is the strongest quasi-experimental design that assesses time-delimited exposures such as COVID-19 on selected outcomes[32]. As such, multiple exposure periods throughout the pandemic were investigated which corresponded to different surges of COVID-19 infection in South Africa. Exposure period 1—April 2020, the first month of the level five lockdown; Exposure period 2—July 2020, the peak of the second wave of infection; Exposure period 3—January 2021, the peak of the third wave of infection; Exposure period 4—July 2021, the peak of the second wave of infection; Exposure period 5—December 2021, the peak of the third wave of infection. The outcomes were compared to the two years before the pandemic started (January 2018- February 2020).

Statistical analysis

The statistical analysis was conducted in Stata version 15[33]. The analysis assumped that a linear relationship existed between time and the respective outcome variables within each segment. Specifically, a least squares regression line was fitted to each segment of the time variable[32]. The model was able to determine the impact of the respective exposures on both outcomes, immediately and over time. The model used terms to investigate the following variables: a constant representing the respective outcome level at the baseline, before COVID-19, and terms describing the immediate changes to outcome levels following a respective COVID-19 exposure as well as the changes in monthly trend after the exposure. The percent change for both indicators immediately after a respective exposure was also reported. The analysis used follows an Ordinary Least Squares (OLS) regression model which assumes that the error terms at respective observations are uncorrelated. Thus, to fit a model that accounts for autocorrelation the Cumby–Huizinga general test[34] was used to assess autocorrelation. The test plotted up to lag order = 12 to assess autocorrelation and seasonality. Newey-west standard errors accounted for autocorrelation. The detailed regression model used for this study is outlined in Supplementary File 1.

Ethics declaration

The study was conducted according to the Helsinki Declaration and the South African POPIA Act[35]. Before the commencement of the analyses, ethical approval was sought and granted by the University of Pretoria's Faculty of Health Sciences Research Ethics Committee (reference number: 652/2021) and from the Health Research and Management Unit of the KZN Department of Health (NHRD Ref: KZ_202112_012). No human participants were involved in this study, therefore, the need for informed consent was waived by the University of Pretoria's Faculty of Health Sciences Research Ethics Committee.

Results

Characteristics of healthcare facilities

A total of 94 healthcare facilities were included in the analyses of TB investigations and 74 for TB confirmations, respectively (Table 1). These facilities comprised primary healthcare clinics (87% and 86%), community health centers (9%), gateway (3% and 4%), and a polyclinic (1%) for investigations and confirmations, respectively. An average of 9965 TB investigations were conducted from health facilities and 754 cases were confirmed as TB every month.

The onset of the pandemic resulted in TB investigations and confirmations being reduced by approximately half (Table 2). TB investigations increased with each subsequent wave reaching pre-pandemic levels by the fourth wave, however, confirmation of cases did not rebound in this manner. The segmented linear regression analysis was used to test the statistical significance of the immediate and long-term effects of the pandemic (lockdown and subsequent waves) on TB investigations and TB confirmations (Figs. 1 and 2). COVID-19 significantly impacted both TB indicators, although, the impact was heterogeneous across the different stages of the pandemic.

TB investigations

Before the COVID-19 pandemic, TB investigations at PHCs were increasing slightly by approximately 23 tests per month from a baseline of 8 860 (95% CI 7998 to 9722) (Fig. 1; Table 3). After the emergence of COVID-19 and the implementation of the level 5 lockdown, the number of investigations declined by 4 165 (95% CI − 5669 to − 2660) which represented a − 45% (95% CI − 55 to − 31) decline relative to the counterfactual. The trends in monthly tests following the lockdown did not differ substantially from those experienced before the pandemic.

	TB investigations			TB confirmations		
Facility type	No. present	%	Mean monthly Investigations	No. present	%	Mean monthly confirmations
Community health centers	7	9	1520 ± 128.5	7	9	201 ± 18.6
Gateway clinics	3	3	337 ± 74.2	3	4	40 ± 7.8
Polyclinics	1	1	284 ± 0.0	1	1	52 ± 0.0
Primary healthcare clinics	83	87	7824 ± 91.2	65	86	463 ± 6.2
Total	94	100	9965	76	100	754

Table 1. Characteristics of the included primary healthcare facilities.

	Period	Number of TB investigations	Number of TB confirmations
Before COVID-19; monthly mean	Jan–Dec 2018	8950	790
	Jan–Dec 2019	9080	835
	Jan–Mar 2020	10,251	840
During COVID-19; actual monthly value	Lockdown Apr 2020	5521	496
	1st wave Jul 2020	6507	483
	2nd wave Jan 2021	8766	625
	3rd wave Jul 2021	10,406	561
	4th wave Dec 2021	9973	636

Table 2. Monthly changes in TB investigations and confirmations at PHCs, before COVID-19 and at different stages of the pandemic.

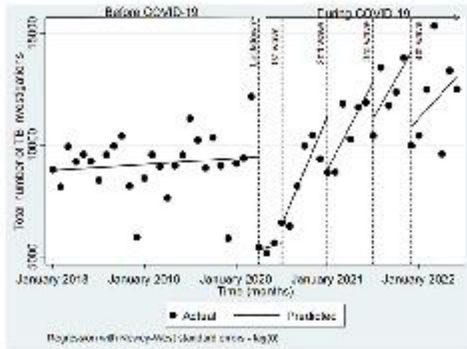

Figure 1. Impact of COVID-19 on TB investigations at PHCs in the eThekwini district, South Africa (January 2018–June 2022). Dashed vertical lines represent the April lockdown and the peaks of the four waves of COVID-19. No autocorrelation was present in the dataset.

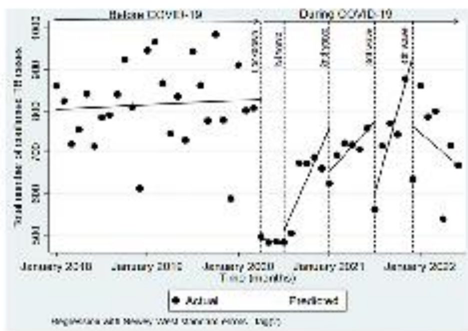

Figure 2. Impact of COVID-19 on TB confirmations at PHCs in the eThekwini district, South Africa (January 2018–June 2022). Dashed vertical lines represent the April lockdown and the peaks of the four waves of COVID-19. Autocorrelation up to lag 2 was adjusted for using Newey-West standard errors.

During the peak of the first wave in July 2020, TB investigations showed a relative increase of 16% (95% CI − 4 to 34) (n = 852; 95% CI − 196 to 1899) compared to the lockdown period. However, the trends in investigations after the first wave increased significantly month-to-month by 712 (95% CI 235 to 1189) compared to the period prior $p = 0.04$.

After five months of marked increases the peak of the second wave, in January of 2021, brought immediate declines to TB investigations of − 23% (95% CI − 32 to − 2) (n = − 156; 95% CI − 643 to 332). The declines persisted month-to-month after the peak though not significantly ($p > 0.05$).

By the third peak of the third wave which was driven by the emergence of the delta variant, the level and subsequent monthly trends of TB investigations continued to decline but in a non-significant manner compared to the 2nd wave.

When the fourth wave peaked, in December 2021 the level of TB investigations dropped by -33% (95% CI 51 to 15) (n = − 3326; 95% CI: − 5435 to − 1218) compared to the 3rd wave. The monthly trends after the peak showed negligible decreases, however, the graphical representation shows that overall, more TB investigations were being conducted in this period than in the time before the COVID-19 pandemic (Fig. 1).

TB confirmations

The monthly trend in the confirmation of cases remained stable before COVID-19, showing little deviation from the baseline amount of 803 (Fig. 2; Table 3). The inception of the pandemic resulted in TB confirmations dropping significantly by − 334 (95% CI − 398 to − 271) in the month of the lockdown which corresponded to − 40% (95% CI 59 to − 28) decline compared with the counterfactual. The significant declines continued month-to-month by approximately 7 cases (95% CI − 11 to − 2) after the lockdown (Fig. 2; Table 3).

	TB investigations	TB confirmations
Before COVID-19		
Starting level intercept	8860	803
Slope before intervention (95% CI)	23 (– 55 to 100)	1 (CI – 3 to 5)
p-value	0.56	0.617
Lockdown April 2020		
Change in the month of exposure (95% CI)	– 4165 (– 5669 to – 2 660)	– 334 (– 398 to – 271)
Percent change (95% CI)	– 45% (– 55 to – 31)	– 40% (– 59 to – 28)
Average monthly change (95% CI)	74 (– 133 to 280)	– 7 (95% CI – 12 to – 2)
p-value	0.48	0.006
1st wave July 2020		
Change in the month of exposure	852 (– 196 to 1899)	35 (– 33 to 104)
Percent change (95% CI)	16 (– 4 to 34)	7 (– 10 to 15)
Average monthly change (95%CI)	712 (234 to 1189)	47 (27 to 68)
p-value	0.004	≤0.0001
2nd wave Jan 2021		
Change in the month of exposure (95% CI)	– 2385 (– 4701 to – 70)	– 104 (– 183 to – 25)
Percent change (95% CI)	– 23 (– 32 to – 1)	– 12 (– 20 to – 3)
Average monthly change (95% CI)	– 156 (– 643 to 332)	21 (– 48 to 5)
p-value	0.523	0.118
3rd wave July 2021		
Change in the month of exposure (95% CI)	– 1627 (– 3647 to 392)	– 173 (– 222 to – 124)
Percent change (95% CI)	– 22 (– 63 to 4)	– 29 (– 52 to – 6)
Average monthly change (95% CI)	– 63 (– 669 to 543)	46 (23 to 68)
p-value	0.84	≤0.0001
4th wave December 2021		
Change in the month of exposure (95% CI)	– 3326 (– 5435 to – 1218)	– 169 (– 293 to – 46)
Percent change (95% CI)	– 33 (– 51 to – 15)	– 26 (– 92 to – 4)
Average monthly change	– 215 (– 897 to 467)	– 82 (– 117 to – 47)
p-value	0.528	≤0.001

Table 3. Statistical changes in TB diagnostic indicators during different phases of COVID-19 (April 2020 Lockdown–January 2021). The table shows the estimates for the absolute changes in the month of the exposure and the monthly trends thereafter for TB investigations and confirmation of cases during the pre-pandemic period, the lockdown, and the subsequent four waves of infection that followed.

At the peak of the 1st wave, the level of TB confirmations rose slightly by 7% (95% CI − 10 to 15) (n = 35; 95% CI − 33 to 104) relative to the lockdown period. In contrast, the monthly trends following the first wave resulted in statistically significant increases of approximately 47 (95% CI − 33 to 104) compared to the previous period ($p \leq 0.0001$).

During the peak of the second wave, the level of TB confirmations experienced a drop of approximately − 12% (95% CI − 20 to − 3) (n = − 104; 95% CI − 183 to − 25). The declines persisted through the months that followed though not significantly.

When the third wave peaked, confirmed cases of TB dropped instantaneously by approximately − 29% (95% CI − 52 to − 6) (n = − 173; 95% CI − 222 to − 124). However, they rose again by an average of 46 (95% CI 23 to 68) monthly cases after the peak compared to the previous wave.

At the peak of the fourth wave, TB confirmations reduced once more by − 26% (95% CI − 92 to − 4) (n = − 169; 95% CI − 293 to − 46) compared to the prior period. The significant declines continued in the months after the peak reducing to monthly estimates lower than those observed before the pandemic (Fig. 2).

Discussion

The regression analysis showed that TB investigation and confirmations of cases at PHCs in eThekwini were greatly affected by COVID-19 but to varying degrees. The largest declines for both indicators occurred during the level-five lockdown period. Conversely, the 1st peak of infection and the months that followed were marked by substantial increases in the monthly trends for both indicators. The following waves of infection had heterogenous effects on the indicators though generally marked by substantial declines at the peaks. Lastly, the confirmation of diagnosis was more severely impacted by the pandemic recording decreases that persisted until the end of the observation period.

Our results reported drastic declines of 40% and 45% for both TB detection indicators at the beginning of the pandemic. These were similar to the reduction that was reported in Uganda (43%)[36] and slightly lower than the reductions experienced by Malawi (39.5%)[10], Nigeria (34%)[5], Brazil (26.4%)[37] and Zambia (22%)[7]. The reasons for the declines were similar, namely, mitigation measures placed restrictions on non-essential travel, and fear of contracting the virus was also heightened during this period which limited the use of health facilities. In China and certain SSA countries the TB case notifications began to rebound in the months to follow[5,7–10], Malawi and Zambia even recording pre-pandemic numbers by December of 2020 and September 2021, respectively[7,10]. These increases were either a result of efforts by respective governments to scale up TB response activities or the relaxing of COVID-19 related restrictions. Similarly, our study also found that both TB indicators began to rebound substantially after the level five lockdown was lifted even returning to pre-pandemic levels by September 2020 when the country moved to level 1 lockdown. This demonstrates the importance of maintaining ease of access to healthcare services during a health crisis and the need for corrective strategies in areas where access was compromised.

Though there has been extensive documentation of the pandemic's effects on TB detection[5–10,20]. These studies are limited to the lockdown period and very few studies have considered the longitudinal impact of the pandemic on important TB service indicators[7,20]. As such, many studies have drawn premature conclusions based on the information available at the time. For instance, a South African study showing the rapid improvement in TB testing after the initial lockdown hypothesized that the quick recovery would not negatively impact TB incidence in the future[22]. Similarly, the World Health Organization has reported that TB case detection in South Africa during 2020 and 2021 was similar to pre-pandemic levels[12]. However, our study reveals that in eThekwini diagnostic services, particularly the confirmation of cases encountered significant declines throughout most of the pandemic suggesting that specific regions within the country were disproportionately affected. We expected confirmation of cases to mirror the pattern of TB investigations given their association with each other. This unexpected reduction in confirmed diagnoses may be due to underreporting or underdiagnosis. Either possibility would have negative implications for disease surveillance and transmission, respectively.

Studies are required to understand what caused the continued reduction of TB detection at PHCs during COVID-19 in eThekwini. Since the effect of undetected TB on mortality is more severe and noticeable in the short term[12], this metric should be monitored to determine whether a true reduction in diagnosed TB took place instead of an increase in underreporting. Given that reduction in diagnoses was more exacerbated during peaks in COVID-19, TB testing capacity at central laboratories may have been compromised at this time because Gene Xpert MTB/RIF machines were repurposed for COVID-19[13]. Likewise, staff and resources at PHCs may have been overstretched at the time of COVID-19 surges leading to underreporting at facility level. Both these hypotheses would need to be confirmed with qualitative studies at both PHCs and laboratories. Health systems should be capable of providing quality care and positive health outcomes despite ongoing health crises[28]. Failure to learn from the pandemic and produce resilient health systems in addition to identifying the cases that may have been missed during the pandemic will have dire consequences for TB management in South Africa.

The study was not without limitations, firstly the data used was from the DHIS and therefore subject to human error during the manual capturing. It is also possible that errors and missing data may have been amplified by the stresses brought on by the pandemic. To help mitigate data inaccuracies, clinics with missing data and outliers were excluded from the analyses. Another limitation was the use of a single-group ITS analysis which by design lacks a control group and assumes that any existing confounders are changing relatively slowly over time such that they would not interfere with the analysis. Including a comparable control group was not possible because COVID-19 impacted the entire country. However, it is unlikely that factors other than the pandemic caused the observed effects on the outcomes given the abrupt and drastic changes that occurred simultaneously with the various stages of COVID-19. Furthermore, the study only investigated the impact of COVID-19 on TB diagnosis and did not consider the development of drug resistance or TB outcomes which were also affected by the pandemic.

Some strengths of this study were the use of a time series analysis, which is the best quasi-experimental design for estimating the effects of an exposure on an outcome when randomization is not possible[32]. Secondly, using multiple exposure periods provides a robust illustration of the impact of COVID-19 on TB detection.

By assessing the patterns of TB diagnostic services at PHCs before and throughout COVID-19 we were able to determine the longitudinal impact of the pandemic on these services. Both TB investigations and confirmed cases of TB were negatively impacted by the level five lockdown, however, confirmed TB remained on the decline despite investigations rebounding as the pandemic continued. The causes for the reductions remain unclear and need to be investigated to strengthen diagnostics at PHCs both currently and for future pandemics.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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References

1. Anderson, R. M., Heesterbeek, H., Klinkenberg, D. & Hollingsworth, T. D. How will country-based mitigation measures influence the course of the COVID-19 epidemic?. *Lancet* 395, 931–934. https://doi.org/10.1016/s0140-6736(20)30567-5 (2020).
2. Xiao, H. *et al.* The impact of the COVID-19 pandemic on health services utilization in China: Time-series analyses for 2016–2020. *Lancet Reg. Health Western Pac.* 9, 100122. https://doi.org/10.1016/j.lanwpc.2021.100122 (2021).
3. Dlangalala, T. *et al.* Evidence of TB services at primary healthcare level during COVID-19: A scoping review. *Diagnostics* 11, 2221. https://doi.org/10.3390/diagnostics11122221 (2021).
4. Siedner, M. J. *et al.* Access to primary healthcare during lockdown measures for COVID-19 in rural South Africa: A longitudinal cohort study. *MedRxiv* https://doi.org/10.1101/2020.05.15.20103226 (2020).

5. Adewole, O. O. Impact of COVID-19 on TB care: Experiences of a treatment centre in Nigeria. *Int. J. Tuberc. Lung. Dis.* **24**, 981–982. https://doi.org/10.5588/ijtld.20.0418 (2020).
6. Rai, D. K., Kumar, R. & Pandey, S. K. Problems faced by tuberculosis patients during COVID-19 pandemic: Urgent need to intervene. *Indian J. Tuberc.* **67**, S173–S174. https://doi.org/10.1016/j.ijtb.2020.07.013 (2020).
7. Lungu, P. *et al.* Interrupted time-series analysis of active case-finding for tuberculosis during the COVID-19 pandemic, Zambia. *Bull. World Health Org.* **100**, 205–215. https://doi.org/10.2471/blt.21.286109 (2022).
8. Fatima, R., Akhtar, N., Yaqoob, A., Harries, A. D. & Khan, M. S. Building better tuberculosis control systems in a post-COVID world: Learning from Pakistan during the COVID-19 pandemic. *Int. J. Infect. Dis.* https://doi.org/10.1016/j.ijid.2021.03.026 (2021).
9. Chen, H. & Zhang, K. Insight into impact of COVID-19 epidemic on tuberculosis burden in China. *Eur. Respir. J.* **56**, 2002710. https://doi.org/10.1183/13993003.02710-2020 (2020).
10. Soko, R. N. *et al.* Effects of coronavirus disease pandemic on tuberculosis notifications, Malawi. *Emerg. Infect. Dis.* https://doi.org/10.3201/EID2707.210557 (2021).
11. World Health Organization. *Global Tuberculosis Report*. https://www.who.int/teams/global-tuberculosis-programme/tb-reports (2021).
12. World Health Organization. *Global Tuberculosis Report*. https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2022 (2022).
13. Karim, Q. A. & Karim, S. S. A. COVID-19 affects HIV and tuberculosis care. *Science* **369**, 366–368. https://doi.org/10.1126/science.abd1072 (2020).
14. Burzynski, J. J., Macaraig, M., Nilsen, D. & Schluger, N. W. Transforming essential services for tuberculosis during the COVID-19 pandemic: Lessons from New York City. *Int. J. Tuberc. Lung Dis.* **24**, 735–736 (2020).
15. Apolisi, I. *et al.* Supporting families with tuberculosis during COVID-19 in Khayelithsa, South Africa. *Lancet Respir. Med.* **10**, 542–543. https://doi.org/10.1016/s2213-2600(22)00121-7 (2022).
16. Alene, K. A., Wangdi, K. & Clements, A. C. A. Impact of the COVID-19 pandemic on tuberculosis control: An overview. *Trop. Med. Infect. Dis.* **5**, 123. https://doi.org/10.3390/tropicalmed5030123 (2020).
17. Aznar, M. L. *et al.* Impact of the COVID-19 pandemic on tuberculosis management in Spain. *Int. J. Infect. Dis.* **108**, 300–305. https://doi.org/10.1016/j.ijid.2021.04.075 (2021).
18. UNAIDS. *90–90–90 Treatment for ALL GENEVA: UNAIDS*, https://www.unaids.org/en/resources/909090 (2020).
19. Pillay, Y., Pienaar, S., Barron, P. & Zondi, T. Impact of COVID-19 on routine primary healthcare services in South Africa. *S. Afr. Med. J.* **111**, 714. https://doi.org/10.7196/samj.2021.v111i8.15786 (2021).
20. Mutyambizi, C. *et al.* Effect of COVID-19 on HIV, tuberculosis, and prevention of mother-to-child transmission of HIV indicators in Mopani district, South Africa. *S. Afr. Med. J.* **111**, 1181. https://doi.org/10.7196/samj.2021.v111i12.15822 (2021).
21. National Institute for Communicable Diseases. *Impact of COVID-19 Intervention on TB Testing in South Africa*. https://www.nicd.ac.za/wp-content/uploads/2020/05/Impact-of-Covid-19-interventions-on-TB-testing-in-South-Africa-10-May-2020.pdf (2020).
22. Abdool Karim, Q. & Baxter, C. COVID-19: Impact on the HIV and tuberculosis response, service delivery, and research in South Africa. *Curr. HIV/AIDS Rep.* **19**, 46–53. https://doi.org/10.1007/s11904-021-00588-5 (2022).
23. Dlangalala, T., Musekiwa, A. & Mashamba-Thompson, T. Towards development of a novel approach for enhancement of TB diagnostic services during the pandemic: A case of primary health care clinics in eThekwini district KwaZulu-Natal: A study protocol. *PLOS ONE* **17**, e0278305. https://doi.org/10.1371/journal.pone.0278305 (2022).
24. District Development Model. *About EThekwini*. https://www.durban.gov.za/pages/government/about-ethekwini (2020).
25. Osman, M. *et al.* Health system determinants of tuberculosis mortality in South Africa: A causal loop model. *BMC Health Serv. Res.* https://doi.org/10.1186/s12913-021-06398-0 (2021).
26. KwaZulu-Natal Department of Health. *COVID-19*. http://www.kznhealth.gov.za/coronavirus.htm (2023).
27. National Institute for Communicable Diseases. *First Case of COVID-19 Coronavirus Reported in SA | NICD*. https://www.nicd.ac.za/first-case-of-covid-19-coronavirus-reported-in-sa/ (2020).
28. Nicholson, G. *Daily Maverick* (South Africa, 2022).
29. Worldometer. *Total Coronavirus Cases in South Africa*. https://www.worldometers.info/coronavirus/country/south-africa/ (2022).
30. Shaw, V. Health information system reform in South Africa: Developing an essential data set. *Bull. World Health Organ.* **83**, 632–636 (2005).
31. Linden, A. Conducting interrupted time-series analysis for single- and multiple-group comparisons. *Stata J.* **15**, 480–500. https://doi.org/10.1177/1536867x1501500208 (2015).
32. Wagner, A. K., Soumerai, S. B., Zhang, F. & Ross-Degnan, D. Segmented regression analysis of interrupted time series studies in medication use research. *J. Clin. Pharm. Ther.* **27**, 299–309. https://doi.org/10.1046/j.1365-2710.2002.00430.x (2002).
33. StataCorp. *Stata Statistical Software: Release 15*. (StataCorp LLC, 2017).
34. Cumby, R. E. & Huizinga, J. Testing the autocorrelation structure of disturbances in ordinary least squares and instrumental variables regressions. *Econometrica* **60**, 185. https://doi.org/10.2307/2951684 (1992).
35. Adams, R. *et al.* POPIA Code of Conduct for Research. *S. Afr. J Sci.* **117**(5/6), 10933. https://doi.org/10.17159/sajs.2021/10933 (2021).
36. Kadota, J. L. *et al.* Impact of shelter-in-place on TB case notifications and mortality during the COVID-19 pandemic. *Int. J. Tuberc. Lung Dis.* **24**, 1212–1214. https://doi.org/10.5588/ijtld.20.0626 (2020).
37. de Souza, C. D. F., Coutinho, H. S., Costa, M. M., Magalhães, M. & Carmo, R. F. Impact of COVID-19 on TB diagnosis in Northeastern Brazil. *Int. J. Tuberc. Lung Dis.* **24**, 1220–1222. https://doi.org/10.5588/ijtld.20.0661 (2020).
38. Kruk, M. E., Myers, M., Varpilah, S. T. & Dahn, B. T. What is a resilient health system? Lessons from Ebola. *Lancet* **385**, 1910–1912. https://doi.org/10.1016/s0140-6736(15)60755-3 (2015).

