FACTORS ASSOCIATED WITH LOW TUBERCULOSIS CASE NOTIFICATION AND TREATMENT SUCCESS AT HEALTH FACILITIES OF ZAMBIA: A CROSS-SECTIONAL STUDY

By

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DECLARATION

I declare that this dissertation is the original work of Tikulirekuti Banda C. It has been prepared in accordance with the guidelines for Masters Dissertations of the University of Zambia. It has not been admitted for a degree at this or any other University.

Student: Tikulirekuti Banda C. Signature…………….Date………………………..

CERTIFICATE OF APPROVAL

We, the undersigned recommend this thesis/dissertation of Tikulirekuti Banda C. has been approved as fulfilling the requirements or partial fulfillment of the requirements for the award of the Degree of Master of Public Health in Health Policy and Management by the University of Zambia.

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ABSTRACT

Introduction: Early detection and successful treatment of people with Tuberculosis (TB) prevents millions of deaths globally. Yet, gaps persist in the detection and treatment of TB. Zambia's weak health system only exacerbates matters with the country having one of the highest TB burdens in the world. Furthermore, 58 per cent of the identified TB patients in Zambia are co-infected with HIV making it a double public health burden.

Aim: To determine health systems factors associated with low tuberculosis case notification and treatment success in health facilities of Zambia as well as determine their variations in the effect size of associations.

Methods: The study used secondary health facility data from the 2019 Health Facility Listing Survey and 2017 and 2018 Health Management Information System data sets. A cross-sectional design was used to analyze data from 81health facilities from 9 provinces of Zambia. Data was managed using STATA version 14. Linear regression analysis was used to analyze factors associated with low TB case notification and treatment success while quantile regression and principal component analysis were used to determine the effect size of these associations.

Results: Linear regression analysis indicated that low TB case notification was positively associated with personnel(P-value 0.00, CI =0.120.62), negatively associated with rural clinic (p-value 0.00, CI= -2.91, 0.84),negatively associated with 3rd level hospital(p-value 0.05, -5.12, 0.15) and negatively associated with having no TB clinic(p-