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Author contributions
T.D. and T.M.-T. contributed toward the conceptualization and design of the study. T.D. and A.M. were responsible for the data and statistical analysis. T.D. drafted the manuscript. Reviewing, revising, editing, and approval of the final manuscript were conducted by all authors.

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Competing interests
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Chapter 6 Manuscripts Addressing Objective 3

Following the evaluation of the impact of TB diagnostic services in Chapter Five, a quality assessment of these services was conducted. This was done to establish the barriers and facilitators to providing quality diagnostic services.

In chapter 6, two manuscripts are presented to address objective 3. The first manuscript presents findings from a facility audit aimed at determining the barriers and enablers to providing quality diagnostic services. The manuscript is titled: "*Quality of TB diagnostic services at primary healthcare clinics in eThekwini District, South Africa*" and is being considered for publication by the journal *PLOS ONE*. The second manuscript explored the quality of TB services from the patients' perspective and is titled: *Quality of TB services at Primary healthcare clinics in eThekwini District, South Africa: Patient perspectives*. This manuscript has undergone an initial round of revisions and is being considered for publication by the journal *BMC Infectious Diseases*.

Quality of TB diagnostic services at Primary healthcare clinics in eThekwini District, South Africa

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Abstract

Overcoming the TB epidemic needs to move past expanding the coverage of healthcare services and look to improve the quality of TB services. During COVID-19, the suboptimal state of TB services has further deteriorated, and little is known about how these services have fared after the pandemic. The study aims to reveal barriers and enablers to providing quality TB diagnostic services in primary health care (PHC) clinics in the eThekwini district, South Africa. Twenty-one clinics with the lowest and highest headcounts from each region of eThekwini were purposively selected. An audit tool adapted from the United States Agency for International Development (USAID) and the national TB guidelines was used to collect data on six different audit components. To assess quality, a 3-point scale was used where clinics could get a rating of either excellent, moderate, or poor performance. Descriptive statistics were employed to summarize and analyze clinic scores in Stata v15.1. Additionally, associations between clinic scores and clinic characteristics were investigated using Pearson's pairwise correlation coefficient and a linear regression model, where $p < 0.05$ was the measure of statistical significance. The audit found that the quality of diagnostic services in eThekwini was moderate. The gaps that required addressing were the lack of TB training among staff, adherence to infection prevention and control practices, and contact screening. Without feasible solutions, these will hinder current TB management strategies and slow progress toward ending the TB epidemic.

Keywords

Quality of care; Health services research; Diagnostic services; Tuberculosis

Introduction

Low- and middle-income countries (LMICs) of sub-Saharan Africa and Asia are the most burdened by Tuberculosis (TB). In 2021, South Africa formed part of the countries that made up the largest global TB burden [1]. At the heart of the TB epidemic in South Africa is the high prevalence of HIV within the population and the people who contract TB but are never diagnosed [2]. In 2019, 32 000 people died from TB, of which 62% were HIV positive [3], and in 2021, 304 000 people contracted the illness while the number of deaths increased to 56 000 [4]. The lives of so many people should not continue to be lost to a curable disease in which policies and interventions are in place to assist with its control [5]. Therefore, it is time to investigate the quality of care at facilities providing TB services in LMICs.

There is agreement that improving TB outcomes must go beyond increasing coverage of healthcare services and shift towards improving the quality of TB care [6, 7]. Evidence shows that half of TB deaths now occur as a result of poor quality rather than limited access to healthcare [8]. Findings like these have prompted a report by the Lancet Global Health Commission, which states that providing healthcare services without the base level of quality is unethical, wasteful, and ineffective [9]. The quality of TB care has been assessed in several countries, and the results revealed suboptimal TB care in both the public and the private sectors [10-14]. Similar studies from South Africa that used standardized patients to measure quality showed better TB management than in other countries. However, there was still sub-optimal management of HIV during TB screenings [10, 11]. This is concerning for a country that has integrated TB and HIV services as a means to manage the high HIV, TB, and HIV-TB coinfection prevalence [15].

COVID-19 has further complicated the provision of essential TB care in high-burden countries [16]. During the initial stages of COVID-19, access to TB services was limited due to the introduction of lockdowns and the diversion of resources to help manage the spread of SARS-CoV-2 [17]. This reduced the case detection in TB-endemic countries like South Africa, wherein TB detection dropped by 26% in 2020 compared to 2019 [16]. Subsequently, the reduction in the number of people diagnosed with TB has also increased TB mortality [16]. The ambitious targets the United Nations (UN) and the World Health Organization (WHO) set to eradicate TB are now out of reach [18, 19]. Rapid restoration of TB services and the scale-up of case detection will play a vital role in getting TB goals back on track, but this would be futile without ensuring quality services at facilities offering care.

Although South Africa has implemented continuous quality improvement to consistently assess the performance of TB and HIV services [20, 21], to our knowledge, no assessments of TB services have been published since the start of the COVID-19 pandemic. For this reason, the study aimed to assess the barriers and facilitators to providing quality TB diagnostic services at primary healthcare clinics in the eThekwini district, South Africa. A study of this nature would reveal the barriers that will guide targeted implementation strategies aimed at quality improvement.

Methods

Study design

A facility audit focused on the quality of TB diagnostic services was conducted at PHCs. An audit allowed us to gain insight into the availability and functionality of the diagnostic resources at the clinics [22]. This study forms part of a larger study that seeks to improve TB diagnostic services at PHCs during pandemics and similar situations [23].

Study setting

The study was undertaken in eThekwini, the largest metropolis in the province of Kwa-Zulu Natal, South Africa. The area is divided into four municipal functional planning regions: the North, South, Central, and Outer West [24]. The population of eThekwini is estimated at 3.9 million, of which the majority reside in the southern region [24]. A key health challenge within the region is the low life expectancy due to high disease prevalence, including TB [25]. The frontline to healthcare services in South Africa are PHCs. eThekwini currently has 113 clinics administered through the local authority or provincial government.

Study population and sampling

The study took place at clinics that offered TB diagnostic and treatment services. The clinics were selected from the four municipal planning regions used in eThekwini [24]. Twenty-one clinics were purposively selected based on patient headcount; each region included clinics with both a small and a large headcount. Six clinics were chosen from the southern and central regions, five from the northern region, and four from the western region.

Data collection tool and scoring guide

An audit assessment tool developed by MEASURE evaluation was used to collect data on TB diagnostic services in eThekwini [26]. The tool was adapted to focus on the diagnostic aspect of TB services and also represented the priorities set by South Africa's National Department of Health (NDoH) (S1 File) [27]. The tool assessed six key components: TB diagnosis and management, HIV-TB integration, TB documents and guidelines, specimen management, infection, prevention and control (IPC), and TB training.

The responses on the audit tool were either "yes" or "no," where "yes" was coded as "1" and "no" as 0. The resulting 'yes' responses were totaled and converted to percentages for every component. The overall facility scores were determined by averaging the percentages from each audit component. The performance was determined using three cut-off points, scores of between 85%-100% signified excellent performance, those between 50%-84% were moderate, and scores lower than 50% represented poor performance.

Data collection procedure

The facility audits took place over three months from January to March 2023. The audit team comprised the primary investigator (PI), clinic managers, and a TB nurse from each audited facility. The PI explained the components of the audit tool to the clinic's respective members. Then, each clinic representative answered the questions on the checklist and showed the PI various items as dictated by the audit checklist. To ensure the audit's efficiency, staff members were notified of the purposes of the audit before the clinic visit.

Pre-test

Before conducting the study, the data collection tool was pre-tested at one facility that was not included. The tool was then adapted based on the outcome of the piloting exercise.

Data analysis

Data were collected manually at respective clinics before being entered into an Excel spreadsheet, where it was cleaned and validated. Once clean, data were exported into Stata version 15.1 for analysis [28]. To estimate the frequencies and the 95% confidence intervals for overall audit scores and respective audit components, the t-test was used. To compare the statistical differences in the performance of the audited clinics by region, a one-way Analysis of Variance (ANOVA) was conducted and adjusted for multiple comparisons using Tukey's post-estimation test, where $p < 0.05$ was significant. The association between the audit scores and clinic characteristics was determined using Pearson's pairwise correlation coefficient, $p < 0.05$, as a measure of significance. Variables were then subjected to a linear regression, which used R^2 to measure the goodness-of-fit and $p < 0.05$ for statistical significance.

Ethical considerations

All methods were carried out in accordance with the declaration of Helsinki and the South African POPIA Act. This study received ethical approval from the University of Pretoria's Health Sciences Research Ethics Committee Reference number 652/2021. Further approvals were obtained from the KwaZulu Natal Department of Health (Ref: KZ_202112_012) and the eThekwini Municipality's Health Unit. Anonymous patient data were extracted and aggregated for this study; thus, informed consent from patients was waived by the University of Pretoria's Health Sciences Research Ethics Committee. Written consent was provided by the clinic staff who participated in the audit.

Results

Characteristics of audited clinics

A total of 21 PHCs were audited from the eThekwini district, South Africa, over three months between January to March 2023. Five clinics were audited from the northern region, six from the southern and central regions, and four from the western region. Eight out of the 21 audited clinics were administered by the provincial government and the remaining 13 were issued by the local municipal government. Eighteen facilities provided TB-related services from Monday to Friday, one from Monday to Saturday, and only two reported providing these services from Monday to Sunday. Fourteen clinics indicated that TB screening was conducted in all consultation rooms within the facility, one clinic had TB services at three points, two clinics provided these services in two areas, and five clinics provided TB services at a single service point. The average quarterly headcount of the clinics ranged between 9 755±2 578 and 21 405± 9 075 patients among the four regions, while the number of people screened for TB varied between 9 213 ± 2 454 and 18 385 ± 7 924. A detailed description of the audited clinics is found in Table 1.

Table 1 Characteristics of the audited PHCs within eThekwini district, South Africa, ± represents the standard deviations.

Region	No. of municipal clinics	No. of provincial clinics	Days per week, TB services are available	TB-related service points	Patient headcount (Quarterly)	Patients screened for TB symptoms (Quarterly)
North	5	0	Monday-Friday	One and all points	9 755 ± 2578	9 213 ± 2 454
South	1	5	Monday-Friday Monday-Saturday Monday-Sunday	One, three, and all points	21 405 ± 9 075	18 385 ± 7 924
Central	3	3	Monday-Friday	Two and all points	19 208 ± 10 859	16 564 ± 8 540
West	4	0	Monday- Friday	One, two, and all points	13 350 ± 5 087	12 590 ± 5 731

Audit scores for facilities in eThekwini District, South Africa

Based on the criterion applied to this research, the results from the audited clinics show individual ratings that range between moderate 64.1% (95% CI: 16.0%-112.3%) and excellent 97.6% (95% CI:91.6%-103.6%) Table 2. Nine out of the 21 clinics scored excellently, and the remaining 12 performed moderately (Table 2). Clinics in the west were the only ones to achieve an excellent rating with a combined score of 94.1%, and conversely, facilities in the central region had the lowest performance at 75.8%; moreover, the difference in scores between these two regions was statistically different ($p < 0.05$). Clinics of the southern and northern regions shared similar scores of 78.1% and 79.3%, respectively (Fig 1).

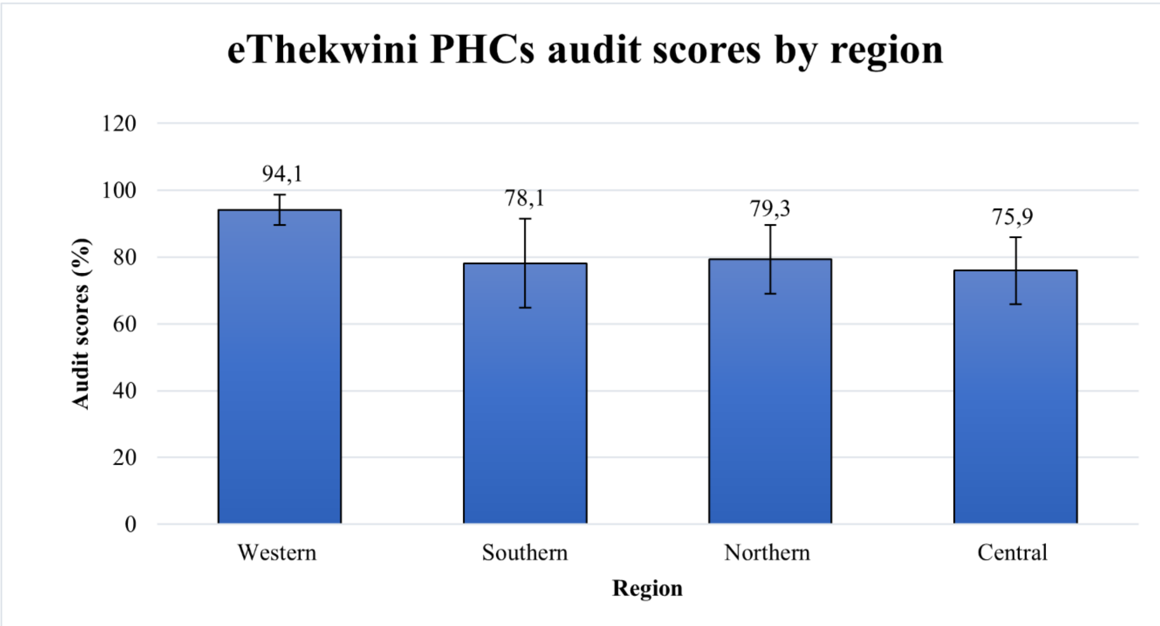

Fig 1 Audit scores for TB diagnostic service at PHCs in eThekwini by region, where error bars represent 95% confidence intervals

Table 2 Individual audit scores and ratings for PHCs in the eThekwini district

		Audit Components (%)							
		Infection Prevention & Control	**Specimen management**	**Documents & guidelines**	**TB training**	**Integration of TB/HIV services**	**TB diagnosis & management**	**Overall percentage per clinic (95% CI)**	**Clinic rating**
Individual clinics represented by region	**South 1**	86	100	100	100	100	50	89.3 (68.2-110.3)	Excellent
	South 2	71	75	57	100	100	40	73.8 (48.9-98.6)	Moderate
	South 3	71	100	14	0	100	100	64.1 (16.0-112.3)	Moderate
	South 4	86	75	57	0	100	83	66.8 (29.4-104.2)	Moderate
	South 5	93	100	86	100	100	100	96.5 (89.4-104.9)	Moderate
	South 6	86	100	100	0	100	83	78.1 (37.1-119.1)	Moderate
	Central 1	57	75	100	100	100	83	85.8 (67.3-104.3)	Excellent
	Central 2	71	100	86	100	100	67	87.3 (71.3-103.3)	Excellent
	Central 3	61	75	86	0	100	60	63.6 (27.2-100.0)	Moderate
	Central 4	64	100	100	0	100	100	77.3 (34.7-119.8)	Moderate
	Central 5	86	100	100	0	20	100	67.6 (19.9-115.3)	Moderate
	Central 6	71	100	86	0	100	83	73.3 (33.9-112.7)	Moderate
	West 1	64	100	100	100	100	83	91.1 (75.4-106.8)	Excellent
	West 2	71	100	100	100	100	100	95.1 (82.7-107.5)	Excellent
	West 3	86	100	100	100	100	100	97.6 (91.6-103.6)	Excellent
	West 4	86	100	86	100	100	83	92.5 (83.8-101.1)	Excellent
	North 1	79	100	71	100	100	50	83.3 (61.7-104.9)	Moderate
	North 2	79	100	85	100	100	50	85.6 (65.0-106.3)	Excellent
	North 3	71	100	75	100	100	67	78.3 (59.6-97.0)	Moderate
	North 4	71	100	86	100	20	75	75.3 (44.1-106.5)	Moderate

	North 5	64	100	86	0	100	50	66.6 (26.4-106.8)	Moderate
	% per component (95% CI)	74.9 (70.3-79.5)	95.2 (90.6-99.8)	83.8 (74.3-93.3)	61.9 (37.5-82.1)	92.3 (81.4-103.3)	76.5 (67.3-85.7)		

Performance by individual audit component

The consolidated scores for each component were determined by averaging the scores from the respective components for all clinics in Table 2. The resulting scores for components: specimen management, integration of HIV/TB services, TB policies and guidelines, TB diagnosis and management, Infection, prevention and control, and TB training; are depicted in Fig 2. The audited clinics showed excellent performance for specimen management and integration of HIV/TB services, with 95.2% (95% CI: 90.6-99.8) and 92.3% (95% CI:81.4-103.3), respectively. The remaining audit components performed moderately; TB training had the lowest score of 61.9% (95% CI: 37.5-82.1). The performance of TB training was significantly different from specimen management, TB documents and guidelines, and integration of TB/HIV services, respectively ($p < 0.05$)

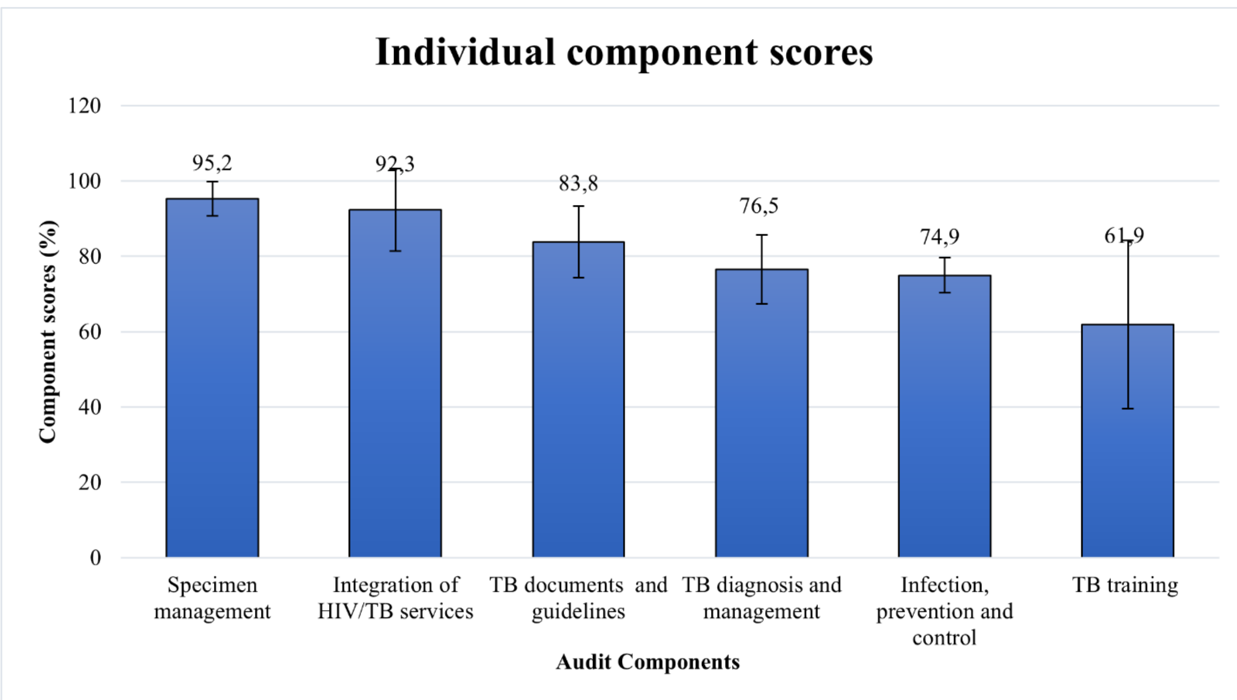

Fig 2 Averages for each audited component of TB diagnostic services in eThekwini, 95% confidence intervals shown with error bars.

Specimen management

This was the best-performing component among all clinics with a total score of 95.2% (95% CI: 90.6-99.8). Only the Southern and Central regions failed to achieve a score of 100% compliance each with two clinics that scored a 75%. Four clinics could not locate their standard operating procedures (SOPs) for specimen collection. All clinics were compliant in the other areas of specimen management in which sputum was stored under the correct conditions and collected from each facility at least once daily.

Integration of TB/HIV services

This service area recorded the second-highest score at 92.3% (95% CI: 81.4-103.3). Every clinic, except two, received a perfect score of 100% for integrating TB/HIV services. All the compliant clinics provided HIV tests to all TB patients and appropriately managed all patients with HIV/TB co-infection according to the national guidelines. One of the clinics that did not fully comply had an HIV/TB coinfected patient who was receiving antiretroviral therapy (ART) from a private doctor. The other non-compliant clinic had a TB patient who was a defaulter and not receiving any HIV care because they still required a referral letter from their previous facility.

TB diagnosis and management

This audit component earned a moderate score of 76.5% (95% CI: 67.3-85.7). Individual clinic scores ranged from 40% to 100%. The western region was the only one that excelled, with a combined score of 91.5%. The shortcomings of this component were turnaround time for gene Xpert results and the lack of identifying and screening close contacts of those with active TB. Twelve clinics failed to meet the <48h turnaround time for Gene Xpert results; however, Labtrak results were returned in less than 24h, but these facilities received them after three days. The other nine clinics returned TB test results within 2 days. Eight facilities failed to identify and screen contacts of patients who had tested TB positive because patients either provided the wrong contact details or failed to give any contact information. All clinics were compliant with using Gene Xpert to diagnose patients, initiating treatment promptly, and investigating the progression of the disease using acid-fast bacillus testing.

Infection prevention and control (IPC)

IPC achieved the second-lowest rating with a score of 74.9% (95% CI: 70.3-79.5). Individual clinic scores ranged from 61% to 93%. The most prominent causes for concern were patient waiting areas and the failure by presumptive TB patients and TB nurses to wear surgical masks and N-95 respirators, respectively. Eleven clinics had waiting areas that were small, congested, and lacked adequate ventilation; the waiting areas in the other ten clinics were either outside or had access to fresh air through open windows and doors. Similarly, eleven clinics did not require presumptive TB patients to wear surgical masks. However, ten did supply surgical masks to coughing patients when masks were available. The remaining ten clinics required all patients entering the facility to wear masks. Only one clinic had a TB nurse who wore an N-95 respirator during patient consultations. Nurses at the other twenty clinics either had no access to N-95 respirators due to stockouts, opted for surgical masks instead, or wore nothing due to the heat and discomfort of wearing a mask. On the other hand, all clinics had a designated coughing area away from other patients, with two clinics having a formal coughing booth with a filtration system. Moreover, all but one clinic separated coughing patients and fast-tracked them for TB evaluation.

TB documents and guidelines

This audit component earned a moderate score of 83.8% (95% CI: 74.3-93.3). Eight clinics achieved a score of 100%, most of those coming from the western and central regions. The remaining 13 clinics had scores ranging from 14% to 86%. Diagnosis and screening flowcharts and TB posters were notably missing from many clinics. Twelve clinics stated that moving between different consultation rooms was the main reason for the misplaced documentation. Another clinic had a wing under construction during the audit, resulting in many misplaced items, including TB documents. Conversely, all but one clinic had copies of the relevant TB guidelines, and every clinic had either a manual or electronic method of reporting diagnosed TB cases.

TB training

TB training was the audit component with the lowest score of 61.9% (95% CI: 37.5-82.1) among all the audited clinics. The western region was the only region that scored 100% in this area, while the central region scored the lowest with only 40%. Eight clinics indicated no staff had received new TB training in the previous 24 months. The two reasons for this were the high staff turnover rate and staff shortages that made it difficult for nurses to leave work to attend offsite training. The remaining 12 clinics had a perfect score (100%) in this area. The TB training received was broad covering topics like the TB cascade of care, up-and-coming diagnostic tools, and loss to follow-up.

Relationship between clinic characteristics and audit scores

The association between the audit scores and the clinic characteristics (TB headcount and number of TB patients screened) was investigated. The results showed a weak to moderate correlation between component scores and clinic characteristics with no statistical significance ($p > 0.05$).

Assessing the association between region audit scores and clinic characteristics turned up similar results, showing that the numbers of screened patients and clinic headcount were not significantly associated with the audit scores achieved by each region, respectively. Similarly, a linear regression of these variables revealed no relationship between the selected clinic characteristics and the component scores, with R-squared values of less than 1% and no statistical significance.

Discussion

Facility audits in four different regions of eThekwini were conducted to assess barriers and enablers to providing quality TB diagnostic services at PHCs. The clinic ratings by region were primarily moderate, with only the western region securing an excellent overall score. Moreover, scores obtained by the highest and lowest-performing regions were significantly different from each other. However, no statistically significant relationships were established between audit scores and clinic characteristics. Assessment of individual component scores showed specimen management and the integration of TB/HIV services to have the highest scores. On the contrary, IPC and TB training had the lowest scores. Other notable areas of concern were times for reporting Xpert results and failing to identify and screen close contacts of TB patients.

To our knowledge, no studies from South Africa have looked at the quality of TB services since the COVID-19 pandemic. The audit showed that specimen management was the component that received the highest score. This is good because mishandling and improper storage of sputum can affect its quality, leading to incorrect diagnoses. Some of our study findings were congruent with those from another audit conducted in South Africa, which reported HIV counseling and testing for TB patients as one of the highest audit scores [21]. Integrating HIV/TB services at public healthcare facilities is relatively new to the country. It has experienced implementation challenges in the past [29, 30], which led to missed opportunities to care for TB patients appropriately [31]. As such, we did not anticipate this area performing well; however, the targeted quality improvement interventions that have been trialed at PHCs in recent years may be the reason for the high quality of HIV/TB services found in this study [20].

Our study also identified areas of weaker compliance with national standards. Similar research has shown that poor adherence to TB guidelines is often linked to high work volumes [21]. In contrast, our findings showed no associations between the number of patients seen and the audit scores obtained. However, findings from Ethiopia and South Africa were comparable to ours in that high staff turnover formed reasons for the lack of recent training among staff [30, 32]. Ironically, continuous education can be an effective tool for improving the quality of TB services [31]. Adequate training has been linked to better implementation of IPC measures, another barrier to quality identified by this study [33]. Although many facilities adhered to WHO IPC standards by triaging coughing patients and separating them from others [34], we also found that clinic infrastructure resulted in overcrowded waiting areas and inadequate ventilation, moreover, there was a poor supply of masks/respirators which led to limited mask use. The same challenges burdened health systems during the COVID-19 pandemic [35, 36]. Poorly implemented IPC measures depleted healthcare workers and perpetuated nosocomial infections [37]. Therefore, addressing these IPC challenges serves a dual purpose of improving TB control efforts and strengthening pandemic preparedness.

A cornerstone of the end TB strategy by the WHO is early diagnosis and treatment initiation [18]. Our findings showed potential barriers to both, specifically through Xpert turnaround time and failure to identify and screen close contacts of TB patients. In South Africa, the introduction of Xpert for TB diagnosis has increased the detection of TB by providing results in less than two hours [38], however, its placement at centralized laboratories delays treatment initiation by returning results to the clinics after several days [21, 39]. This was also true for our results. To this end, the National Health Laboratory Services has introduced automated text messages for presumptive TB patients for faster linkage to care [40], however, this is still in its infancy and has had limited success as of February 2023 [4]. Thus, improving the quality of care needs to look at optimizing the current strategies by working toward delivering same-day diagnosis at the point of care. Indeed, prompt diagnosis reduces the development of more severe forms of TB and curbs community transmission likewise rapidly detecting close contacts of TB patients can also reduce the potential for community transmission. However, our findings identified this as another barrier to the quality of TB care. Contact tracing is known to be poorly implemented in resource-limited settings [18, 41] but, is a better approach than passive case finding for managing TB [42]. Thus, it requires optimization at PHCs where uptake is mediocre at best.

The study was not without limitations. To assess TB diagnosis and management as well as integration of TB/HIV service a random patient file from each facility was chosen. The number of files was small compared to the volume of patients seen by these facilities and may not be a true reflection of the two audit components and thus cannot be generalized to the rest of the PHCs in eThekwini. Therefore, a larger study investigating these two parameters would be able to yield more precise estimates. Moreover, while we reported on the high quality of HIV/TB integration services our research only accounted for patients receiving TB care which means the HIV program could be missing opportunities to screen and test presumptive TB cases.

Recommendations

Some of the main barriers to providing quality TB care were the need for recent health education on TB among staff, better adherence to IPC measures, turnaround time for results, and contact tracing; based on those we recommend the following: Equipping all staff members working at clinics with TB training so to maintain trained staff. To this end, training can be used to reinforce IPC practices. However, the training should include practical aspects to address the know-do gap. In many cases, the nurses in our study knew the importance of wearing N-95 respirators but did not use them. Furthermore, all patients at PHCs should be mandated to wear masks. This is an effective way of preventing nosocomial infections. COVID-19 has already set a precedent for this and should be leveraged by all health facilities. This would also remove the financial burden from the health system to provide masks for presumptive TB cases, and these funds could be reallocated to purchasing N-95 respirators instead. Moreover, making all patients wear masks will remove any feelings of stigma and discrimination that TB patients may experience. Facilities should use natural ventilation by opening windows and doors. This is an inexpensive way of disrupting the TB transmission cycle by introducing airflow into overcrowded facilities. Using natural airflow over mechanical ventilation is also advantageous, as the country is regularly experiencing scheduled blackouts that would not always make mechanical ventilation possible. Since COVID-19 ignited the development of novel diagnostic tools, similar efforts should be used to develop a true point-of-care test for TB that would make same-day treatment initiation possible. Authors from Malawi have explored patient-delivered screening interventions for improving contact tracing and initiation of preventative therapy [43]. Similar interventions should be examined for the South African context to assist with the low uptake of contact screening at clinics. Lastly, continuous quality assessments at PHCs should continue to determine areas that need to be addressed and establish the efficiency of any practices that have been newly implemented.

Conclusion

We found that the overall quality of TB diagnostic services was moderate throughout PHCs in the eThekwini district. While specimen management and integration of HIV/TB services excelled, some IPC measures, TB training, reporting of results, and contact tracing, performed poorly. These underperforming areas have the potential to undermine TB management strategies that are currently in place and therefore will need to be adequately addressed to continue making progress in the fight against TB especially in light of the COVID-19 pandemic that has slowed down many of the gains achieved in recent years.

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List of Abbreviations

ANOVA: Analysis of Variance

ART: Antiretroviral therapy

IPC: Infection, prevention, and control

NDoH: National Department of Health

NTP: National Tuberculosis Program

PHCs: Primary Healthcare clinics

PI: Primary Investigator

SDGs: Sustainable Development Goals

TB: Tuberculosis

USAID: United States Agency for International Development

WHO: World Health Organization

References

1. World Health Organization. Global Tuberculosis Report Geneva2022 [cited 2023 02-28-2023]. Available from: https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2022.

2. Pillay Y, Pienaar S, Barron P, Zondi T. Impact of COVID-19 on routine primary healthcare services in South Africa. South African Medical Journal. 2021;111(8):714. doi: 10.7196/samj.2021.v111i8.15786.

3. World Health Organization. Global tuberculosis report Geneva: World Health Organization; 2020 [cited 2023 02-28-2023]. Available from: https://www.who.int/publications/i/item/9789240013131.

4. National Institute for Communicable Diseases. Strengthen the link between people diagnosed with TB and treatment initiation South Africa: National Institute for Communicable Disease; 2023 [cited 2023]. Available from: https://www.nicd.ac.za/strengthening-the-link-between-people-diagnosed-with-tb-and-treatment-initiation/.

5. Pai M, Temesgen Z. Quality: The missing ingredient in TB care and control. Journal of clinical tuberculosis and other mycobacterial diseases. 2018;14:12-3. doi: 10.1016/j.jctube.2018.12.001. PubMed PMID: 31720411.

6. Pai M, Temesgen Z. Quality of Tuberculosis care. Journal of Clinical Tuberculosis and Other Mycobacterial Diseases

1377:68-70.

7. Arsenault C, Roder-DeWan S, Kruk ME. Measuring and improving the quality of tuberculosis care: A framework and implications from the Lancet Global Health Commission. Journal of Clinical Tuberculosis and Other Mycobacterial Diseases. 2019;16:100112. doi: 10.1016/j.jctube.2019.100112.

8. Kruk ME, Gage AD, Joseph NT, Danaei G, García-Saisó S, Salomon JA. Mortality due to low-quality health systems in the universal health coverage era: a systematic analysis of amenable deaths in 137

countries. The Lancet. 2018;392:2203-12. doi: 10.1016/S0140-6736(18)31668-4. PubMed PMID: 30195398.

9. Kruk ME, Gage AD, Arsenault C, Jordan K, Leslie HH, Roder-Dewan S, et al. High-quality health systems in the Sustainable Development Goals era: time for a revolution. The Lancet Global Health. 2018;6(11):e1196-e252. doi: 10.1016/s2214-109x(18)30386-3.

10. Christian C, Gerdtham U-G, Hompashe D, Smith A, Burger R. Measuring Quality Gaps in TB Screening in South Africa Using Standardised Patient Analysis. International Journal of Environmental Research and Public Health. 2018;15(4):729. doi: 10.3390/ijerph15040729.

11. Boffa J, Moyo S, Chikovore J, Salomon A, Daniels B, Kwan AT, et al. Quality of care for tuberculosis and HIV in the private health sector: a cross-sectional, standardised patient study in South Africa. BMJ Global Health. 2021;6(5):e005250. doi: 10.1136/bmjgh-2021-005250.

12. Daniels B, Dolinger A, Bedoya G, Rogo K, Goicoechea A, Coarasa J, et al. Use of standardised patients to assess quality of healthcare in Nairobi, Kenya: a pilot, cross-sectional study with international comparisons. BMJ Global Health. 2017;2(2):e000333. doi: 10.1136/bmjgh-2017-000333.

13. Sylvia S, Xue H, Zhou C, Shi Y, Yi H, Zhou H, et al. Tuberculosis detection and the challenges of integrated care in rural China: A cross-sectional standardized patient study. PLOS Medicine. 2017;14(10):e1002405. doi: 10.1371/journal.pmed.1002405.

14. Kwan A, Daniels B, Saria V, Satyanarayana S, Subbaraman R, McDowell A, et al. Variations in the quality of tuberculosis care in urban India: A cross-sectional, standardized patient study in two cities. PLOS Medicine. 2018;15(9):e1002653. doi: 10.1371/journal.pmed.1002653.

15. Kalonji D, Mahomed OH. Health system challenges affecting HIV and tuberculosis integration at primary healthcare clinics in Durban, South Africa. African Journal of Primary Health Care & Family Medicine. 2019;11(1). doi: 10.4102/phcfm.v11i1.1831.

16. World Health Organization. Global tuberculosis report Geneva2021 [cited 2023 02-28-2023]. Available from: https://www.who.int/teams/global-tuberculosis-programme/tb-reports.

17. Dlangalala T, Musekiwa A, Brits A, Maluleke K, Jaya ZN, Kgarosi K, et al. Evidence of TB Services at Primary Healthcare Level during COVID-19: A Scoping Review. Diagnostics. 2021;11(12):2221. doi: 10.3390/diagnostics11122221.

18. World Health Organization. End TB Strategy: World Health Organization; 2015 [cited 2023 23-09-2023]. 1-20]. Available from: https://www.who.int/tb/End_TB_brochure.pdf?ua=1.

19. United Nations. Sustainable Development Goals 2021 [cited 2023 03-01-2023]. Available from: https://unstats.un.org/sdgs/metadata/?Text=&Goal=3&Target=3.3.

20. Gengiah S, Naidoo K, Mlobeli R, Tshabalala MF, Nunn AJ, Padayatchi N, et al. A Quality Improvement Intervention to Inform Scale-Up of Integrated HIV-TB Services: Lessons Learned From

KwaZulu-Natal, South Africa. Global Health: Science and Practice. 2021;9(3):444-58. doi: 10.9745/ghsp-d-21-00157.

21. Gaga S, Mqoqi N, Chimatira R, Moko S, Igumbor JO. Continuous quality improvement in HIV and TB services at selected healthcare facilities in South Africa. Southern African Journal of HIV Medicine. 2021;22(1). doi: 10.4102/sajhivmed.v22i1.1202.

22. Colvin C, De Silva G, Garfin C, Alva S, Cloutier S, Gaviola D, et al. Quality of TB services assessment: The unique contribution of patient and provider perspectives in identifying and addressing gaps in the quality of TB services. Journal of Clinical Tuberculosis and Other Mycobacterial Diseases. 2019;17:100117. doi: 10.1016/j.jctube.2019.100117.

23. Dlangalala T, Musekiwa A, Mashamba-Thompson T. Towards development of a novel approach for enhancement of TB diagnostic services during the pandemic: A case of primary health care clinics in eThekwini district KwaZulu-Natal: A study protocol. PLOS ONE. 2022;17(12):e0278305. doi: 10.1371/journal.pone.0278305.

24. District Development Model. About EThekwini South Africa2020 [cited 2023 02-03-2023]. Available from: https://www.durban.gov.za/pages/government/about-ethekwini.

25. KwaZulu-Natal Department of Health. eThekwini District Health Plan 2015/16 2015 [cited 2023 02-05-2023]. Available from: http://www.kznhealth.gov.za/Strategic/DHP/2015-16/ethekwini.pdf.

26. MEASURE Evaluation. Quality of Tuberculosis Services Assessment: Global Tools 2020 [cited 2023]. Available from: https://www.measureevaluation.org/resources/publications/tl-19-41.html.

27. National Department of Health. National Tuberculosis Management Guidelines 2014 2014 [cited 2023 03-25-2023]. Available from: https://www.tbonline.info/media/uploads/documents/national_tuberculosis_management_guidelines_%282014%29.pdf.

28. StataCorp. Stata Statistical Software: Release 15. TX: StataCorp LLC: College Station, 2017.

29. Loveday M, Zweigenthal V. TB and HIV integration: obstacles and possible solutions to implementation in South Africa. Tropical Medicine & International Health. 2011;16(4):431-8. doi: 10.1111/j.1365-3156.2010.02721.x.

30. Pillay Y. Integrating HIV and Tuberculosis care in South Africa. Bull World Health Organ. 2018;96:302-3. doi: doi.org/10.2471/BLT.18.030518.

31. Kweza PF, Van Schalkwyk C, Abraham N, Uys M, Claassens MM, Medina-Marino A. Estimating the magnitude of pulmonary tuberculosis patients missed by primary health care clinics in South Africa. The International Journal of Tuberculosis and Lung Disease. 2018;22(3):264-72. doi: 10.5588/ijtld.17.0491.

32. Gebreegziabher SB, Yimer SA, Bjune GA. Qualitative Assessment of Challenges in Tuberculosis Control in West Gojjam Zone, Northwest Ethiopia: Health Workers' and Tuberculosis Control Program Coordinators' Perspectives. Tuberculosis Research and Treatment. 2016;2016:1-8. doi: 10.1155/2016/2036234.

33. Achmat B, Gerber B. Challenges to infection control in early communication intervention: A scoping review. South African Journal of Communication Disorders. 2022;69(2). doi: 10.4102/sajcd.v69i2.911.

34. World Health Organization. WHO guidelines on tuberculosis infection prevention and control 2019 update Geneva: World Health Organization; 2019 [cited 2023]. Available from: https://apps.who.int/iris/bitstream/handle/10665/311259/9789241550512-eng.pdf.

35. Soko RN, Burke RM, Feasey HRA, Sibande W, Nliwasa M, Henrion MYR, et al. Effects of Coronavirus Disease Pandemic on Tuberculosis Notifications, Malawi. Emerging Infectious Diseases. 2021;27(7). doi: 10.3201/EID2707.210557.

36. Stop TB Partnership Civil society-led TB/COVID-19 Working Group. The impact of COVID-19 on the TB epidemic: A community Perspective Geneva: Stop TB Partnership; 2020 [cited 2023 03-10-2023]. Available from: https://stoptb.org/assets/documents/resources/publications/acsm/Civil%20Society%20Report%20on%20TB%20and%20COVID.pdf?fbclid=IwAR3SOY4kyBs5a_35HIeUhcvwRIWspePA4vVHESqcQxio7G4irivJ90cSU8k.

37. Patel LN, Kozikott S, Ilboudo R, Kamateeka M, Lamorde M, Subah M, et al. Safer primary healthcare facilities are needed to protect healthcare workers and maintain essential services: lessons learned from a multicountry COVID-19 emergency response initiative. BMJ Global Health. 2021;6(6):e005833. doi: 10.1136/bmjgh-2021-005833.

38. Lawn SD, Kerkhoff AD, Wood R. Location of Xpert® MTB/RIF in centralised laboratories in South Africa undermines potential impact [Correspondence]. The International Journal of Tuberculosis and Lung Disease. 2012;16(5):701-. doi: 10.5588/ijtld.12.0131.

39. Cohen GM, Drain PK, Noubary F, Cloete C, Bassett IV. Diagnostic Delays and Clinical Decision Making With Centralized Xpert MTB/RIF Testing in Durban, South Africa. JAIDS Journal of Acquired Immune Deficiency Syndromes. 2014;67(3).

40. South African Government. Deputy Minister Sibongiseni Dhlomo: Opening Plenary of seventh SA TB Conference South Africa2022 [cited 2023 06-11-2023]. Available from: https://www.gov.za/speeches/keynote-address-dr-sibongiseni-dhlomo-health-deputy-minister-during-opening-plenary-7th-sa.

41. Storla DG, Yimer S, Bjune GA. A systematic review of delay in the diagnosis and treatment of tuberculosis. BMC Public Health. 2008;8(1):15. doi: 10.1186/1471-2458-8-15.

42. Stuckler D, Basu S, McKee M, Lurie M. Mining and Risk of Tuberculosis in Sub-Saharan Africa. American Journal of Public Health. 2011;101(3):524-30. doi: 10.2105/ajph.2009.175646.

43. Kaswaswa K, Macpherson P, Kumwenda M, Mpunga J, Thindwa D, Nliwasa M, et al. Effect of patient-delivered household contact tracing and prevention for tuberculosis: A household cluster-randomised trial in Malawi. PLOS ONE. 2022;17(9):e0269219. doi: 10.1371/journal.pone.0269219.

Quality of TB services at primary healthcare clinics in eThekwini district, South Africa: Patient perspectives

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Abstract

Ambitious efforts to diagnose and treat Tuberculosis (TB) are required to reduce the burden of disease in low-resource settings, particularly in South Africa, where TB is highly prevalent. Quality of care is now recognized as the missing piece in TB management, though few studies have sought to understand it from a user perspective, especially in South Africa. Our study, therefore, aimed to explore the quality of TB services at clinics in the eThekwini district from the patients' perspectives. The study utilized a qualitative research design. Ten purposively selected patients receiving TB treatment at different primary healthcare clinics (PHCs) in eThekwini were interviewed. The interviews were transcribed, translated and coded, followed by a thematic analysis. We found that patients were unaware of TB symptoms, making them present later to health facilities. Moreover, patients identified that long queues at patient registration, negative staff attitudes, and drug stockouts were significant obstacles to the quality of TB services. Nevertheless, they noted that the patient-centered approach adopted by TB staff enhanced the quality of services delivered. The results suggest that solutions should improve patient flow at clinics and strengthen monitoring systems that report stockouts. The reasons for the differences in the care staff provide at different facilities should also be explored and addressed to ensure that every clinic in eThekwini delivers high-quality care to its patients.

Keywords

Quality of care; health services research; qualitative research; South Africa; Patient perspective; Tuberculosis

Background

Tuberculosis (TB) is an infectious disease that affects a quarter of the globe's population [1]. In 2021, 10.6 million people developed the illness, representing a 4.6% increase from the previous year [1]. The rise in TB incidence resulted from COVID-19 which disrupted TB health services in 2020 [2]. TB diagnosis and treatment initiation were services that were disproportionately impacted in many high-burden countries [2, 3]. As a consequence, TB mortality has increased for the first time in over a decade, reflecting a reversal in the gains won in the fight against the disease [1].

Before the pandemic, progress in achieving TB goals resulted from joint efforts by the World Health Organization (WHO) and the United Nations (UN) [4, 5]. In 2015, ambitious targets were set by the WHO in line with the sustainable development goals (SDGs) to end TB by 2035 [4]. The fight to end the disease was further boosted in 2018 when the United Nations High-Level Meeting (UNHLM) produced targets and commitments for the end of 2022 [6]. By 2019, good progress had been made. However, some of the 2022 targets were not on track to be met [6]. In 2020, the pandemic greatly impacted access to TB care on both the supply and the demand side [3]. Consequently, TB detection massively declined, slowing or reversing many previously acquired gains [2]. Although some recovery has been made, TB detection has not yet reached pre-pandemic levels [1]. To continue toward TB goals and ultimately conquer the epidemic, interventions should strengthen areas of the health system that are known to be vulnerable.

Quality of care is identified as the "missing ingredient" in TB care and management [7, 8]. The failure to maintain essential TB services during COVID-19 exposed what was already considered sub-optimum quality of care [9]. As the Lancet Global Health Commission has highlighted, the TB community should look beyond expanding coverage of crucial interventions but also provide high-quality health systems that are tailored for each context through continuous provision of care that betters or maintains health by being reliable and trusted by its users and by adapting to the populations' changing needs [8]. TB management has often neglected this patient-centered approach to healthcare delivery [10, 11]. However, it is impossible to produce desired health outcomes without accounting for the needs and experiences of the people who use these systems. Considering users can lend itself to better retention in care, treatment adherence, and public trust and, therefore, an area that demands attention [12].

Qualitative research is one way to assess the quality of TB care, and it is often done through in-depth interviews, which helps gain insight into social issues [13]. While previous qualitative studies have examined patient barriers to accessing healthcare [14-16], treatment adherence [17-19] and explored provider perspectives [20], less work has been done on the quality of TB care from patients' perspectives. Reviews of quantitative and mixed-methods studies have been conducted to explore patient satisfaction and user experience [11, 21]. However, qualitative studies assessing the quality of care from patient perspectives were lacking in the literature, and none were from South Africa. For this reason, we wish to add to the existing body of evidence by assessing the quality of TB services at primary healthcare clinics in eThekwini, South Africa. This was done by exploring barriers and enablers to the quality of TB care from patients' perspective. Improving the quality of TB services is crucial in a post-pandemic world; it can improve TB case detection and treatment adherence downstream by gaining patients' trust at the primary healthcare clinics which serve as the first point of contact with the formal health system for many TB patients.

Methods

This study was conducted as part of a bigger research project titled: Towards development of a novel approach for enhancement of TB diagnostic services during the pandemic: A case of primary health care clinics in eThekwini district KwaZulu-Natal [22].

Research paradigm

The study applied an interpretive research paradigm to explore the quality of care from the perspectives of the users of TB services. This approach attempts to understand the patient, their viewpoint, and their interpretation of the quality of the service they receive at PHCs [23].

Study design

An exploratory qualitative study design was used to explore user perspectives on TB services' quality at PHCs in eThekwini.

Study setting

PHCs are most South Africans' first contact with the public health system [24]. They offer a wide range of routine services including voluntary testing and treatment services for drug-susceptible TB (DS-TB). TB diagnosis mainly happens through passive case finding, where symptomatic individuals who present to facilities are screened with the WHO's four symptom screen [25]. TB samples are sent to centralized laboratories that use Xpert MTB/RIF Ultra as the first-line diagnostic test. This real-time PCR assay simultaneously detects the presence of *Mycobacterium tuberculosis* and rifampicin resistance [26]. Patients with DS-TB and uncomplicated rifampicin-resistance are initiated on treatment and managed at PHCs. All other drug-resistant forms are referred to and managed at district hospitals.

PHCs in South Africa's eThekwini district were selected as the study location. eThekwini district is situated in the province of KwaZulu Natal. The province has the highest burden of TB in the country with the eThekwini district at the epicenter [27]. Both TB and HIV are the main causes of years of life lost among the population [24]. Therefore, patients diagnosed and receiving TB treatment at PHCs in the eThekwini district were recruited for the study.

Study sample and recruitment

The in-depth interviews were conducted following an audit of the quality of the TB services at 21 clinics in eThekwini [22]. One patient was purposively selected from each audited clinic until data saturation was reached. Data saturation was determined to be the point at which no new codes and themes were generated. For the current study, this occurred after ten interviews. A recent study found that data saturation can be achieved with a sample size of 9-15 interviews if the population is relatively homogenous [28]. Our study had a narrow aim and used a targeted population; thus, data saturation was reached after ten interviews.

Only those participants who were already diagnosed and receiving treatment were selected for the study; these individuals had spent enough time navigating the cascade of care and could, therefore, give robust data. Participants who had not received a diagnosis or initiated treatment were excluded from the study. TB patients arrived early at facilities to collect treatment from nurses. Following a consultation, the nurses were asked to refer any patients who fit the inclusion criteria to the principal investigator (PI). The PI explained the purpose of the study and took them through the informed consent form. All patients were asked to sign a consent form upon agreeing to participate. A total of 14 patients were recruited, but four declined to participate due to time constraints.

Data collection

Data collection occurred over three months from January 2023 to March 2023. The principal investigator, who had previous experience with qualitative research, conducted in-person, in-depth interviews with TB patients visiting PHCs in eThekwini. The interviews were conducted in a private area of the clinic where patients could speak freely. Interview times ranged from 25 – 50 minutes. An interview guide was used to generate data on patients' experiences navigating the TB care cascade at PHCs (Additional File 1). The interview guide was developed using the Lancet Commission's high-quality health systems framework [8], which was further adapted for measuring the quality of TB care [12]. The framework constitutes three domains: health system foundations, processes of care and quality impacts (Table 1). The framework stipulates that quality should be measured using processes of care and quality impacts and health system foundations should be targeted with solutions. Therefore, the interview questions were semi-structured and centered around the framework's processes of care and quality impacts. All interviews were conducted in the local language (isiZulu) and were audio-recorded with patients' permission.

Table 3 High-quality health systems framework

Components	
Quality impacts	
Confidence in health system	• Use of health providers outside the public healthcare system • Time taken to report to public healthcare system
Processes of care	
Competent care and systems	• Time taken to receive diagnosis and initiate treatment. • Availability of resources
Positive user experience	• Patient perception on waiting times. • Patient perception on provider attitudes, communication, and information received

The table has been adapted from the Lancet's commission framework for high-quality health systems [8, 12].

Data management

The audio-recorded interviews were transcribed verbatim by the PI. Once complete, the transcripts were double-checked for quality purposes by listening to the recordings while reading them. The principal investigator, proficient in isiZulu and English, translated all the transcripts into English. All transcripts were stored in a password-protected laptop that could only be accessed by the authors of the study. Moreover, personal identifying data were omitted from the transcripts to protect patient privacy.

Data analysis

A thematic analysis was conducted to manually analyze the data, as described by authors Braun and Clarke [29]. Firstly, the PI (TD) familiarized herself with the transcripts by transcribing and translating all verbal audio from the interviews. Initial codes were generated from the data set and then organized into themes and sub-themes. Lastly, verbatim quotes were extracted from the data to support the findings.

Researcher characteristics and positionality

TD conducted the study's data collection and analysis. TD is a black Zulu-speaking female with a master's degree; she was receiving doctoral training in Public Health and was 30 years old at the time of the study. She brought with her the insider-outsider experience to each interview; as a black person who grew up in the eThekwini district, she could use this to relate and connect better with the participants, who were all black and around the same age. However, she has never had TB or, because of her middle-class positionality, had to navigate the public health system care system. To put patients at ease and ensure they responded honestly, they were informed that the researcher was not involved in their healthcare provision but was attempting to understand their perspective on the quality of TB care to inform improved service provision.

Results

Ten patients were interviewed about their perspective on the quality of TB services at PHCs in eThekwini. Fifty percent of the respondents were female, while the other 50% were male, with ages that ranged between 20-40 years old (mean: 30). Fifty percent of the patients were unemployed, and 40% had HIV. The participants either had a high school (80%) or university-level education (20%). The time it took patients to present to clinics for a TB test after noticing symptoms ranged between 2 weeks and 8 weeks with an average time of 3.3 weeks. Table 2 provides the detailed characteristics of the interviewed TB patients.

Table 2 Demographic and clinical characteristics of participants included in the study.

PATIENT CODE	GENDER	AGE	EMPLOYMENT STATUS	HIV STATUS	LEVEL OF EDUCATION	LENGTH OF TIME BEFORE DIAGNOSIS
P#1	Female	20	unemployed	Positive	High School	4 weeks
P#2	Female	40	unemployed	Positive	High School	2 weeks
P#3	Male	31	employed	Positive	High school	3 weeks
P#4	Female	31	employed	Negative	University	2 weeks
P#5	Male	30	unemployed	Positive	High School	2 months
P#6	Male	37	unemployed	Negative	High School	4 weeks
P#7	Male	31	unemployed	Negative	High School	3 weeks
P#8	Female	28	employed	Negative	High School	2 weeks

P#9	Male	31	employed	Negative	High school	3 weeks
P#10	Male	21	employed	Negative	University	2 weeks

Patients' diagnostic seeking journey

Patients reported experiencing several symptoms before presenting to the clinics these included: weight loss, shortness of breath, fatigue, loss of appetite, and night sweats.

"It was especially the weight loss, and then it was the loss of appetite and energy. Then it became apparent that I had no energy, and that made me realize that I was sick on another level that's what made me seek help." **#P2**

Patients described self-medicating before presenting to the clinics. In certain instances, they believed their symptoms to be flu-related, which they either treated with flu medication from a pharmacy or a private doctor. The persistent nature of the cough finally prompted them to go to the clinic.

"Yes, I was sick for the entire December, but I wasn't paying any attention to it. I kept on going to buy cough medicines and tablets at pharmacies and then I asked myself what kind of cough refuses to go away, the medicines are running out, the tablets are running out maybe I should go to the clinic, that was around January." **#P6**

Notably, once patients presented to the clinics with their TB-related symptoms, they received appropriate management and were swiftly started on treatment on the same day of their diagnosis.

"*So, I arrived and went to register. They opened a file for me and then they said I should go to the TB side; this was after I had checked my blood because my HIV results came out at the same time. Once they turned out negative, they said the only thing left to check for was TB so I came to this side when I got here, they said that I had the symptoms from what I was describing and then they asked me to take a cough sample and they said that it would come back after four or five days. When the results came back after those* *stipulated days, they called me and told me to come to fetch my results. When I got there, they opened them, and they were positive for TB and that day I started treatment*." **#P9**

The main themes and sub-themes that were identified as the barriers and enablers of TB services have been listed in Figure 1.

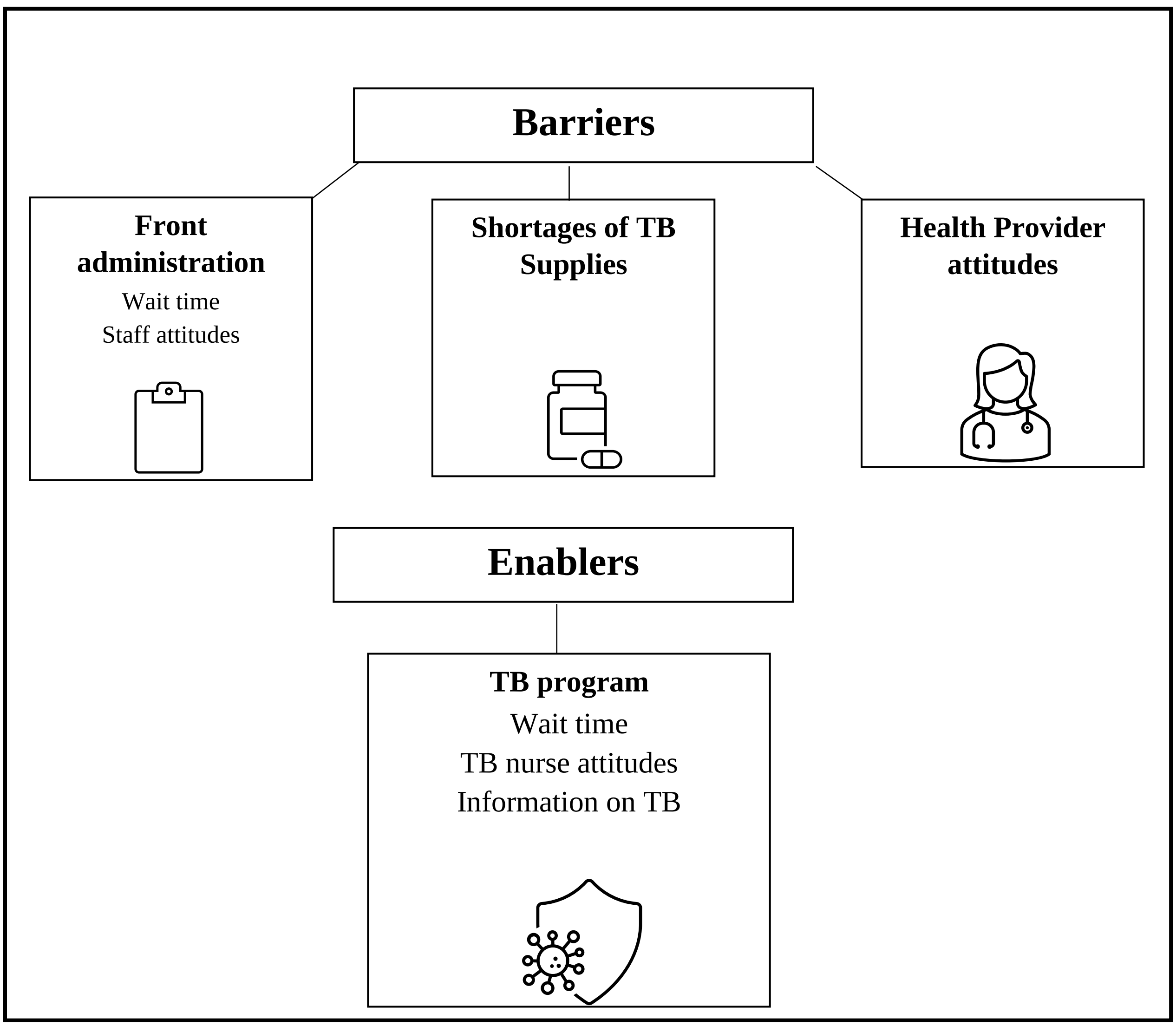

Figure 1 Barriers and enablers to quality TB services identified by patients.

Barriers

Front administration

Wait times

Before consulting with a health professional patients must first register at the front of the clinics and collect their files. Patients expressed discontentment with the amount of time they had to wait at the front of the clinics. In certain instances, patients complained of staff socializing among themselves and being on their phones instead of working which lengthened longer wait times.

"*There are those who don't do their jobs properly they will make patients wait for instance what usually happens in the front…the people in front should pay attention to the patients, fix those kinds of things. When patients have arrived, they need to take care of them because in the end they say they are helping us, but they are only helping themselves. Other times you'll find that by the time you receive help, you are very annoyed you'll even want to leave. Sometimes you must make a fuss and complain before you get help, only then will they help you or start moving quickly.*" **P#6**

"But what I would complain about is that side (front of the clinic) is slow in terms of getting your file, you can't just come here without your file so you could wait 30 minutes to an hour that side just to get your file before coming to this side. That's the only thing I see as an issue." **P#9**

However, some patients were fine with waiting long hours because they were aware that healthcare facilities deal with a large patient load.

"I: So, you believe two hours is fast? P: Yes, yes, yes. It's not bad because it's not like you are first in line you are in front of others in the queue you see" **#P3**

Administration staff attitudes

Patients complained about the attitudes displayed by the staff at the front desk of the clinic. In certain instances, staff members were rude and unwilling to expedite patients who believed themselves to be severely ill.

"*For instance, when I got here, I was very sick you could tell that I was in no condition to be waiting in line I was supposed to get the help I needed and go home. When I first got here, I couldn't even talk because of the coughing. They just stared at me, so, I waited for a bit on the benches all the while I was coughing uncontrollably*" **#P5**

Shortages in TB medication

Patients shared frustrations with facilities running out of their TB treatment and believed that the staff were not forthcoming about the reasons for these shortages.

"They tend to run out of pills… These are our lives, if they have explained to a person that these are the pills that they should take, and that they must make sure to always take them all, you tell yourself that all the pills have a specific role. So now when they don't give me all my pills and they tell me that it's okay, I begin to doubt whether these pills work. So, I have come here and the pills that I came for are finished which makes me think that I should have just continued drinking the ones I have at home because the pills they gave me today I already have." **#P4**

Health provider attitudes

Negative interactions with healthcare providers were experienced by some patients. Some believed that their TB nurses were apathetic showing no regard for their concerns.

"*I think the way that they assist us and our concerns mustn't be treated like they don't matter… They should pay more attention to us the patients. They should listen to our needs, and let us meet each other halfway in a way. It mustn't feel that just because you know more things than us then what we have to say doesn't matter."* **#P4**

One patient even described an instance where the results that would allow them to progress from the intensive phase to the continuation phase not changing and how the TB nurse would not give a possible explanation for this.

"*Even now they haven't explained once why my results won't change. They just told me that my results aren't changing. When I asked the nurse who usually helps me why my results won't change they just kept quiet and did not explain the possible reasons for the lack of change and not knowing why my results were not changing bothered me."* **#P2**

Enablers

TB program

Wait times

Although many patients complained about the wait times at the front of the clinic, they were happy with the short wait times at the TB department.

"So, at the clinic, it's slow but here on the TB side things move quickly." **#P9**

"It's not bad because it's not like you are first in line you are behind others in the queue you see, because as I speak to you, I'm about to be assisted and I don't believe an hour has gone by since I have arrived… Things move fast on this side." **#P3**

There were instances of patients presenting to the clinics for the first time in critical condition and clinic staff including the TB nurses made sure to attend to them urgently.

"I have never had to because the first time I came to the clinic I was not OK I was sick and using a wheelchair so when I arrived things were expedited for me the sister fetched my file and card they would be the one running around for me" **P#2**

Healthcare provider attitudes

Although patients complained of the negative interactions with the staff at the front of the clinic, many patients were happy and grateful for the level of service and care displayed by their TB nurses. They believed the nurses to be attentive, patient, and concerned with their recovery process.

"They care especially here on the TB side, the way that they speak to you and how they treat you. You know when you come in, she (nurse) doesn't even have to look at your file, she knows you which means she cares about you and your wellbeing, she doesn't forget you." **#P9**

"This nurse over here he works and he has no issue with explaining things, he even asks you if you understood everything and allows you to ask questions so it's easy when you receive help from him, by following his instructions to see results because even with me if you saw what I looked like when I first got here I was about 30 something kilograms today that has changed it is about 60 something every time I weigh myself meaning there is improvement and that's because of that man in there." **#P3**

Information on TB

Before their diagnosis patients admitted to having a rudimentary knowledge of the disease which they either received from school or listening to the radio, however, believed that the nurses equipped them with relevant TB information. The patients mentioned that nurses informed them on the length of TB treatment and the behaviors that they should avoid while on treatment but the most helpful was information on treatment side effects.

"I would say I had a basic knowledge of the disease, the things that I remember are from school… They told me before I was initiated that I shouldn't be surprised when my urine changes, my urine will change. I also shouldn't be alarmed when time goes by, and my body starts to itch you see. They also said that I shouldn't be surprised after a while if I get pimples on my face or break out in a rash throughout my body. Even with me, the pimple started around February but that wasn't a surprise because it's something that I had been told about. My body did itch but not for long I just got pimples on my face. I would say the things they told me helped me with what was to come." **#P7**

There was only one instance where a patient complained of the nurse not informing them about treatment side effects but they noted that the nurse was forthcoming about the side effects when they came back to query.

"*What I noticed were the side effects from taking the pills. They should have told me that this is what to expect, and then from there, I could categorize whether I have certain symptoms or not. I noticed side effects but when I came back to query about them stating that strange things were happening to me, they told me that those were side effects. I was wondering why the strange things were happening like my skin itching 24/7 even when I scratch it. They told me it was because of the pills that I am taking, some people itch while others swell, I also suffered from constipation and my pee was red, yeah these are things I didn't know that I just experienced so I came to ask about whether they were normal and I told it was because of the pills*." **#P6**

Discussion

In the current study, patients identified the barriers and enablers to quality TB services at clinics in eThekwini. A barrier to early diagnosis was patients seeking care in the private sector because they believed their symptoms to be flu-related. Regarding quality of care, staff attitudes and wait times at file collection and registration, treatment shortages and health worker attitudes were identified as factors impeding quality care. On the other hand, the overall experience with the TB program at various facilities was highlighted as an enabler. This included the TB provider attitudes, wait times, and the information on TB that the patients received.

In many Low- and middle-income countries (LMICs), a lack of trust in public healthcare systems or having to travel long distances to health facilities manifests itself in patients seeking private healthcare for TB symptoms [12, 30-32]. Of the 47% of patients lost throughout the TB care cascade in South Africa, only 5% never receive a test, signaling that access does not impede diagnostic services [33]. This was congruent with our findings that saw patients self-medicating or seeking out private healthcare providers from a belief that their symptoms were flu-related and would quickly resolve rather than difficulty accessing PHCs. This misinterpretation of symptoms resulted in diagnostic delays that averaged 3.3 weeks. Misconceptions about TB symptoms coincided with another study finding where patients admitted to having little knowledge of the disease before their diagnoses. However, the reported diagnostic delays from our study were shorter than in other settings [31, 34]. It has been recognized that same-day diagnosis and treatment using molecular tests like Xpert MTB/RIF can assist in reducing diagnostic delays [26]. Nonetheless, this was not the reality for the patients in this study, who waited several days to receive a diagnosis. Approximately 13% of patients are lost to follow-up (LTFU) at this stage of the care cascade, which is partly due to patients not returning for results [33]. Xpert MTB/RIF has been used in South Africa for over a decade; however, their position at centralized laboratories greatly undermines their ability to provide same-day diagnosis [35]. Although patients from this study were already within the continuum of care there is still a need to reduce diagnostic delays by raising public awareness of TB symptoms and providing true point-of-care tests capable of producing a diagnosis on a patient's initial visit. A true point-of-care test reduces diagnostic delays and the economic burden of multiple clinic visits.

Lengthy wait times at health facilities are associated with patient dissatisfaction [36-38]. This factor was recognized as a barrier to quality of care. However, rather than complaints about the generic waiting time, patients expressly point to the delays experienced at card registration. This is because every patient must first collect their file and, in many facilities, the lack of appointment and queue management systems leads to overcrowding and long lines [39]. These systems have effectively reduced wait times in some South African clinics [38]. Ideally, it has been stipulated that clinic visits in South Africa should not exceed 3 hours [39]. Notably, patients praised the speed at which they received care after this file registration. This is likely because of efforts to reduce nosocomial TB infection in South Africa, which sees TB patients “fast-tracked,” resulting in less time at facilities compared to other clinic goers [39]. Another South African study found that the acceptability of TB services at clinics was higher than that of other services because they were easier to navigate [40]. Despite this, some patients from our study were displeased with interactions with TB providers, which left them feeling unheard and disempowered. This type of apathy and failure from healthcare providers to facilitate effective communication with patients has been linked to losses in follow-up [41]. Healthcare workers must create conversational environments where patients can voice their preferences and receive tailored care that achieves treatment success. Some nurses are already fostering this kind of patient-centered care, as many patients in the study highlighted that TB nurses' treatment, respect, and care were the best part of their TB journeys. Whether this positive user experience translates to better outcomes or retention in care should be studied further. Furthermore, the cause for the discrepant care from providers at various facilities should also be explored to improve and ensure quality services for all patients in eThekwini.

Drug stockouts were another barrier identified in the study. These are common in South Africa [42, 43], however, their occurrence reinforces negative perceptions and distrust in public healthcare [20]. These sentiments were echoed by a patient who questioned the effectiveness of their treatment after receiving an incomplete regimen without proper explanation. This lack of transparency undermines the quality of care by breeding mistrust, moreover, the failure to provide the correct treatment exposes patients to drug resistance, treatment interruptions, treatment failure, and possible death [43]. So beyond providing an accurate diagnosis, facilities must also promptly initiate patients onto treatment and ensure an adequate supply of medicines throughout a patient’s TB journey. To achieve this, facilities should identify the weaknesses in their supply chain and implement robust monitoring and reporting systems.

A strength of the study was that it was conducted in a region of South Africa with a high TB burden to gain an in-depth understanding of the quality of TB services from the patient’s perspective. Some limitations were that provider perspectives were not considered, which may have given valuable insight into some health system-related factors that enable or impede quality services. The study was isolated to one district and may not be transferable to other settings. Since interviews were conducted at health facilities patients may have been hesitant to share all their reservations about where they were still receiving treatment.

Conclusion

The quality of TB services at primary healthcare clinics in eThekwini District, South Africa, is a critical factor in the fight against TB. Patient perspectives provide valuable insights into the strengths and weaknesses of these services. The study showed that knowledge of TB symptoms caused patients to present later to health facilities. Moreover, patients identified several barriers hindering the quality of TB services which include long wait times, negative provider attitudes, and shortages of TB drugs. These influence treatment adherence, increases diagnostic delays, and LTFU. Interventions are needed to tackle these barriers to improve case detection and retention in care to enhance the quality of care. Conversely, the patient-centeredness and respect displayed by TB nurses and the short wait times at the TB department were all enabling factors of quality. Whether this translates to better outcomes should be investigated and the findings should be used to strengthen the quality of TB care for patients.

List of Abbreviations

DS-TB:	Drug-susceptible TB
LMICs:	Low- and middle- income countries
LTFU:	Loss to follow-up
PHC:	Primary HealthCare Clinic
PI:	Principal Investigator
SDGs:	Sustainable Development Goals
TB:	Tuberculosis
WHO:	World Health Organization

UN: United Nations

UNHLM: United Nations High-Level Meeting

References

1. **Global Tuberculosis Report** [https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2022]
2. **Global tuberculosis report** [https://www.who.int/teams/global-tuberculosis-programme/tb-reports]
3. Dlangalala T, Musekiwa A, Brits A, Maluleke K, Jaya ZN, Kgarosi K, Mashamba-Thompson T: **Evidence of TB Services at Primary Healthcare Level during COVID-19: A Scoping Review**. *Diagnostics* 2021, **11**(12):2221.
4. **End TB Strategy** [https://www.who.int/tb/End_TB_brochure.pdf?ua=1]
5. **Sustainable Development Goals** [https://unstats.un.org/sdgs/metadata/?Text=&Goal=3&Target=3.3]
6. Sahu S, Ditiu L, Sachdeva KS, Zumla A: **Recovering from the Impact of the Covid-19 Pandemic and Accelerating to Achieving the United Nations General Assembly Tuberculosis Targets**. *International Journal of Infectious Diseases* 2021.
7. Pai M, Temesgen Z: **Quality: The missing ingredient in TB care and control**. *Journal of clinical tuberculosis and other mycobacterial diseases* 2018, **14**:12-13.
8. Kruk ME, Gage AD, Arsenault C, Jordan K, Leslie HH, Roder-Dewan S, Adeyi O, Barker P, Daelmans B, Doubova SV *et al*: **High-quality health systems in the Sustainable Development Goals era: time for a revolution**. *The Lancet Global Health* 2018, **6**(11):e1196-e1252.
9. Cazabon D, Alsdurf H, Satyanarayana S, Nathavitharana R, Subbaraman R, Daftary A, Pai M: **Quality of tuberculosis care in high burden countries: the urgent need to address gaps in the care cascade**. *International Journal of Infectious Diseases* 2017, **56**:111-116.
10. Mehra C, Lokhande D, Chavan D, Rane S: **What quality of care means to tuberculosis survivors**. *Journal of Clinical Tuberculosis and Other Mycobacterial Diseases* 2020, **19**:100157.
11. Cazabon D, Pande T, Sen P, Daftary A, Arsenault C, Bhatnagar H, O'Brien K, Pai M: **User experience and patient satisfaction with tuberculosis care in low- and middle-income countries: A systematic review**. *J Clin Tuberc Other Mycobact Dis* 2020, **19**:100154.

12. Arsenault C, Roder-DeWan S, Kruk ME: **Measuring and improving the quality of tuberculosis care: A framework and implications from the Lancet Global Health Commission**. *Journal of Clinical Tuberculosis and Other Mycobacterial Diseases* 2019, **16**:100112.
13. McDowell A, Engel N, Daftary A: **In the eye of the multiple beholders: Qualitative research perspectives on studying and encouraging quality of TB care in India**. *Journal of Clinical Tuberculosis and Other Mycobacterial Diseases* 2019, **16**:100111.
14. Haldane V, Zhang Z, Ma Q, Yin T, Zhang B, Li Y, Pan Q, Dainty KN, Rea E, Pasang P *et al*: **A qualitative study of perspectives on access to tuberculosis health services in Xigaze, China**. *Infectious Diseases of Poverty* 2021, **10**(05):28-39.
15. Gele AA, Sagbakken M, Abebe F, Bjune GA: **Barriers to tuberculosis care: a qualitative study among Somali pastoralists in Ethiopia**. *BMC Research Notes* 2010, **3**(1):86.
16. Needham DM, Bowman D, Foster SD, Godfrey-Faussett P: **Patient care seeking barriers and tuberculosis programme reform: a qualitative study**. *Health Policy* 2004, **67**(1):93-106.
17. Aibana O, Dauria E, Kiriazova T, Makarenko O, Bachmaha M, Rybak N, Flanigan TP, Petrenko V, Becker AE, Murray MB: **Patients' perspectives of tuberculosis treatment challenges and barriers to treatment adherence in Ukraine: a qualitative study**. *BMJ Open* 2020, **10**(1):e032027.
18. Anthoney J, De Wildt G, Meza G, Skelton J, Newell I: **Patients' perspectives on factors facilitating adherence to tuberculosis treatment in Iquitos, Peru: a qualitative study**. *BMC Health Services Research* 2021, **21**(1).
19. Pradipta IS, Idrus LR, Probandari A, Lestari BW, Diantini A, Alffenaar J-WC, Hak E: **Barriers and strategies to successful tuberculosis treatment in a high-burden tuberculosis setting: a qualitative study from the patient's perspective**. *BMC Public Health* 2021, **21**(1).
20. Cattamanchi A, Miller CR, Tapley A, Haguma P, Ochom E, Ackerman S, Davis JL, Katamba A, Handley MA: **Health worker perspectives on barriers to delivery of routine tuberculosis diagnostic evaluation services in Uganda: a qualitative study to guide clinic-based interventions**. *BMC Health Services Research* 2015, **15**(1):10.
21. Bhatnagar H: **User-experience and patient satisfaction with quality of tuberculosis care in India: A mixed-methods literature review**. *Journal of Clinical Tuberculosis and Other Mycobacterial Diseases* 2019, **17**:100127.
22. Dlangalala T, Musekiwa A, Mashamba-Thompson T: **Towards development of a novel approach for enhancement of TB diagnostic services during the pandemic: A case of primary health care clinics in eThekwini district KwaZulu-Natal: A study protocol**. *PLOS ONE* 2022, **17**(12):e0278305.

23. Kivunja C, Kuyini AB: **Understanding and applying research paradigms in educational contexts**. *International Journal of higher education* 2017, **6**(5):26-41.
24. **eThekwini District Health Plan 2015/16** [http://www.kznhealth.gov.za/Strategic/DHP/2015-16/ethekwini.pdf]
25. Osman M, Karat AS, Khan M, Meehan S-A, Von Delft A, Brey Z, Charalambous S, Hesseling AC, Naidoo P, Loveday M: **Health system determinants of tuberculosis mortality in South Africa: a causal loop model**. *BMC Health Services Research* 2021, **21**(1).
26. Boehme CC, Nicol MP, Nabeta P, Michael JS, Gotuzzo E, Tahirli R, Gler MT, Blakemore R, Worodria W, Gray C *et al*: **Feasibility, diagnostic accuracy, and effectiveness of decentralised use of the Xpert MTB/RIF test for diagnosis of tuberculosis and multidrug resistance: a multicentre implementation study**. *The Lancet* 2011, **377**(9776):1495-1505.
27. **Welcoming remarks by KZN Health MEC, Nomagugu Simelane, on the occasion of the 7th SA TB Conference** [https://www.kznhealth.gov.za/mediarelease/2022/welcoming-remarks-sa-tb-conference-13092022.htm]
28. Hennink M, Kaiser BN: **Sample sizes for saturation in qualitative research: A systematic review of empirical tests**. *Social Science & Medicine* 2022, **292**:114523.
29. Braun V, Clarke V: **Using thematic analysis in psychology**. *Qualitative Research in Psychology* 2006, **3**:77-101.
30. Reid MJA, Arinaminpathy N, Bloom A, Bloom BR, Boehme C, Chaisson R, Chin DP, Churchyard G, Cox H, Ditiu L *et al*: **Building a tuberculosis-free world: The Lancet Commission on tuberculosis**. *The Lancet* 2019, **393**(10178):1331-1384.
31. Sreeramareddy CT, Qin ZZ, Satyanarayana S, Subbaraman R, Pai M: **Delays in diagnosis and treatment of pulmonary tuberculosis in India: a systematic review**. *The International Journal of Tuberculosis and Lung Disease* 2014, **18**(3):255-266.
32. Storla DG, Yimer S, Bjune GA: **A systematic review of delay in the diagnosis and treatment of tuberculosis**. *BMC Public Health* 2008, **8**(1):15.
33. Naidoo P, Theron G, Rangaka MX, Chihota VN, Vaughan L, Brey ZO, Pillay Y: **The South African Tuberculosis Care Cascade: Estimated Losses and Methodological Challenges**. *J Infect Dis* 2017, **216**(suppl_7):S702-s713.
34. Santos JA, Leite A, Soares P, Duarte R, Nunes C: **Delayed diagnosis of active pulmonary tuberculosis - potential risk factors for patient and healthcare delays in Portugal**. *BMC Public Health* 2021, **21**(1).

35. Lawn SD, Kerkhoff AD, Wood R: **Location of Xpert® MTB/RIF in centralised laboratories in South Africa undermines potential impact [Correspondence]**. *The International Journal of Tuberculosis and Lung Disease* 2012, **16**(5):701-701.
36. Anderson RT, Camacho FT, Balkrishnan R: **Willing to wait?: The influence of patient wait time on satisfaction with primary care**. *BMC Health Services Research* 2007, **7**(1).
37. Michael M, Schaffer SD, Egan PL, Little BB, Pritchard PS: **Improving Wait Times and Patient Satisfaction in Primary Care**. *Journal for Healthcare Quality* 2013, **35**(2):50-60.
38. Egbujie BA, Grimwood A, Mothibi-Wabafor EC, Fatti G, Tshabalala AMET, Allie S, Vilakazi G, Oyebanji O: **Impact of 'Ideal Clinic' implementation on patient waiting time in primary healthcare clinics in KwaZulu-Natal Province, South Africa: A before-and-after evaluation**. *South African Medical Journal* 2018, **108**(4):311.
39. Karat AS, McCreesh N, Baisley K, Govender I, Kallon II, Kielmann K, Macgregor H, Vassall A, Yates TA, Grant AD: **Estimating waiting times, patient flow, and waiting room occupancy density as part of tuberculosis infection prevention and control research in South African primary health care clinics**. *PLOS Global Public Health* 2022, **2**(7):e0000684.
40. Bucyibaruta BJ, Eyles J, Harris B, Kabera G, Oboirien K, Ngyende B: **Patients' perspectives of acceptability of ART, TB and maternal health services in a subdistrict of Johannesburg, South Africa**. *BMC Health Services Research* 2018, **18**(1):839.
41. Moodley N, Saimen A, Zakhura N, Motau D, Setswe G, Charalambous S, Chetty-Makkan CM: **'They are inconveniencing us' - exploring how gaps in patient education and patient centred approaches interfere with TB treatment adherence: perspectives from patients and clinicians in the Free State Province, South Africa**. *BMC Public Health* 2020, **20**(1).
42. Koomen LEM, Burger R, Van Doorslaer EKA: **Effects and determinants of tuberculosis drug stockouts in South Africa**. *BMC Health Services Research* 2019, **19**(1).
43. Hwang B, Shroufi A, Gils T, Steele SJ, Grimsrud A, Boulle A, Yawa A, Stevenson S, Jankelowitz L, Versteeg-Mojanaga M *et al*: **Stock-outs of antiretroviral and tuberculosis medicines in South Africa: A national cross-sectional survey**. *PLOS ONE* 2019, **14**(3):e0212405.

Declarations

Ethics approval and consent to participate

All methods were carried out in accordance with the declaration of Helsinki and the South African POPIA act. The study was approved by the University of Pretoria's Health Sciences Research Ethics Committee (Ref No. 652/2021) and the Health Research and Management unit of the KZN Department of Health (Ref

No. KZ_202112_012). Further approval was sought and obtained from the eThekwini Health unit to gain access to the municipal clinics. Lastly, all patients who participated in the interviews gave written informed consent before the interviews took place.

Consent for publication

Not applicable.

Competing interests

The authors have no competing interests to declare.

Authors contribution

TD conceptualized the study, undertook data collection, data analysis and wrote the first draft of the manuscript under the supervision of TM-T and AM. TM-T and AM critically reviewed the final draft. All authors have read and agreed to the final version of the manuscript.

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Availability of data and materials

The anonymized data that was generated and analyzed is available from the corresponding author upon reasonable request.

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Chapter 7 Manuscript Addressing Objective 4

Chapter 6 evaluated the quality of TB diagnostic services at PHCs using an audit and patient interviews, which highlighted the areas that need improvement. In objective four, the challenges that faced diagnostic services, specifically during the pandemic, are explored. This was done to co-create an approach to improve these services for high-burden settings using a Nominal Group Technique (NGT).

Thus, chapter 7 presents the methods and findings of the NGT. The chapter has been presented in a manuscript format in line with the target journal. The manuscript is currently being considered for publication by the journal *Discover Health Systems* under the title: "*Enhancing TB diagnostic services at primary healthcare clinics in the eThekwini district, South Africa, post-COVID-19: a nominal group technique*"

Enhancing TB diagnostic services at primary healthcare clinics in the eThekwini district, South Africa, post-COVID-19: a nominal group technique

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1. Abstract

The widespread disruption of Tuberculosis (TB) services due to the COVID-19 pandemic led to significant reductions in TB detection in many high-disease-burden countries. This was true for South Africa, which sustained the highest incidence of COVID-19 in Africa. Therefore, the strengthening of the current diagnostic services is paramount for pandemic preparedness. This study proposed an approach to enhance TB diagnostic services at primary healthcare clinics (PHCs) in the eThekwini district, South Africa, through collaboration with TB stakeholders. An online nominal group technique (NGT) was conducted in two phases; in the first phase, TB stakeholders identified the barriers to diagnostic services during the COVID-19 pandemic. In phase 2, solutions for the top five barriers were proposed. The most significant barriers identified were the misdiagnosis of TB, financial difficulties, fear of contracting COVID-19, the neglect of TB, and long waiting periods at PHCs. Seventeen strategies were proposed to overcome barriers. Together, these strategies constitute the improved approach to diagnostic services. The strategies included integrating TB and COVID-19 services, decentralizing TB testing to mobile clinics, the use of Point-of-Care (POC) diagnostics, increasing PHC staff, universal mask-wearing, and use of social media as an education platform for TB and emergent diseases. In conclusion, TB stakeholders proposed sustainable holistic strengthening of TB diagnostic services at PHCs in eThekwini. The solutions offered should be assessed for feasibility and implemented where possible.

2. Introduction

Resilience is a hallmark of a high-quality health system. It is marked by the capacity for and response to crisis without disrupting essential functions and being amenable to change when situations demand it.[1] The advent of the Coronavirus disease 2019 (COVID-19) caused significant disruptions to health systems through the prioritization of health resources to pandemic response at the global and national level.[2] The focus on the COVID-19 pandemic response was shown to be detrimental to managing other epidemics, such as Tuberculosis (TB).[2] A survey by the Global Fund to Fight Against AIDS, Tuberculosis, and Malaria showed that 78% of countries experienced disruptions to their respective TB programs during COVID-19.[3] South Africa was not immune to these disruptions caused by the COVID-19 pandemic.

South Africa reported the highest COVID-19 incidence in Africa, accounting for 34% of the continent's cases.[4] This occurred while the country continued to grapple with the long-standing TB epidemic. In 2021, 513 TB cases per 100 000 population were reported, making South Africa one of the countries with the highest TB incidence globally.[5] The TB burden is closely linked to the HIV epidemic. In 2021, the World Health Organization (WHO) estimated that of 56 000 people who died from TB in South Africa, 59% were TB-HIV co-infected.[5] The burden of both diseases disproportionately affects the east coast provinces.[2] In the Kwa-Zulu Natal (KZN) province notably, TB has been reported as one of the leading causes of death throughout all age groups.[6]

Early disease detection has been shown to have a positive impact on curbing community spread.[7,8] It is therefore concerning that TB detection in the KZN province began to decline between 2019 and 2020 because of the COVID-19 pandemic. In a recent study, we showed that the confirmed TB cases in KZN's eThekwini district sustained reductions throughout the pandemic with a slight recovery.[9] This comes after the province had made marked strides toward improving TB incidence rates within the past decade.[10] Therefore, in addition to catch-up plans, the holistic strengthening of diagnostic services is required to continue progressing toward ending TB.

Since the disruptions by COVID-19, multiple strategies aimed at achieving the abovementioned goals are in place. In South Africa, the government has launched its National Strategic Plan (NSP) for 2023-2028, in which a detailed multi-sectoral approach to reduce barriers and improve access to equitable TB, HIV, and STI services is presented.[11] To complement these plans, we collaborated with key stakeholders to co-create an approach for enhancing TB diagnostic services at primary healthcare clinics within the eThekwini district, using lessons learned from COVID-19. It is anticipated that this approach can aid in delivering targeted context-specific solutions for eThekwini and similarly affected high-burden regions. Furthermore, the implementation of the proposed solutions can assist in the strengthening of PHCs for pandemics and analogous health emergencies.

3. Methods

3.1 Study design

A nominal group technique (NGT) was employed; this is a structured group discussion that allows participants to reach a consensus on a topic.[12,13] For this study, a stakeholder was defined as someone with experience or expertise navigating TB diagnostic services at the PHC level. The current study forms a part of a bigger research project.[14] In the first phase of the study, we conducted a geospatial analysis to map the geographic accessibility of TB diagnostic services in the eThekwini district. In the second phase, the impact of COVID-19 on TB diagnostic services was assessed.[9] Phase 3 examined the barriers and enablers to providing quality diagnostic services. The NGT formed the last phase of the study and was based on the findings from phase 2.

3.2 Sampling and recruitment of participants

Eight stakeholders took part in the NGT. The literature has shown that member of between 5-12 are the most conducive for discussions and reaching consensus during NGTs.[12,13] These were chosen at the primary investigator's discretion as those who could contribute invaluable insight and solutions to the issues facing TB diagnostic services during the COVID-19 pandemic. Purposive criterion-based sampling was initially used. The participants were invited by email which explained the purpose of the NGT. If a participant was unavailable or felt another individual was better suited for the workshop, snowballing was used to recruit the recommended individual.

3.3 Data collection

Due to the varying locations of the participants and the inability of some to take time off work, the discussion was conducted online using the Google Meet platform. The principal investigator and a research assistant facilitated the NGT session, which was recorded. The different steps involved in an NGT are depicted in Figure 1.

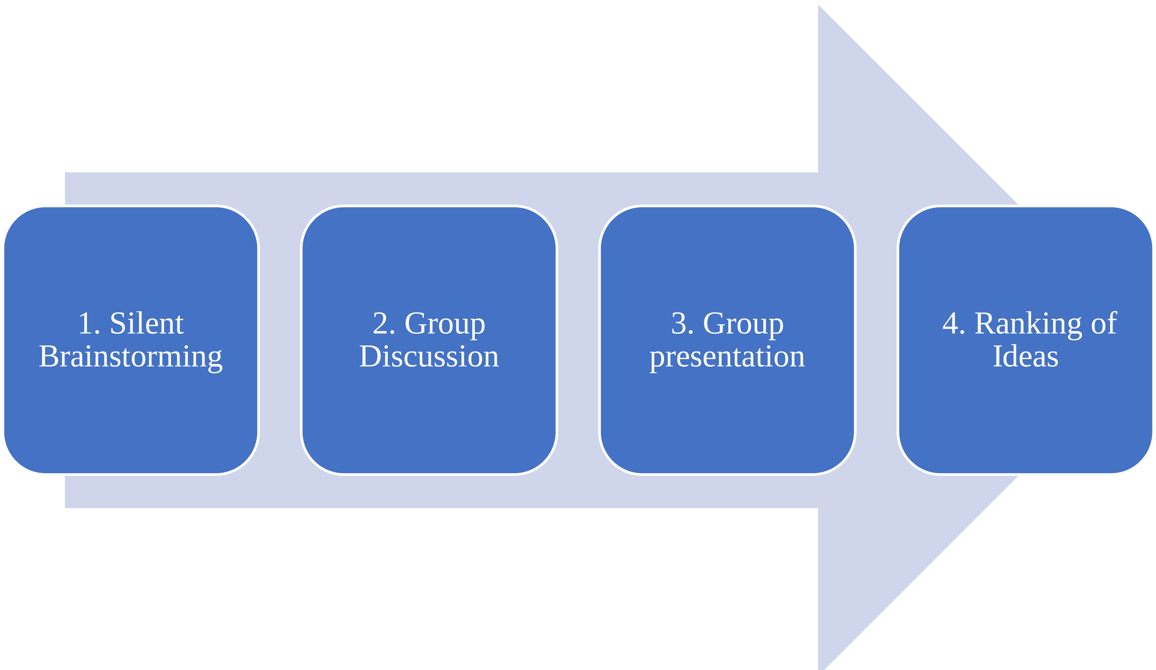

Figure 1 The four steps of an NGT

The Nominal group technique was conducted in two stages:

During the first phase, the meeting began with brief introductions from the attendees. Following introductions, participants were requested to share barriers encountered when attempting to provide TB diagnostic services during the COVID-19 pandemic at the PHC level. Next, the members were given five minutes to privately brainstorm their ideas before each participant shared them with the group. After every member had shared their ideas, the participants proceeded to clarify and add more ideas. During the discussion, the research assistant categorized the ideas into themes representing different barriers. The barriers were compiled into a Google form and distributed to the participants to rank using a Likert scale that ranged from 1 (representing the least severe) to 7 (representing the most severe).

In the second phase of the NGT, the stakeholders were presented with the top five barriers that emerged after voting and asked to propose strategies for each. The same steps from the previous stage were followed, which began with the silent generation of ideas and concluded with the ranking of ideas using a Likert scale. The strategies proposed were categorized according to the headings that make up the Swiss Cheese Model for Ending TB.[15] The model states that societal, health system and personal factors must be concurrently addressed to end the TB epidemic.

3.4 Data management and analysis

The quantitative data that were generated during the ranking step of each phase were given a priority score. This was done by adding the total votes for each barrier/strategy, respectively. The qualitative data was analyzed using thematic content analysis, where the data from discussions was inductively placed into themes.

3.5 Ethical consideration

This research was reviewed and approved by the University of Pretoria's Faculty of Health Sciences Research Ethics Committee, reference number 652/2021, and the Health Research and Management unit of the KZN Department of Health (Ref No. KZ_202112_012). All participants gave written consent before participating in the NGT.

4. Results

4.1 Characteristics of the Participants

A total of 8 participants took part in the NGT. Seven participants (87.5%) were women, and one (12.5%) was a man. The participants' roles in TB services varied from patients to healthcare providers, and to researchers. Two participants (25%) were TB patients, four were researchers (50%) and two (25%) were nurses (Table 1).

Table 1. Characteristics of the study participants.

Gender	Age in years	Occupation	Role in TB services
Female	24	Health Science student	End-user (Patient)
Male	33	Retail Assistant	End-user (Patient)
Female	25	Junior researcher	Health Researcher
Female	32	Post-doctoral researcher	Researcher (Implementation of point-of-care diagnostics)
Female	32	Post-doctoral researcher	Researcher (TB therapeutics)
Female	33	Post-doctoral researcher	Researcher (Implementation of point-of-care diagnostics)
Female	32	Clinical Nurse Practitioner	Healthcare provider
Female	35	Professional Nurse	Healthcare provider

4.2 Stakeholder perspectives on barriers to TB diagnostic services at PHCs during COVID-19 pandemic

Stakeholders identified eight barriers to TB diagnostic services during the COVID-19 pandemic (Figure 2). For each barrier, the voting score given by each participant were added to determine a total score out of 56. The voting process recognized misdiagnosis of TB due to shared symptoms with COVID-19 as the largest barrier, with a score of 48/56. Financial difficulties preventing people from presenting to clinics and the fear of contracting COVID-19 infection at the health facilities ranked as the second highest barriers, each with a score of 47/56. The neglect of TB due to COVID-19 ranked fourth (46/56) and long wait times at health facilities were the fifth highest barrier with a total score of 41/56. The stakeholders considered reduced awareness of symptoms as the least important barrier (39/56). This was followed by a long turnaround time to receive TB test results (32/56).

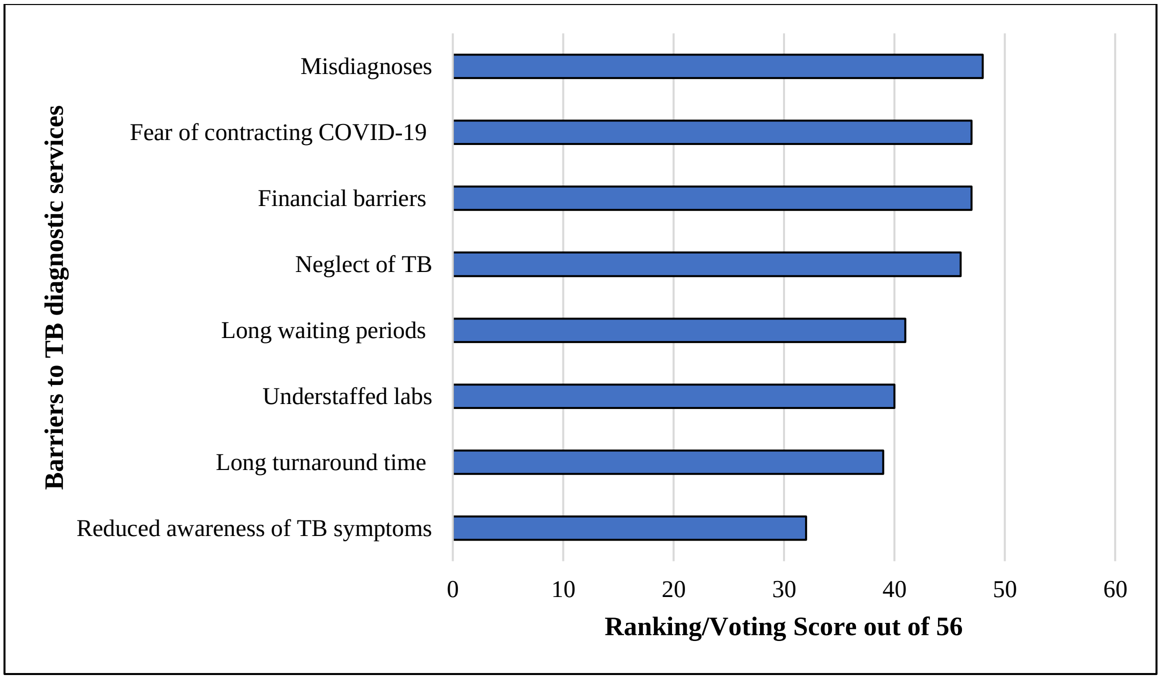

Figure 2 Barriers to TB diagnostic services in eThekwini during the COVID-19 pandemic

4.3 Development of the enhanced approach to TB diagnostic services during COVID-19 pandemic

4.3.1 Proposed strategies for TB diagnostic services

The stakeholders suggested 17 strategies for improving TB diagnostic services during the COVID-19 pandemic. These strategies were based on the top five barriers. These form part of the improved approach to diagnostic services. To determine the priority score for each strategy, we added the scores from each vote to determine a total (out of 56). The scores were then converted to percentages. The strategies and their priority scores are listed in Table 2. The presented strategies should constitute the enhanced approach for TB testing services in eThekwini. The scores can determine which strategies to prioritize when implementing the approach.

To overcome the misdiagnosis of TB and COVID-19, the stakeholders voted dual testing and screening as the most effective strategies, with scores of 89% and 82%, respectively. For improving the neglect of TB services at the start of the pandemic, dual testing (92%) and learning from the mistakes made during the pandemic (75%) received the highest votes. Increasing human resources at clinics (95%) and decentralizing TB testing (77%) to communities through mobile clinics were deemed the most important solutions for overcoming long waiting times. The introduction of at-home POC tests (95%) and mobile clinics (89%) were voted the most important strategies for alleviating financial barriers that were associated with visiting clinics during the start of the pandemic. To overcome the fear of contracting COVID-19 infection at clinics, social media was suggested as a platform that could be used to communicate about the safety of facilities and address misinformation and stigma of both diseases (96%). The universal use of masks within the clinics by nurses and patients was also voted an important strategy for overcoming the fear of contracting COVID-19 infection (91%).

Table 2. Strategies for improving TB diagnostic services and their priority scores.

Proposed strategies for improving the top barriers to TB diagnostic services during COVID-19	**No. of votes received from 1-7 1 = low priority 7 = high priority**							**Total score/56**	**Percentage (%)**
	1	2	3	4	5	6	7		
Misdiagnosis of TB									
Dual testing					2	2	4	50	**89**
Dual screening					1	4	3	46	**82**
Health education on TB symptoms for health providers	1				2	1	4	45	80
Public awareness of TB symptoms			1	1	1	2	3	45	80
Neglect of TB									
Dual testing						2	6	52	**92**
Learn from mistakes made during COVID-19.		1		2		3	2	42	**75**
Continuous TB training/education	1				2	1	4	40	71
Long wait times									
Increase human resources					1	1	6	53	**95**
Mobile clinics		1	1		2		4	43	**77**
POC tests	1			2	2		3	40	71
Wait time estimators	1		1		1	4	1	40	71
Financial barriers									
At home tests					1	1	6	53	**95**
Mobile clinics			1		1		6	50	**89**

Address underlying poverty					5	3	1	45	80
Fear of getting COVID-19									
Use social media to disseminate information and combat misinformation.						2	6	54	**96**
Universal mask use				1		2	5	51	**91**
Strengthening infection, prevention and control (IPC)				1	3		4	41	73

4.3.2 Categorization of Strategies according to the Swiss Cheese model

The Swiss Cheese Model which was adapted for TB by Zimmer and Colleagues, acknowledges that effective elimination of TB can only be achieved by targeting different levels of the disease.[15] Therefore, we grouped all the strategies and the barriers they address according to the three levels (health system, societal and personal) that comprise the model (Table 3; Figure 3).

Health system

The following strategies enable the strengthening of health systems in various ways. First, integrating COVID-19 and TB responses (screening and testing) would minimize misdiagnosis and reduce the chances of "missing" a potential TB diagnosis. For the same purpose, healthcare workers receiving continuous training, including identifying atypical TB symptoms, can mitigate misdiagnosis. Second, strengthening infection prevention and control (IPC) measures can boost public confidence in the safety of health facilities while preventing nosocomial infections. Finally, point-of-care (POC) testing can help reduce waiting times by lowering the time spent inside the facility. Likewise, decentralizing TB testing to mobile clinics or TB within the community can also help reduce wait times by alleviating the workload of healthcare workers at facilities. It is also important to create systems that inform patients of the expected waiting time so that they can make informed decisions on whether to stay at a given PHC or seek help elsewhere.

Societal

Some of the strategies that were suggested for health system strengthening can be used to address societal barriers. For instance, decentralizing TB testing to the communities through mobile clinics can help to overcome financial barriers associated with accessing PHCs. Similarly, introducing at-home TB tests (like those used for COVID-19) can bring healthcare to the patient's doorstep.

Furthermore, the stakeholders acknowledged the social relief grants provided by the government to alleviate the economic hardships introduced by COVID-19, however, they also emphasized a need for long-term solutions to address poverty.

Personal

There were a few strategies related to personal aspects of TB management. Community awareness campaigns/educating the public on TB symptoms can help empower patients to be advocates for their health by requesting a TB test if they have TB symptoms. Moreover, TB awareness can prompt patients to continue wearing masks even though they are no longer mandatory at many PHCs in South Africa. Social media can be leveraged by disseminating educational content while also being used to dispel misinformation that propagates stigma and unwarranted fear.

Table 3. Classification of strategies according to TB management aspect

Barriers and challenges	Strategies/approaches	TB management aspect
Misdiagnosis of TB	Refresher TB training	Health system
	Health education on TB for communities	Personal
	Dual screening	Health system
	Dual Testing	Health system
Financial barriers	Mobile testing clinics	Societal
	At home tests	Societal
	Address poverty	Societal
Fear of contracting COVID-19 at health facilities	Improve IPC at clinics	Health system
	Universal mask wearing	Personal/Health System

	Use social media to inform the public about PHC safety and combat misinformation.	Personal
Neglect of TB	Health Education	Health system
	Dual testing	Health system
	Draw from lessons learned from COVID-19.	All
Long waiting periods at the clinic	Mobile clinics in communities	Societal
	Increase human resources	Health system
	Point-of-care tests	Health system
	Inform patients on wait times	Health system

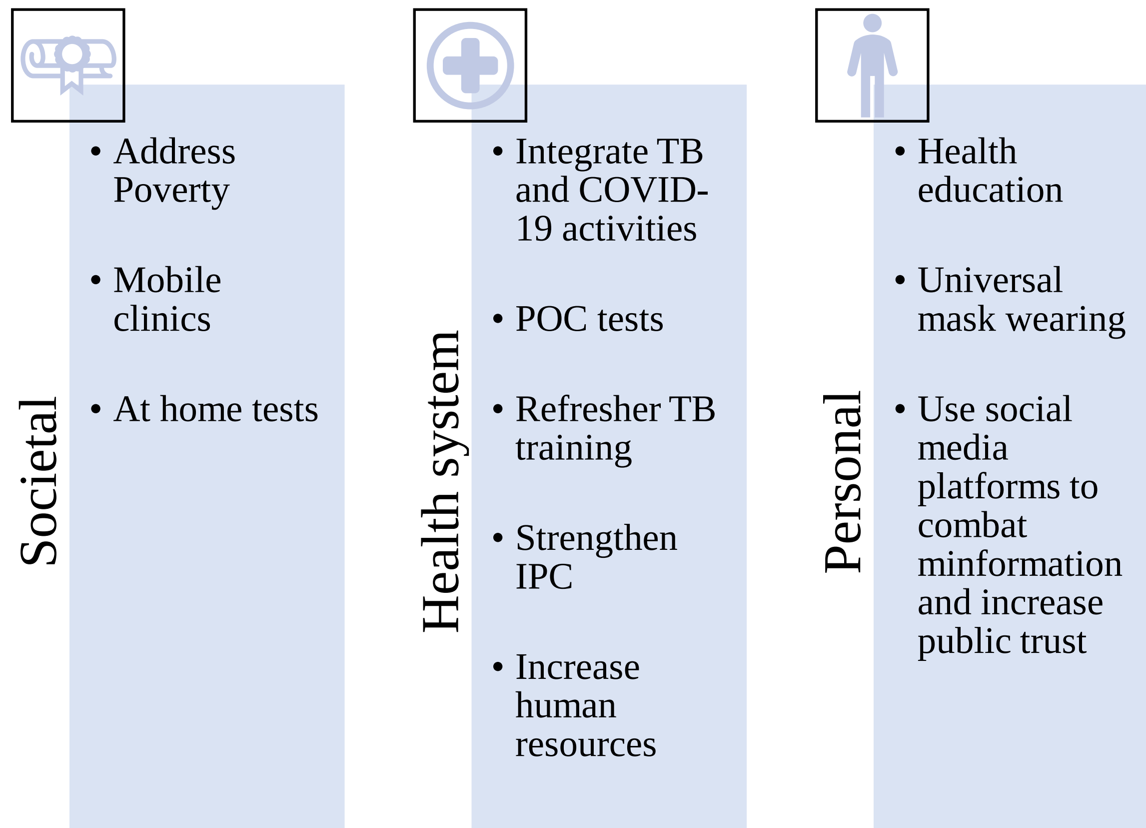

Figure 3. Summary of the strategies and the different levels of TB management they address

5. Discussion

Our collaboration with TB stakeholders from a high-burden region of South Africa has enabled us to co-create an approach for improving TB diagnostic services at primary healthcare clinics. The approach was targeted at addressing the following challenges to efficient TB diagnostics service delivery: misdiagnoses of TB with COVID-19, financial barriers, fear of contracting COVID-19 at clinics, and neglect of TB as well as long wait times at facilities. The proposed approach to address the above barriers includes the following: combined screening and testing for both diseases, deploying mobile clinics into communities, increasing staff at health facilities, use of

POC tests both at clinics and at home, universal mask-wearing, and the use of social media as a tool for health education. This approach is multifaceted, addressing several levels of TB.

TB detection was disproportionately affected by the pandemic, which was evidenced by the large reduction in newly diagnosed people.[16] One of the most widely reported reasons for these decreases was the reduced patient attendance at health facilities due to fear of contracting COVID-19.[17-22] This fear of viral exposure at clinics was a key barrier to TB diagnostic services, as presented by stakeholders in this study. In addition, financial constraints was another impediment to accessing diagnostic services identified by the stakeholders. A report by the Stop TB partnership echoed this finding, reporting that patients in various countries could not access care due to the cost of transportation.[20] A consequence of COVID-19 is that TB services were deprioritized as healthcare workers and diagnostic platforms were reallocated to the COVID-19 response.[22,23] This shift of focus to COVID-19 at the expense of TB was identified as an important barrier and also likely caused TB to be misdiagnosed and presumed to be COVID-19 in certain instances. The stakeholders from our study agreed that this was the biggest barrier facing diagnostic services. This was also a problem in West Africa, where healthcare workers presumably labeled all coughs as COVID-19.[20] Together, these barriers have contributed to the reduction in TB detection experienced during the COVID-19 pandemic, pointing to a need to strengthen these services for similar health emergencies.

The consensus is that to continue making progress toward TB elimination goals and undo the damage caused by COVID-19, an integrated approach is required that targets multiple aspects of TB management.[15,21,22,24] Likewise, our findings proposed solutions for health-system, societal, and personal factors of the disease. Health-system strengthening interventions are already underway; a study from KZN, South Africa, showed that online training for integrating TB and

COVID-19 testing at various clinics was associated with increased TB testing and positivity rates.[24] Both training for healthcare workers (HCWs) and integrating TB and COVID-19 activities were strategies proposed during the NGT for strengthening testing services. Capitalizing on digital platforms can also assist in managing patient fears by disseminating relevant information on diseases and dispelling misinformation. Dheda et al. have emphasized the need for digital platforms to improve TB care through training and public education.[21] These tools can equip HCWs with best practices for managing respiratory diseases like COVID-19 and TB and help combat associated public stigma.[21] Therefore, online platforms should be considered for health system strengthening.

Our study proposed decentralizing TB testing to mobile clinics and investing in at-home POC tests to bring healthcare closer to the communities. This can alleviate the financial barriers associated with seeking care. Community-based mobile clinics have demonstrated success in increasing TB testing and reducing the time to treatment initiation in high-burden settings, particularly for high-risk groups.[25] Introducing alternative testing models not only increases case finding but also accessibility to testing services – a vital factor during health emergencies. Moreover, these models offer the added benefit of reducing foot traffic at clinics, which can alleviate wait times. This was an additional barrier to diagnostic services identified by the study. The COVID-19 pandemic also exposed economic vulnerabilities; these were heightened by lockdown measures resulting in the loss of income for already vulnerable TB patients.[26,27] Stakeholders from the studies noted that in addition to making testing services readily accessible, social protections are required for TB patients to prevent them from facing catastrophic costs.

It is imperative to integrate the strategies from this study in a cohesive manner to achieve a synergistic impact on the strengthening of the healthcare system. Where possible, the strategies from this study should be piloted in high-burden settings and evaluated against routinely collected TB data to assess whether they have improved TB service indicators and monitored long-term to see impact on disease incidence.

The strength of the study was the use of an NGT, which provided a structured discussion that did not allow any members to dominate the conversation but instead gave participants equal opportunities to speak.[28] In addition, the NGT enabled us to use insights from different stakeholders to allow for a robust presentation of ideas from different perspectives, including those of TB patients who are end users of these services. Discussions about healthcare provision that do not involve the users of these services are unethical, thus stripping patients of the agency to provide feedback to improve the care that they receive.[29] A limitation of the study was that there were no representatives from the diagnostic laboratories to share challenges from their perspective. Furthermore, the NGT included the insight of young stakeholders, senior personnel from PHCs may have yielded additional insight.

Conclusion

COVID-19 had a severe impact on TB detection. This study identified the barriers to diagnostic services in a high-burden region of South Africa. The approach proposed to overcome these barriers was multi-faceted, addressing different levels of TB management. To strengthen diagnostic services, implementing this approach should be prioritized and the progress monitored to assess its performance.

List of Abbreviations

COVID-19: Coronavirus disease 2019

HCWs: Healthcare workers

HIV: Human Immunodeficiency Virus

IPC: Infection, Prevention and Control

LMICs: Low- Middle- Income- Countries

NSP: National Strategic Plan

NGT: Nominal Group Technique

PHCs: Primary Healthcare clinics

POC: Point-of-Care

TB: Tuberculosis

WHO: World Health Organization

Declarations

Ethics approval and consent to participate

All methods were carried out following the declaration of Helsinki and the South African POPIA Act. This study received ethical approval from the University of Pretoria's Health Sciences Research Ethics Committee Reference number: 652/2021. All participants of the NGT provided written consent.

Consent for publication

Not applicable.

Competing interests

The authors have no competing interests to declare.

Authors contribution

TD conceptualized the study, undertook data analysis, and wrote the first draft of the manuscript under the supervision of TM-T and AM. KM and SRN assisted with data collation and facilitation of the workshop. BS, TS, SR, BT, MN, and TN participated in the workshop and provided data for the study. TM-T and AM critically reviewed the final draft. All authors have read and agreed to the final version of the manuscript.

Availability of data and materials

All data generated and analyzed is available from the corresponding author upon reasonable request.

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References

1 Kruk, M. E. *et al.* High-quality health systems in the Sustainable Development Goals era: time for a revolution. *The Lancet Global Health* **6**, e1196-e1252 (2018). https://doi.org:10.1016/s2214-109x(18)30386-3

2 Abdool Karim, Q. & Baxter, C. COVID-19: Impact on the HIV and Tuberculosis Response, Service Delivery, and Research in South Africa. *Current HIV/AIDS Reports* **19**, 46-53 (2022). https://doi.org:10.1007/s11904-021-00588-5

3 The Global Fund. *The impact of COVID-19 on HIV, TB and malaria services and systems for health*, <https://www.theglobalfund.org/en/updates/other-updates/2021-04-13-the-impact-of-covid-19-on-hiv-tb-and-malaria-services-and-systems-for-health/> (2021).

4 Africa CDC. *Africa CDC COVID-19 Dashboard*, <https://africacdc.org/covid-19/> (2023).
5 World Health Organization. *Global Tuberculosis Report*, <https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2022> (2022).
6 KwaZulu Natal Department of Health. *Strategic Plan 2020/21 – 2024/25*, <http://www.kznhealth.gov.za/Strategic-plan-2020-2025-rev.pdf> (2020).
7 Uplekar, M. *et al.* WHO's new end TB strategy. *The Lancet* **385**, 1799-1801 (2015). https://doi.org:10.1016/S0140-6736(15)60570-0
8 Dheda, K., Ruhwald, M., Theron, G., Peter, J. & Yam, W. C. Point-of-care diagnosis of tuberculosis: Past, present and future. *Respirology* **18**, 217-232 (2013). https://doi.org:10.1111/resp.12022
9 Dlangalala, T., Musekiwa, A. & Mashamba-Thompson, T. Impact of COVID-19 on TB diagnostic services at primary healthcare clinics in eThekwini district, South Africa. *Scientific Reports* **13**, 16645 (2023). https://doi.org:10.1038/s41598-023-43589-7
10 KwaZulu Natal Department of Health. *Welcoming remarks by KZN Health MEC, Nomagugu Simelane, on the occasion of the 7th SA TB Conference*, <https://www.kznhealth.gov.za/mediarelease/2022/welcoming-remarks-sa-tb-conference-13092022.htm> (2022).
11 National Department of Health. *The National Strategic Plan for HIV, TB, and STIs 2023-2028*, <https://knowledgehub.health.gov.za/elibrary/national-strategic-plan-hiv-tb-and-stis-2023-2028> (2023).
12 Allen, J., Dyas, J. & Jones, M. Building consensus in health care: a guide to using the nominal group technique. *British journal of community nursing* **9**, 110-114 (2004). https://doi.org:10.12968/bjcn.2004.9.3.12432
13 Bartunek, J. M. & Murninghan, J. K. The Nominal Group Technique: Expanding the Basic Procedure and Underlying Assumptions. *Group & Organization Studies* **9**, 417-432 (1984). https://doi.org:10.1177/105960118400900307
14 Dlangalala, T., Musekiwa, A. & Mashamba-Thompson, T. Towards development of a novel approach for enhancement of TB diagnostic services during the pandemic: A case of primary health care clinics in eThekwini district KwaZulu-Natal: A study protocol. *PLOS ONE* **17**, e0278305 (2022). https://doi.org:10.1371/journal.pone.0278305
15 Zimmer, A. J. *et al.* Tuberculosis in times of COVID-19. *Journal of Epidemiology and Community Health* **76**, 310-316 (2022). https://doi.org:10.1136/jech-2021-217529
16 World Health Organization. *Global tuberculosis report* <https://www.who.int/teams/global-tuberculosis-programme/tb-reports> (2021).
17 Oga-Omenka, C. *et al.* Tuberculosis service disruptions and adaptations during the first year of the COVID-19 pandemic in the private health sector of two urban settings in Nigeria—A mixed methods study. *PLOS Global Public Health* **3**, e0001618 (2023). https://doi.org:10.1371/journal.pgph.0001618
18 Pillay, Y., Pienaar, S., Barron, P. & Zondi, T. Impact of COVID-19 on routine primary healthcare services in South Africa. *South African Medical Journal* **111**, 714 (2021). https://doi.org:10.7196/samj.2021.v111i8.15786
19 Nkereuwem, O. *et al.* Exploring the perspectives of members of international tuberculosis control and research networks on the impact of COVID-19 on tuberculosis services: a cross sectional survey. *BMC Health Services Research* **21** (2021). https://doi.org:10.1186/s12913-021-06852-z
20 Stop TB Partnership Civil society-led TB/COVID-19 Working Group. *The impact of COVID-19 on the TB epidemic: A community Perspective*, <https://stoptb.org/assets/documents/resources/publications/acsm/Civil%20Society%20Report%20on%20TB%20and%20COVID.pdf?fbclid=IwAR3SOY4kyBs5a_35HIeUhcvwRIWspePA4vVHESqcQxio7G4irivJ90cSU8k> (2020).
21 Dheda, K. *et al.* The intersecting pandemics of tuberculosis and COVID-19: population-level and patient-level impact, clinical presentation, and corrective interventions. *The Lancet Respiratory Medicine* **10**, 603-622 (2022). https://doi.org:10.1016/s2213-2600(22)00092-3

22 Loveday, M. *et al*. Opportunities from a new disease for an old threat: Extending COVID-19 efforts to address tuberculosis in South Africa. *South African Medical Journal* **110**, 1160 (2020). https://doi.org:10.7196/samj.2020.v110i12.15126
23 Karim, Q. A. & Karim, S. S. A. COVID-19 affects HIV and tuberculosis care. *Science* **369**, 366-368 (2020). https://doi.org:10.1126/science.abd1072
24 Curran, R. *et al*. A health systems intervention to strengthen the integration of tuberculosis and COVID-19 detection: Outcomes of a quasi-experimental study in a high burden tuberculosis district in KwaZulu Natal, South Africa. *Trop Med Int Health* **28**, 324-334 (2023). https://doi.org:10.1111/tmi.13860
25 Esmail, A. *et al*. Comparison of two diagnostic intervention packages for community-based active case finding for tuberculosis: an open-label randomized controlled trial. *Nature Medicine* **29**, 1009-1016 (2023). https://doi.org:10.1038/s41591-023-02247-1
26 Vanleeuw, L., Zembe-Mkabile, W. & Atkins, S. Falling through the cracks: Increased vulnerability and limited social assistance for TB patients and their households during COVID-19 in Cape Town, South Africa. *PLOS Global Public Health* **2**, e0000708 (2022). https://doi.org:10.1371/journal.pgph.0000708
27 Ellaban, M. M., Basyoni, N. I., Boulos, D. N. K., Rady, M. & Gadallah, M. Assessment of Household Catastrophic Total Cost of Tuberculosis and Its Determinants in Cairo: Prospective Cohort Study. *Tuberculosis and Respiratory Diseases* **85**, 165-174 (2022). https://doi.org:10.4046/trd.2021.0028
28 Olsen, J. The Nominal Group Technique (NGT) as a Tool for Facilitating Pan-Disability Focus Groups and as a New Method for Quantifying Changes in Qualitative Data. *International Journal of Qualitative Methods* **18**, 160940691986604 (2019). https://doi.org:10.1177/1609406919866049
29 Mehra, C., Lokhande, D., Chavan, D. & Rane, S. What quality of care means to tuberculosis survivors. *Journal of Clinical Tuberculosis and Other Mycobacterial Diseases* **19**, 100157 (2020). https://doi.org:https://doi.org/10.1016/j.jctube.2020.100157

Chapter 8 Synthesis: Summary, Discussion, Conclusion and Recommendations

Introduction

This chapter summarizes and discusses the study's main findings based on the scoping review of TB services during the COVID-19 pandemic, the GIS analysis of the accessibility of TB diagnostic services, the pre-post quasi-experimental study assessing the impact of COVID-19 on TB diagnostic services; the audit of the barriers and enablers to providing quality diagnostic services, the qualitative study's exploration of patient perspectives of the quality TB services, and the co-creation workshop to enhance TB diagnostic services during the COVID-19 pandemic. The study's methodological strengths and limitations will also be discussed before presenting recommendations for practice and future research.

Background

The end TB strategy by the World Health Organization (WHO) emphasizes early diagnosis,[7] which is one of the TB management services that was severely compromised by the COVID-19 pandemic. During the first year of the COVID-19 pandemic, TB detection experienced reductions of 18% compared to the previous year.[15] This widened the gap between the estimated number of people with disease and those who had been notified to respective TB programs.[9] These disruptions to routine TB services were predicted to have the highest impact in high TB burden countries, such as South Africa.[24, 27] South Africa was also reported to have the highest incidence of COVID-19 in Africa.[28] By the middle of the first year (2020), TB testing had decreased by 50% compared to the year prior[18]; these declines persisted with each wave of the pandemic.[29] Therefore, to continue making progress toward TB targets, the undiagnosed people would need to be reached and initiated on treatment. For this purpose, a TB recovery plan has been implemented in South Africa. However, the holistic strengthening of healthcare systems is also required so that they are resilient against COVID-19 and analogous health emergencies. Therefore, in this study, we aimed to develop a novel approach to enhance TB diagnostic services at primary healthcare clinics (PHCs) for high TB burden settings.

Summary of key findings

This PhD utilized a mixed methods study approach to develop a novel approach to improve TB diagnostic services in high-burden settings. This allowed triangulation and a more robust understanding of the phenomenon studied in this thesis. The main findings from the thesis have been summarized in Table 1. The initial phase of the thesis consisted of a scoping review, which mapped global the available evidence on TB services at the PHC level during COVID-19. The scoping review revealed that TB services across the globe were impacted by the pandemic and revealed research gaps to guide the research question addressed in this thesis. The following themes emerged from the scoping review: consequences of the COVID-19 pandemic on TB services; patient and provider experiences; recommendations and adaptations for TB services; and implementing the recommendations. The inception of the pandemic brought on widespread reductions in TB detection. Moreover, TB staff were redirected to COVID-19 response and PHC facilities saw reduced patient attendance. During this period, patients could not access facilities due to closures or other restrictions. The potential for exposure to the virus at health facilities also acted as a deterrent. Likewise, healthcare workers (HCWs) were afraid of treating cough-related symptoms. These prolific effects prompted recommendations to adapt TB services. These recommendations included: the use of telemedicine for medical triage, integration of COVID-19 and TB activities, multi-month dispensation of treatment, strengthening infection prevention and control (IPC) at facilities, and providing COVID-19 training for staff. In some countries, these adaptations to TB services were taken up.

Guided by the scoping review results, a geospatial analysis was conducted to determine the accessibility of TB diagnostic services in the eThekwini district. The analysis showed that TB diagnostic services were highly accessible, with 92.6% of the population capable of accessing a diagnostic facility within 5km. The two regions of eThekwini with the highest accessibility were predominantly urban and sub-urban. While the remaining two regions which were both predominately rural, showed moderate accessibility. Of the population that resided in these remote areas, 40.7% were located more than 5km from a clinic. The analysis also showed more TB cases in urban and sub-urban regions compared to the predominately rural regions. Moreover, hospitals in eThekwini were also highly accessible, with 98.4% located within a 30km radius of a PHC. However, most hospitals are concentrated in one region of eThekwini showing poor spatial distribution.

Following the GIS study, we conducted a pre-post quasi-experimental study, using an interrupted time series analysis (ITSA), to determine the impact of the COVID-19 pandemic on TB services at primary healthcare in the eThekwini District. The results showed that TB investigations and the confirmed number of cases decreased by 45% and 40% because of the lockdown period. In months that followed both TB indicators rose considerably. The changes of the two indicators varied throughout the pandemic, however, they were mostly marked by significant declines at the peaks of infection. By the end of the observation period, the confirmed number of TB cases had sustained the biggest impact, recording lower numbers than before the pandemic started.

In the next stage of the study, barriers and enablers to providing quality diagnostic services were investigated through an audit of primary health facilities and by conducting patient interviews. The audit showed that individual clinics achieved quality assessment scores ranging from moderate to excellent. Scores from three of the four regions in eThekwini achieved moderate assessment scores while only one received an excellent rating. The individual audit components specimen management and integration of TB/HIV services received the highest scores. Conversely, the audit components with the lowest scores were the refresher training among staff, IPC, Xpert turnaround times (TAT), and contact tracing. The interviewed patients revealed that long wait times at the registration point, staff attitudes, and drug stockouts were the barriers to receiving quality care. On the other hand, they stated that the care they receive once they reach the TB department was excellent from health worker attitudes to the information they provided on TB.

In the final phase of the study, an NGT was conducted guided by findings from the scoping review and quasi-experimental study. The NGT aimed to explore the barriers to TB diagnostic services during COVID-19 and propose an approach to enhance these services. The stakeholders from the study identified the following as the most important barriers to TB diagnostic services during the pandemic: misdiagnosis of TB; fear of COVID-19 exposures, financial barriers, neglect of TB, and excessive wait times at PHCs. The stakeholders then agreed on strategies to overcome the barriers. The strategies were elements of the novel approach and they included: dual TB/COVID-19 management; providing decentralized testing through mobile units; strengthening IPC; universal use of masks inside clinics; use of Point-of-Care (POC) tests; and leveraging social media for disseminating relevant information on both diseases.

Table 1 Summary of key findings and recommendations

	Article Title	Donabedian Component	Approach	Key findings	Recommendations
Chapter 2	Evidence of TB Services at Primary Healthcare Level during COVID-19: A Scoping Review	**All**	The available evidence on TB services at the primary healthcare level during COVID-19 was mapped using the Arksey and O'Malley framework,[30] Levac et al,[31] and Joana Briggs institute guidelines[32]	Four themes emerged: 1 **Consequences of COVID-19 pandemic on TB services** • Reduction in TB detection • Reallocation of healthcare workers • Reduction in patient attendance 2 **Patient and provider experiences** • Difficulty accessing healthcare • Reluctance/fear of treating patients presenting with cough • Fear of contracting COVID-19 • Need for nutritional and financial support for patients 3 **Recommendations and adaptations for TB services during the COVID-19** • Use of telemedicine	▪ More primary studies to understand the impact of COVID-19 on TB services ▪ Continued monitoring of TB services throughout the pandemic ▪ Implementing recommendations for regions that had not done so ▪ Active-case-finding efforts for missed diagnoses ▪ Investigate whether the reduction in detection was a result of reduced transmission (due to non-pharmaceutical measures)

				• Sample collections to be conducted at home • Integrating COVID-19 and TB screening • Dispensation of TB medicine for several months • COVID-19 training for staff • Strengthening of IPC measures • Ensure the availability of medications 4 **Implementing the recommendations** • Integration of COVID-19 and TB screening • Strengthening of IPC measures • Use of telemedicine • Home visits instead of clinic visits Administering of oral medications over injectables	
Chapter 3	Geographical accessibility of TB diagnostic services at primary healthcare clinics in eThekwini District, South Africa	Structural	GIS analysis was used to measure travel distances from residential areas to PHCs and from PHCs to hospitals. The spatial distribution of TB	▪ 92.6% of the population could access diagnostic services within 5km. ▪ Predominantly urban regions had high accessibility while the predominately rural regions had moderate accessibility.	▪ Deploy mobile units with comprehensive TB/HIV services in rural regions ▪ Continuous quality assessments for mobile units and PHCs ▪ Active-case finding for asymptomatic high-risk

			cases was also assessed.	▪ 40.7% of the rural population >5km from a PHC ▪ TB cases were higher in urban areas compared to rural areas ▪ 98.4% of PHCs are within 30km of a hospital ▪ Majority of clinics are concentrated in one region	groups in rural and urban settings ▪ Upgrade existing facilities to hospitals in certain regions

Chapter 4	Impact of COVID-19 on TB diagnostic services at primary healthcare clinics in eThekwini district, South Africa	Processes of care	An ITSA was conducted to determine the changes in TB investigations and confirmed TB cases during four pandemic periods	▪ During the lockdown, TB investigations and confirmed cases dropped by -45% and -40%, respectively. ▪ TB investigations and confirmed cases rose significantly in the months following the lockdown ▪ Both TB detection indicators experienced variations in levels throughout the pandemic but were marked by decreases at peaks of infection ▪ Confirmed cases were more severely impacted with decreases sustained until the end of the observation period	▪ Maintain access to TB diagnostic service during health emergencies. ▪ TB mortality should be monitored to determine if true drops in detection took place ▪ Determine whether underreporting took place and investigate reasons ▪ Active case finding and linking people to care
Chapter 5	Quality of TB diagnostic services at Primary healthcare clinics in eThekwini District, South Africa	Structural and Processes of Care	A facility audit was conducted to determine the barriers and enablers to providing quality diagnostic services	▪ Audit scores range from moderate to excellent between the facilities ▪ Three regions achieved moderate overall scores and one achieved an excellent rating	▪ Provide refresher TB training to all staff members ▪ Use TB training to reinforce IPC practices among staff ▪ Improve IPC inside facilities ○ using simple mechanisms like natural airflow

				▪ Specimen management and integration of TB services were the audit components with the highest scores ▪ TB training among staff, Xpert turn around times, IPC, and contact tracing were the audit components with the lowest scores	○ encouraging mask use by patients ▪ Explore patient-delivered screening mechanisms for contact tracing ▪ Conduct continuous quality assessments among facilities
Chapter 5	Quality of TB services at primary healthcare clinics in eThekwini district, South Africa: Patient perspectives	Processes of care and Outcomes	Qualitative research study, designed to understand patient perspectives on the quality of TB services	**Barriers:** ▪ Long queues at file registration ▪ Administration staff attitudes ▪ Drug stockouts **Enablers:** Clinic TB department ▪ Health provider attitudes ▪ Wait time TB information	▪ Implementing queue management systems at clinics ▪ Sensitivity training healthcare workers and clinic staff ▪ Identifying weaknesses in the supply chain and improving monitoring systems Studies on whether good quality TB care translates to better TB outcomes
Chapter 6	Enhancing TB diagnostic services at primary healthcare clinics in the eThekwini district, South Africa, post-COVID-19: a nominal group technique	All	Co-create potential solutions to barriers to TB diagnostic services during the COVID-19 pandemic	**Barriers** • Misdiagnosis of TB with COVID-19 • Financial impediments • Fear of COVID-19 exposure at facilities • Neglect of TB • Long wait times **Proposed strategies** • Using improved IPC measures, integrated COVID-19/TB activities, POC tests, and TB training can strengthen healthcare systems • Decentralize TB testing to mobile clinics and introduce	▪ The elements of the proposed approach should be piloted for feasibility adapted and as necessary. Routinely collected data should be used to identify the performance of these strategies.

				at-home tests to overcome socioeconomic barriers • Encourage mask-wearing and education on TB symptoms to strengthen personal factors in disease prevention	

Discussion

The emergence of the COVID-19 pandemic has exposed gaps in the already overburdened health systems. This became particularly evident as the management of existing infectious diseases began to suffer because of the pandemic. TB is an example of what can happen when health systems are unprepared for public health emergencies. Therefore, to meet goals set for TB, endemic settings like South Africa will need to learn from COVID-19 and develop methods to improve the quality and delivery of TB services. For this reason, our study developed an approach to enhance TB diagnostic services for health emergencies such as COVID-19, for high-disease burden settings.

The scoping review conducted at the start of the study provided an overview of the state of TB services because of the pandemic. The findings showed that TB services in many high-burden countries were negatively affected by COVID-19. In the review, we surmised that these disruptions to TB services could lead to TB cases going undetected. The WHO 2021 TB report confirmed these suspicions showing that TB detection had decreased by 18% in the first year of the pandemic.[9] The quasi-experimental results aligned with both WHO and scoping review findings, showing large reductions in TB detection indicators during the lockdown period in eThekwini district. Other studies showed significant increases in TB detection following the lockdown, once restrictions became less stringent.[10, 20, 33, 34] Together, these outcomes demonstrate the importance of keeping healthcare accessible despite health emergencies. It is possible that the reduction in TB detection resulted from the non-pharmaceutical measures used to contain COVID-19 which in turn reduced community transmission. However, the effects on TB transmission would likely be experienced over time. The sharp declines in TB detection associated with each variant-driven surge suggest that other factors were likely at play. The possible reasons for these reductions were explored by the NGT and corroborated by the scoping review, namely: access to facilities was limited, and patients were not presenting to clinics because of the stigma associated with cough-like symptoms or concerns about contracting COVID-19 at facilities. This seems to suggest that patients were not assured of their safety at health facilities.

The study's evaluation of the quality of diagnostic services showed that patient concerns were not unwarranted. The findings revealed that the quality of TB diagnostic services was moderate in eThekwini. Among the areas of non-compliance was IPC along with TB training among staff. The results revealed that clinic infrastructure and availability of resources (N-95 respirators) hindered the IPC performance at clinics. Poor implementation of IPC disproportionately burdens health systems during epidemics including COVID-19 by perpetuating transmission among patients and depleting HCWs.[35] The scoping review also pointed to challenges in IPC with many countries reporting a lack of Personal Protective Equipment (PPE). The literature suggests that continuous training can improve IPC adherence.[36, 37] Ironically, this was another area of non-compliance found by this study, partly due to a high staff turnover that resulted in recently trained staff leaving the facility. Therefore, IPC practices will need to be strengthened by ensuring an adequate supply of resources, and continuous training of staff at all levels with a focus on infectious diseases. This will ensure that health systems can safely provide routine services but are also prepared for outbreaks that may occur.

Both continuous training and universal masking were strategies proposed for barriers to diagnostic services during the NGT. Universal mask use has been associated with reduced SARS-CoV-2 infections among HCWs.[38] The South African government no longer require masks at public facilities and this was evident at many of the audited clinics. However, PHCs in high-burden settings could benefit from universal masking by HCWs and patients to prevent nosocomial transmission. Klompas and colleagues emphasize that universal masking should be done in parallel with other IPC measures.[39] Likewise, continuous training on best practices for TB, emerging diseases such as COVID-19, and other diseases endemic to a setting are required for improved quality of care and health system strengthening. For similar purposes, digital training on integrating TB and COVID-19 activities was associated with increased TB testing and contact tracing.[40] Therefore, online platforms should be leveraged to train HCWs on TB and other diseases that may burden health systems.

Contact tracing, a common challenge in LMICs,[7, 41] was another barrier identified by the audit. Patients would provide incomplete or no contact details of household contacts. A study in Malawi recognized these shortcomings and piloted a patient-delivered model for screening household contacts which moderately improved TB detection.[42] Similarly, in South Africa, community-based mobile clinics interventions, equipped with POC diagnostic tools, were more effective at TB detection than traditional methods.[43] This decentralized approach to TB testing has added benefits of bringing TB care closer to the communities, potentially reducing financial costs associated with clinic visits and alleviating the long lines at facilities. These barriers to TB diagnostic services were identified during the NGT and qualitative study. Therefore, exploring new models for contact tracing and case detection in high TB burden settings should be a priority in the post-COVID-19 era.

Rebuilding health systems post pandemic should focus on providing high-quality of care since poor quality is a bigger barrier to reducing mortality than insufficient access.[44, 45] Furthermore, high-quality health systems should be patient-centered, and capable of gaining and maintaining the population's trust.[44] This study investigated both geographic access and quality of care and found that diagnostic services were highly accessible, however, a large proportion of the rural population remains inadequately served. This has been commonly reported in other Low- to Middle-Income Countries (LMICs).[46-48] In terms of quality of care, patient perspectives revealed long wait times, drug stockouts, and negative staff attitudes created dissatisfaction with the care received. Both challenges in access and poor quality of services are linked to poorer disease outcomes.[49-52] For infectious diseases like TB this has further implications on community transmission and the development of drug resistance.[51-53] Therefore, in addition to deploying mobile health units in rural areas to ensure equitable access to diagnostic services, sustainable procurement of TB drugs and staff sensitivity training are also required.

The COVID-19 pandemic has demonstrated what a lack of trust in the health system can do for infectious diseases like TB. Therefore, as strategies are put in place to strengthen health systems, the public must be aware of such implementations. This transparency can prompt confidence in the health systems that may improve regular facility attendance despite the emergence of other infectious outbreaks. During the NGT, stakeholders recommended using social media platforms to keep the public informed about important diseases and the measures being taken to ensure their safety.

Strengths of the study

The study used a mixed methods study design, leveraging the strengths of quantitative and qualitative research methods. This provides a holistic understanding of the study phenomena.[54] The use of quantitative methods showed the magnitude of the research problem. On the other hand, the qualitative aspects provided possible reasons for the results from the quantitative data. This allowed for more robust conclusions to be drawn.

Before the start of data collection, a scoping review was conducted. This evidence synthesis method allows researchers to map the available evidence on a research question. It is ideal for areas of emerging research because it incorporates all research designs including those found in grey literature.[31] The study began at the start of the pandemic, therefore, using a scoping review maximized all the available evidence at the time. The review was done in a rigorous, transparent, and reproducible guided by a predetermined framework.[30, 31]

The use of GIS techniques is a powerful tool for measuring spatial equity in healthcare.[55] This method combines the use of clinical, population, and geographic data to provide an in-depth understanding of a region's care, health, and overall services.[56] This in turn can guide targeted decisions on health service delivery.

This study applied a pre-post quasi-experimental study, which is the strongest statistical method for analyzing the impact of exposure (COVID-19) over time when randomization is not possible.[57] The analysis further used multiple exposure periods which controlled for the possible changes in the time series therefore giving a more accurate and robust representation of the exposure effects.

The use of both an audit and a qualitative analysis for evaluating the quality of services provided different insights into the research problem. This boosts the validity and interpretation of the results. The audit sampled clinics from the different regions of eThekwini to give a representative sample of the entire district. The use of a qualitative analysis explored patient perspectives, which provides meaningful outcomes that meet patient expectations and preferences which can lead to better uptake of interventions.

Likewise, the NGT included patients as key TB stakeholders. This research method also facilitated equal contribution from all participants by not allowing any member to dominate the discussion. Furthermore, it allowed for a large generation of ideas. The involvement of various TB services stakeholders allowed diverse contributions to the barriers and solutions.

Limitations of the study

Some of the methodological limitations of the study are worth noting. The geospatial analysis only evaluated the potential accessibility, which is the availability and proximity of healthcare facilities, and did not assess revealed accessibility, which is determined by utilization. The analysis did not account for health insurance membership and assumed all members of the population used government funded PHCs. Moreover, no private health facilities were included in the analysis. DHIS data was used to map the spatial distribution of TB, these data are manually collected and are subject to human error.

When conducting the ITSA, a control group was not used which is the best way to identify confounding factors that may influence the outcome. However, it was impossible to include a comparable control group because the impact of COVID-19 was universal. DHIS data was also used for the ITSA, which is subject to inaccuracies.

A small number of patient files were used to audit the integration of TB/HIV services, therefore, the findings from this component may not be generalizable. Furthermore, no rural clinics were included in the audit, which may have yielded a different overall result. For the qualitative analysis, the provider perspectives were not considered, which may have given more insight into the health system-related factors to diagnostic services. Moreover, only patients from one setting were interviewed, thus limiting the generalizability of these findings. The NGT did not include laboratory stakeholders who may have contributed insight into the technical barriers facing diagnostic services during the pandemic. The NGT participants were also predominately female, however, they were chosen based on their knowledge of TB services. Moreover, one male participant was a representative of the male users of these services.

Conclusion

In conclusion, the study provided evidence that contributed toward the development of a novel approach for improving TB diagnostic services at PHCs during pandemics, using eThekwini district as a study setting. To do this, the thesis investigated the accessibility as well as the impact of the pandemic on TB diagnostic services. Moreover, a quality assessment of these services was done before conducting an NGT, which would inform the strategies for the novel approach. The findings were consolidated into a framework to optimize and provide high-quality TB diagnostic services for high TB burden settings. The framework is characterized by solutions that target structural factors and processes of care resulting in outcomes that boost confidence in health systems and provide economic benefits.

Recommendations

Recommendations for practice

The current study was guided by two conceptual frameworks: Donabedian's model for assessing quality of care and the high-quality health system framework discussed in Chapter 3.[44, 58] Informed by the study findings, the consolidated framework was used to make practice recommendations that constitute the novel approach for improving TB diagnostic services. The framework to improve TB diagnostic services provides solutions for structural factors and processes of care, which, if implemented, can produce outcomes that can increase confidence in health systems and provide economic benefits to users and health systems alike. The elements of the framework for improving TB diagnostic services are described in detail in the section below and depicted in Figure 1.

Structural Factors

Structural factors are the physical characteristics of PHCs which include their location, tools/equipment available and workforce characteristics. Using mobile health units for mobile for rural populations is a pivotal strategy for increasing access to TB diagnostic services. Simultaneously, upgrading clinic infrastructure offers the potential to enhance IPC measures for example creating outdoor waiting areas within certain facilities can prevent overcrowding inside the facilities. Similarly, all facilities should make use of mechanical ventilation such open windows and doors to promote airflow and disrupt the nosocomial TB transmission. Moreover, increasing workforce by hiring more staff at health facilities can improve quality of care by allowing staff to be more attentive to patients while also alleviating wait time. It is also imperative that existing staff member are adequately trained on the latest standard operating procedures (SOPs) for TB. Lastly, there should be provision of sufficient personal protective equipment for TB staff, likewise patients should always be mandated to wear masks to ensure the safety of both parties while at health facilities.

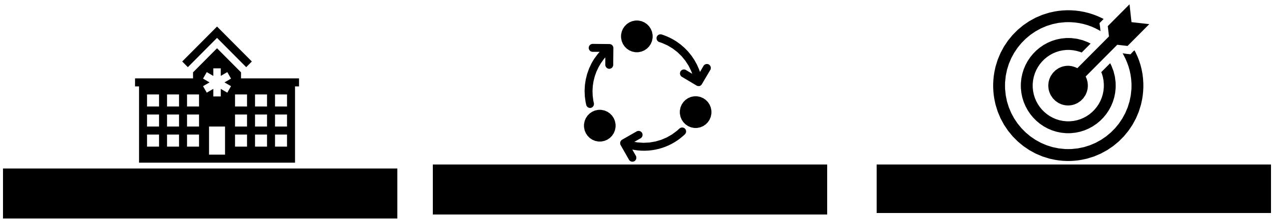
Processes of care

Enhancing processes of care involves three key strategies: providing competent care, optimizing systems, and improving the user experience. The findings of the PhD suggest that enhancing competent care can be achieved by integrating activities for diseases of importance (COVID-19 and TB), implementing patient-delivered contact-screening methods, and intensifying active case finding efforts. Furthermore, online platforms can be used to administer continuous TB training for nurses so that they can receive up to date SOPs without leaving the facility. Similarly, improving competent systems can be realized through the implementation of better disease reporting systems, adoption of point-of-care tests, and conducting continuous quality improvement assessments. Additionally, enhancing the user experience can be facilitated by reducing wait times through the introduction of efficient queue management systems. These strategies, when executed effectively, contribute to a more robust and patient-centric healthcare system.

Outcomes

Targeting the above-mentioned structural factors and the processes of care can contribute to boosting the confidence in health-systems while also producing an economic benefit to both the users and the health system. Economic benefits can be derived from improving access in rural areas and decentralizing TB testing to mobile health units closer to communities. By bringing healthcare closer to the communities that need them, patients can readily seek TB care without the incurring additional travel costs. Moreover, improving geographic access can prevent diagnostic delays and help patients to seek care sooner thereby preventing unnecessary costs to health system that are associated with hospitalizations. Likewise, ensuring the availability of PPE for staff and mandating mask use inside the facilities can prevent infections and costs associated with nosocomial transmissions. Lastly, by capitalizing on social and traditional media platforms improvements to health facilities can be made known publicly. Doing this can help boost trust in health systems which was found to be lacking during the pandemic and resulted in many being fearful to seek care.

Overall, the framework seeks to improve on TB diagnostic services through a multidimensional approach. It is envisaged that through the implementation of this approach TB diagnostic services at PHCs will be able to better withstand future health emergencies. The next steps are to explore the feasibility of this approach in high TB burden settings.



STRUCTURAL FACTORS

Facility characteristics

- Deploy mobile health units in rural regions according to the need.
- Upgrade clinic infrastructure to improve IPC.
- Use mechanical ventilation to improve airflow.

Staff characteristics

- Train HCWs on TB management, IPC, COVID-19, patient sensitivity
- Increase clinic workforce.

Healthcare setting characteristics

- Improve the procurement of TB drugs and N-95 respirators.
- Encourage universal masking.

PROCESSES OF CARE

Competent care

- Provide continuous TB training using online platforms.
- Integrate TB/COVID-19 activities.
- Introduce patient-delivered contact screening methods.
- Intensify active case finding for high-risk groups.

Component systems

- Improve reporting systems for TB detection data.
- Introduce decentralized POC tests.
- Conduct continuous quality assessments.

User experience

- Introduce queue management systems.

OUTCOMES

Confidence in health systems

- Use social media to distribute information on IPC measures taken at facilities and provide relevant information on TB and COVID-19

Economic

- Using mobile clinics to decentralize TB testing and the development of at-home tests can reduce costs associated with seeking care

- Improving access, IPC, TB drug procurement, and processes of care can reduce healthcare expenditure by preventing hospitalization in patients

Figure 1 Consolidated framework for improving TB diagnostic services at PHCs in a high-burden settings

Recommendations for future research

Although these study findings contributed to the existing body of evidence on TB diagnostic services during the pandemic, the work conducted was not exhaustive. Therefore, the research gaps that emerged require further investigation.

- The geographic accessibility of TB diagnostic services was established; however, more work is needed to determine the relationship between the utilization of these services and distances traveled.
- The ITSA showed the impact of COVID-19 on TB diagnostic services by using TB detection indicators. However, to determine whether this was a true decrease in detection rather than underreporting, TB incidence and mortality must be measured closely.
- The audit did not include rural clinics, therefore, rural PHCs in the eThekwini district must be subject to quality assessments including patients' perspectives.
- The feasibility of the strategies proposed by the NGT should be established and implemented where possible.
- Similar studies should be conducted in other high TB-burden regions of South Africa because COVID-19 had varied impacts throughout the country. Therefore, other regions may require different solutions.

References

1. Meneguim AC, Rebello L, Das M, Ravi S, Mathur T, Mankar S, et al. Adapting TB services during the COVID-19 pandemic in Mumbai, India. The international journal of tuberculosis and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease. 2020; 24(10):1119-21.
2. A dictionary of epidemiology. New York: Oxford University Press; 2001.
3. Bloom BR, Atun R, Cohen T, Dye C, Fraser H, Gomez GB, et al. Tuberculosis. The World Bank; 2017. p. 233-313.
4. Dheda K, Ruhwald M, Theron G, Peter J, Yam WC. Point-of-care diagnosis of tuberculosis: Past, present and future. Respirology. 2013; 18:217-32. doi:10.1111/resp.12022
5. Stop TB Partnership Civil society-led TB/COVID-19 Working Group [Internet]. The impact of COVID-19 on the TB epidemic: A community Perspective. Geneva: Stop TB Partnership; 2020 [cited 2023 03-10-2023]. Available from: https://stoptb.org/assets/documents/resources/publications/acsm/Civil%20Society%20Report%20on%20TB%20and%20COVID.pdf?fbclid=IwAR3SOY4kyBs5a_35HIeUhcvwRIWspePA4vVHESqcQxio7G4irivJ90cSU8k.
6. World Health Organization [Internet]. Global tuberculosis report Geneva: World Health Organization; 2020 [cited 2023 02-28-2023]. Available from: https://www.who.int/publications/i/item/9789240013131.
7. World Health Organization [Internet]. End TB Strategy. World Health Organization; 2015 [cited 2023 23-09-2023]. Available from: https://www.who.int/tb/End_TB_brochure.pdf?ua=1.
8. Sahu S, Ditiu L, Sachdeva KS, Zumla A. Recovering from the Impact of the Covid-19 Pandemic and Accelerating to Achieving the United Nations General Assembly Tuberculosis Targets. International Journal of Infectious Diseases. 2021; doi:10.1016/j.ijid.2021.02.078
9. World Health Organization [Internet]. Global tuberculosis report Geneva2021 [cited 2023 02-28-2023]. Available from: https://www.who.int/teams/global-tuberculosis-programme/tb-reports.
10. Soko RN, Burke RM, Feasey HRA, Sibande W, Nliwasa M, Henrion MYR, et al. Effects of Coronavirus Disease Pandemic on Tuberculosis Notifications, Malawi. Emerging Infectious Diseases. 2021; 27(7) doi:10.3201/EID2707.210557
11. Karim QA, Karim SSA. COVID-19 affects HIV and tuberculosis care. Science. 2020; 369:366-8. doi:10.1126/science.abd1072
12. Fei H, Yinyin X, Hui C, Ni W, Xin D, Wei C, et al. The impact of the COVID-19 epidemic on tuberculosis control in China. The Lancet Regional Health - Western Pacific. 2020; 3:100032. doi:10.1016/j.lanwpc.2020.100032
13. Alene KA, Wangdi K, Clements ACA. Impact of the COVID-19 Pandemic on Tuberculosis Control: An Overview. Tropical Medicine and Infectious Disease. 2020; 5:123. doi:10.3390/tropicalmed5030123
14. Abdool Karim Q, Baxter C. COVID-19: Impact on the HIV and Tuberculosis Response, Service Delivery, and Research in South Africa. Current HIV/AIDS Reports. 2022; 19(1):46-53. doi:10.1007/s11904-021-00588-5
15. World Health Organization [Internet]. Global Tuberculosis Report. Geneva2022 [cited 2023 02-28-2023]. Available from: https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2022.
16. Karim SSA, Churchyard GJ, Karim QA, Lawn SD. HIV infection and tuberculosis in South Africa: an urgent need to escalate the public health response. The Lancet. 2009; 374(9693):921-33. doi:10.1016/s0140-6736(09)60916-8

17. Churchyard GJ, Mametja LD, Mvusi L, Ndjeka N, Hesseling AC, Reid A, et al. Tuberculosis control in South Africa: Successes, challenges and recommendations. South African Medical Journal. 2014; 104(3):244. doi:10.7196/samj.7689
18. Dheda K, Perumal T, Moultrie H, Perumal R, Esmail A, Scott AJ, et al. The intersecting pandemics of tuberculosis and COVID-19: population-level and patient-level impact, clinical presentation, and corrective interventions. The Lancet Respiratory Medicine. 2022; 10(6):603-22. doi:10.1016/s2213-2600(22)00092-3
19. National Institute for Communicable Diseases [Internet]. Impact of COVID-19 intervention on TB testing in South Africa South Africa: National Institute for Communicable Diseases; 2020 [cited 2023 09-11-2023]. Available from: https://www.nicd.ac.za/wp-content/uploads/2020/05/Impact-of-Covid-19-interventions-on-TB-testing-in-South-Africa-10-May-2020.pdf.
20. Pillay Y, Pienaar S, Barron P, Zondi T. Impact of COVID-19 on routine primary healthcare services in South Africa. South African Medical Journal. 2021; 111(8):714. doi:10.7196/samj.2021.v111i8.15786
21. Burzynski JJ, Macaraig M, Nilsen D, Schluger NW. Transforming essential services for tuberculosis during the COVID-19 pandemic: lessons from New York City. The international journal of tuberculosis and lung disease : the official journal of the International Union against Tuberculosis and Lung Disease. 2020; 24(7):735-6.
22. Rai DK, Kumar R, Pandey SK. Problems faced by tuberculosis patients during COVID-19 pandemic: Urgent need to intervene. Indian Journal of Tuberculosis. 2020; 67(4):S173-S4. doi:10.1016/j.ijtb.2020.07.013
23. Cilloni L, Fu H, Vesga JF, Dowdy D, Pretorius C, Ahmedov S, et al. The potential impact of the COVID-19 pandemic on the tuberculosis epidemic a modelling analysis. EClinicalMedicine. 2020; 28:100603. doi:10.1016/j.eclinm.2020.100603
24. Hogan AB, Jewell BL, Sherrard-Smith E, Vesga JF, Watson OJ, Whittaker C, et al. Potential impact of the COVID-19 pandemic on HIV, tuberculosis, and malaria in low-income and middle-income countries: a modelling study. The Lancet Global Health. 2020; 8:e1132-e41. doi:10.1016/S2214-109X(20)30288-6
25. Stop TB Partnership [Internet]. The potential impact of the COVID-19 response on tuberculosis in high-burden countries: A modelling analysis. 2020 [cited 08-23-2023]. Available from: http://www.stoptb.org/assets/documents/news/Modeling%20Report_1%20May%202020_FINAL.pdf.
26. McQuaid CF, Vassall A, Cohen T, Fiekert K, White RG. The impact of COVID-19 on TB: a review of the data. Int J Tuberc Lung Dis. 2021; 25(6):436-46. doi:10.5588/ijtld.21.0148
27. Finn McQuaid C, McCreesh N, Read JM, Sumner T, Houben RMGJ, White RG, et al. The potential impact of COVID-19-related disruption on tuberculosis burden. European Respiratory Journal. 2020; 56 doi:10.1183/13993003.01718-2020
28. Africa CDC [Internet]. Africa CDC COVID-19 Dashboard. 2023 [cited 2023 08-09-2023]. Available from: https://africacdc.org/covid-19/.
29. National Institute for Communicable Diseases [Internet]. Strengthen the link between people diagnosed with TB and treatment initiation. South Africa: National Institute for Communicable Disease; 2023 [cited 2023]. Available from: https://www.nicd.ac.za/strengthening-the-link-between-people-diagnosed-with-tb-and-treatment-initiation/.
30. Arksey H, O'Malley L. Scoping studies: Towards a methodological framework. International Journal of Social Research Methodology: Theory and Practice. 2005; 8:19-32. doi:10.1080/1364557032000119616

31. Levac D, Colquhoun H, O'Brien KK. Scoping studies: Advancing the methodology. Implementation Science. 2010; 5:69. doi:10.1186/1748-5908-5-69
32. Peters MD, et al. Updated methodological guidance for the conduct of scoping reviews. JBI Evidence Synthesis. 2020; 18(10):2119.
33. Lungu P, Kerkhoff A, Muyoyeta M, Kasapo C, Nyangu S, Kagujje M, et al. Interrupted time-series analysis of active case-finding for tuberculosis during the COVID-19 pandemic, Zambia. Bulletin of the World Health Organization. 2022; 100(03):205-15. doi:10.2471/blt.21.286109
34. Mutyambizi C, Dunlop J, Maluleke C, Ranoto L, Chetty T, Ndou R, et al. Effect of COVID-19 on HIV, tuberculosis, and prevention of mother-to-child transmission of HIV indicators in Mopani district, South Africa. South African Medical Journal. 2021; 111(12):1181. doi:10.7196/samj.2021.v111i12.15822
35. Patel LN, Kozikott S, Ilboudo R, Kamateeka M, Lamorde M, Subah M, et al. Safer primary healthcare facilities are needed to protect healthcare workers and maintain essential services: lessons learned from a multicountry COVID-19 emergency response initiative. BMJ Global Health. 2021; 6(6):e005833. doi:10.1136/bmjgh-2021-005833
36. Kweza PF, Van Schalkwyk C, Abraham N, Uys M, Claassens MM, Medina-Marino A. Estimating the magnitude of pulmonary tuberculosis patients missed by primary health care clinics in South Africa. The International Journal of Tuberculosis and Lung Disease. 2018; 22(3):264-72. doi:10.5588/ijtld.17.0491
37. Achmat B, Gerber B. Challenges to infection control in early communication intervention: A scoping review. South African Journal of Communication Disorders. 2022; 69(2) doi:10.4102/sajcd.v69i2.911
38. Wang X, Ferro EG, Zhou G, Hashimoto D, Bhatt DL. Association Between Universal Masking in a Health Care System and SARS-CoV-2 Positivity Among Health Care Workers. JAMA. 2020; 324(7):703. doi:10.1001/jama.2020.12897
39. Klompas M, Morris CA, Sinclair J, Pearson M, Shenoy ES. Universal Masking in Hospitals in the Covid-19 Era. New England Journal of Medicine. 2020; 382(21):e63. doi:10.1056/nejmp2006372
40. Curran R, Murdoch J, van Rensburg AJ, Bachmann M, Awotiwon A, Ras CJ, et al. A health systems intervention to strengthen the integration of tuberculosis and COVID-19 detection: Outcomes of a quasi-experimental study in a high burden tuberculosis district in KwaZulu Natal, South Africa. Trop Med Int Health. 2023; 28(4):324-34. doi:10.1111/tmi.13860
41. Storla DG, Yimer S, Bjune GA. A systematic review of delay in the diagnosis and treatment of tuberculosis. BMC Public Health. 2008; 8(1):15. doi:10.1186/1471-2458-8-15
42. Kaswaswa K, Macpherson P, Kumwenda M, Mpunga J, Thindwa D, Nliwasa M, et al. Effect of patient-delivered household contact tracing and prevention for tuberculosis: A household cluster-randomised trial in Malawi. PLOS ONE. 2022; 17(9):e0269219. doi:10.1371/journal.pone.0269219
43. Esmail A, Randall P, Oelofse S, Tomasicchio M, Pooran A, Meldau R, et al. Comparison of two diagnostic intervention packages for community-based active case finding for tuberculosis: an open-label randomized controlled trial. Nature Medicine. 2023; 29(4):1009-16. doi:10.1038/s41591-023-02247-1
44. Arsenault C, Roder-DeWan S, Kruk ME. Measuring and improving the quality of tuberculosis care: A framework and implications from the Lancet Global Health Commission. Journal of Clinical Tuberculosis and Other Mycobacterial Diseases. 2019; 16:100112. doi:10.1016/j.jctube.2019.100112
45. Kruk ME, Gage AD, Arsenault C, Jordan K, Leslie HH, Roder-Dewan S, et al. High-quality health systems in the Sustainable Development Goals era: time for a revolution. The Lancet Global Health. 2018; 6(11):e1196-e252. doi:10.1016/s2214-109x(18)30386-3

46. Ashiagbor G, Ofori-Asenso R, Forkuo EK, Agyei-Frimpong S. Measures of geographic accessibility to health care in the Ashanti Region of Ghana. Scientific African. 2020; 9:e00453. doi:https://doi.org/10.1016/j.sciaf.2020.e00453
47. Dangisso MH, Datiko DG, Lindtjørn B. Accessibility to tuberculosis control services and tuberculosis programme performance in southern Ethiopia. Global Health Action. 2015; 8(1):29443. doi:10.3402/gha.v8.29443
48. Kuupiel D, Adu KM, Apiribu F, Bawontuo V, Adogboba DA, Ali KT, et al. Geographic accessibility to public health facilities providing tuberculosis testing services at point-of-care in the upper east region, Ghana. BMC Public Health. 2019; 19(1) doi:10.1186/s12889-019-7052-2
49. Hierink F, Okiro EA, Flahault A, Ray N. The winding road to health: A systematic scoping review on the effect of geographical accessibility to health care on infectious diseases in low- and middle-income countries. PLOS ONE. 2021; 16(1):e0244921. doi:10.1371/journal.pone.0244921
50. Tadesse T, Demissie M, Berhane Y, Kebede Y, Abebe M. Long distance travelling and financial burdens discourage tuberculosis DOTs treatment initiation and compliance in Ethiopia: a qualitative study. BMC public health. 2013; 13:424-. doi:10.1186/1471-2458-13-424
51. Cazabon D, Pande T, Sen P, Daftary A, Arsenault C, Bhatnagar H, et al. User experience and patient satisfaction with tuberculosis care in low- and middle-income countries: A systematic review. J Clin Tuberc Other Mycobact Dis. 2020; 19:100154. doi:10.1016/j.jctube.2020.100154
52. Cazabon D, Alsdurf H, Satyanarayana S, Nathavitharana R, Subbaraman R, Daftary A, et al. Quality of tuberculosis care in high burden countries: the urgent need to address gaps in the care cascade. International Journal of Infectious Diseases. 2017; 56:111-6. doi:10.1016/j.ijid.2016.10.016
53. Reid MJA, Arinaminpathy N, Bloom A, Bloom BR, Boehme C, Chaisson R, et al. Building a tuberculosis-free world: The Lancet Commission on tuberculosis. The Lancet. 2019; 393(10178):1331-84. doi:10.1016/s0140-6736(19)30024-8
54. John W C. Research Design Qualititative, Quantitative and Mixed Methods Approach. 3rd ed. Thousand Oaks: SAGE Publications; 2009.
55. Mokgalaka H. Measuring Access to Primary Health Care: Use of a GIS-Based Accessibility Analysis. In: Patel Y, Minyuku N, Van Der Bank C, Mohan K, Ogra A, editors. Sixth Planning Africa Conference; 19-22 October 2014; Durban2014.
56. Shaw N, McGuire S. Understanding the use of geographical information systems (GIS) in health informatics research: A review. Journal of Innovation in Health Informatics. 2017; 24(2):228. doi:10.14236/jhi.v24i2.940
57. Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. J Clin Pharm Ther. 2002; 27(4):299-309. doi:10.1046/j.1365-2710.2002.00430.x
58. Donabedian A. The quality of care. How can it be assessed? JAMA: The Journal of the American Medical Association. 1988; 260(12):1743.

Appendices

• Appendix 1: University of Pretoria Ethics Approval

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

Institution: The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.

- FWA 00002567, Approved dd 22 May 2002 and Expires 03/20/2022.
- IORG #: IORG0001762 OMB No. 0990-0279 Approved for use through February 28, 2022 and Expires: 03/04/2023.

Faculty of Health Sciences **Research Ethics Committee**

24 November 2021

Approval Certificate
New Application

Dear Miss TN Dlangalala

Ethics Reference No.: 652/2021
Title: Towards Development of a Novel Approach for Enhancement of TB Diagnostic Services during the Pandemic: A case of Primary Health Care Clinics in eThekwini District KwaZulu-Natal

The **New Application** as supported by documents received between 2021-11-02 and 2021-11-24 for your research, was approved by the Faculty of Health Sciences Research Ethics Committee on 2021-11-24 as resolved by its quorate meeting.

Please note the following about your ethics approval:

- Ethics Approval is valid for 1 year and needs to be renewed annually by 2022-11-24.
- Please remember to use your protocol number (652/2021) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

On behalf of the FHS REC, Dr R Sommers
MBChB, MMed (Int), MPharmMed, PhD
Deputy Chairperson of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health)

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Fakulteit Gesondheidswetenskappe
Lefapha la Disaense tša Maphelo

• Appendix 2: University of Pretoria Amended Ethics Approval

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

Institution: The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH GCP guidelines and has US Federal wide Assurance.

- FWA 00002567, Approved dd 18 March 2022 and Expires 18 March 2027.
- IORG #: IORG0001762 OMB No. 0990-0278 Approved for use through August 31, 2023

Faculty of Health Sciences **Research Ethics Committee**

20 May 2022

Approval Certificate
Amendment

Dear Miss TN Dlangalala,

Ethics Reference No.: 652/2021 – Line 1
Title: Towards Development of a Novel Approach for Enhancement of TB Diagnostic Services during the Pandemic: A case of Primary Health Care Clinics in eThekwini District KwaZulu-Natal

The **Amendment** as supported by documents received between 2022-04-20 and 2022-05-20 for your research, was approved by the Faculty of Health Sciences Research Ethics Committee on 2022-05-20 as resolved by its quorate meeting.

Please note the following about your ethics approval:

- Please remember to use your protocol number (652/2021) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

On behalf of the FHS REC, Dr R Sommers
MBChB, MMed (Int), MPharmMed, PhD
***Deputy Chairperson** of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria*

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health).

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Fakulteit Gesondheidswetenskappe
Lefapha la Disaense tša Maphelo

● **Appendix 3: KwaZulu Natal Department of Health Ethics Approval**

health
Department:
Health
PROVINCE OF KWAZULU-NATAL

Physical Address: 330 Langalibalele Street, Pietermaritzburg
Postal Address: Private Bag X9051
Tel. 033 395 2505/ 3180/ 3123 Fax: 033 394 3782
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DIRECTORATE:
Health Research & Knowledge Management

NHRD Ref: KZ_202112_012

Dear Ms TN Dlangalala
(University of Pretoria)

Approval of research

1. The research proposal titled **'Towards Development of a Novel Approach for Enhancement of TB Diagnostic Services during the Pandemic: A case of Primary Health Care Clinics in eThekwini District KwaZulu-Natal'** was reviewed by the KwaZulu Natal Department of Health (KZN-DoH).

   The amendment to protocol and the ethics approval (Ethics reference no.: 652/2021 – Line 1) is hereby noted and **approved** for research to be undertaken at all clinics that offer TB testing in eThekwini Health District as well as DHIS and GIS data.

2. You are requested to take note of the following:
   a. *All research conducted in KwaZulu-Natal must comply with government regulations relating to Covid-19. These include but are not limited to: regulations concerning social distancing, the wearing of personal protective equipment, and limitations on meetings and social gatherings.*
   b. *Kindly liaise with the facility manager BEFORE your research begins in order to ensure that conditions in the facility are conducive to the conduct of your research. These include, but are not limited to, an assurance that the numbers of patients attending the facility are sufficient to support your sample size requirements, and that the space and physical infrastructure of the facility can accommodate the research team and any additional equipment required for the research.*
   c. *Please ensure that you provide your letter of ethics re-certification to this unit, when the current approval expires.*
   d. *Provide an interim progress report and final report (electronic and hard copies) when your research is complete to* ***HEALTH RESEARCH AND KNOWLEDGE MANAGEMENT, 10-102, PRIVATE BAG X9051, PIETERMARITZBURG, 3200*** *and e-mail an electronic copy to* hrkm@kznhealth.gov.za
   e. *Please note that the Department of Health shall not be held liable for any injury that occurs as a result of this study.*

For any additional information please contact Mr X. Xaba on 033-395 2805.

Yours Sincerely

E Lutge

Dr E Lutge
Chairperson, Health Research Committee
Date: 13/06/2022

Fighting Disease, Fighting Poverty, Giving Hope

• Appendix 4: eThekwini Municipality Research Health Approval Letter

ETHEKWINI MUNICIPALITY
Community & Emergency Services Cluster
Health Unit

3 Archie Gumede Place
Durban 4001
P O Box 2443
Durban 4000
Tel: (031) 311 2505
Fax: (031) 311 3710
Website: http://www.durban.org.za

Ref. No. 30/1/1 / 6/3/1

To: Thobeka Dlangalala

16 February 2023

Dear Researcher,

<u>Subject: Approval of a Research Proposal</u>

The Research Proposal Titled: "**Towards Development of a Novel Approach for Enhancement of TB Diagnostic Services during the Pandemic: A case of Primary Health Care Clinics in eThekwini District KwaZulu-Natal.**" was reviewed by the eThekwini Municipal Health Department Research Committee. The study is hereby **approved to be conducted at eThekwini Municipal Clinics as per attached Annexure A, until 13 October 2023.**

The <u>following conditions</u> need to be <u>noted:</u>

- Submission of the indemnity form obtainable from the eThekwini Municipality Health Unit before commencement of the study
- Prior arrangements to be made with the facility and an assurance that clinic services will not be disrupted.
- No staff member should be used for collecting data for the researchers.
- **Progress reports to be provided and the final report of the study to the eThekwini Municipality Health Unit or emailed to: Bongi.Ntombela@durban.gov.za**
- Obtain permission from the eThekwini municipality health department for press releases and release of results to communities/stakeholders.
- The department has to receive recognition for the assistance given.
- Any amendment to the study must be communicated with the eThekwini Municipality Health Unit and the relevant amendment form obtainable from the unit to be submitted.
- Withdrawal of permission to conduct research will be left to the discretion of the eThekwini Municipality Health Unit.
- **Please take note of the duration of the study approval.**
- **An extension may be applied for if required. The Committee will review such a request and provide feedback accordingly.**

Yours sincerely

Mrs. Rosemary Van Heerden

Head of Health

ETHEKWINI MUNICIPALITY
HEALTH UNIT
TELEPHONE NO: 031 311 3509/8

● **Appendix 5: Informed Consent Form**

PARTICIPANT'S INFORMATION & INFORMED CONSENT DOCUMENT

STUDY TITLE: Towards Development of a Novel Approach for Enhancement of TB Diagnostic Services during the Pandemic: A case of Primary Health Care Clinics in eThekwini District KwaZulu-Natal

Principal Investigators: Thobeka Nomzamo Dlangalala

Institution: University of Pretoria

DAYTIME AND AFTER HOURS TELEPHONE NUMBER(S):

Daytime number/s: 078 915 3494

Afterhours number: 078 915 3494

DATE AND TIME OF FIRST INFORMED CONSENT DISCUSSION:

				:
Date	**month**	**year**		**Time**

Dear Prospective Participant

Dear Mr. / Mrs. ....

1) INTRODUCTION

You are invited to volunteer for a research study. I am doing research for a PhD Degree purpose at the University of Pretoria. This information in this document is to help you to decide if you would like to participate. Before you agree to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this document, do not hesitate to ask the researcher. You should not agree to take part unless you are completely happy about all the procedures involved.

2) THE NATURE AND PURPOSE OF THIS STUDY

The aim of this study aims to investigate the state of TB diagnostic services at primary healthcare (PHC) clinics during COVID-19. By doing so we wish to find a way to improve TB diagnostic services at primary healthcare clinics during pandemics.

3) EXPLANATION OF PROCEDURES AND WHAT WILL BE EXPECTED FROM PARTICIPANTS.

This study involves answering some questions regarding your experience with the TB services that you received.

4) POSSIBLE RISKS AND DISCOMFORTS INVOLVED

There are no medical risks associated with the study. The only possible risk and discomfort involved is sharing any negative experiences about the health facility that you regularly attend. You can decline to answer any questions that cause you discomfort.

5) POSSIBLE BENEFITS OF THIS STUDY

Although you may not benefit directly. The study results may help us to improve the TB services at primary healthcare clinics.

6) COMPENSATION

You will not be paid to take part in the study. There are no costs involved for you to be part of the study.

7) YOUR RIGHTS AS A RESEARCH PARTICIPANT

Your participation in this trial is entirely voluntary and you can refuse to participate or stop at any time without stating any reason. Your withdrawal will not affect your access to other medical care.

8) ETHICS APPROVAL

This Protocol was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, telephone numbers 012 356 3084 / 012 356 3085 and written approval has been granted by that committee (Approval Number…652/2021…………………). The study was also submitted to the Health Research and Knowledge Management Unit of the KZN department of health, telephone number 033 395 2046 and has received written ethical approval (Approval Number… Ref: KZ_202112_012….). The study has been structured in accordance with the Declaration of Helsinki (last update: October 2013), which deals with the recommendations guiding doctors in biomedical research involving human/subjects. A copy of the Declaration may be obtained from the investigator should you wish to review it.

9) INFORMATION

If I have any questions concerning this study, I should contact:

Prof Mashamba-Thompson Tel: (+27) 21 319 2102/2198

10) CONFIDENTIALITY

All information obtained during the course of this study will be regarded as confidential. Each participant that is taking part will be provided with an alphanumeric coded number e.g. A001. This will ensure confidentiality of information so collected. Only the researcher will be able to identify you as participant. Results will be published or presented in such a fashion that patients remain unidentifiable. The hard copies of all your records will be kept in a locked facility at the Department of Public Health, The University of Pretoria.

11) CONSENT TO PARTICIPATE IN THIS STUDY

- I confirm that the person requesting my consent for my child to take part in this study has told me about the nature and process, any risks or discomforts, and the benefits of the study.
- I have also received, read and understood the above written information about the study.
- I have had adequate time to ask questions and I have no objections to participate in this study.
- I am aware that the information obtained in the study, including personal details, will be anonymously processed and presented in the reporting of results.
- I understand that I will not be penalised in any way should I wish to discontinue with the study and that withdrawal will not affect my further treatments.

- I am participating willingly.
- I have received a signed copy of this informed consent agreement.

Participant's name (Please print)	Date	
Participant's signature	Date	
Researcher's name (Please print)	Date	
Researcher's signature	Date	
Signature of the Witness	Date	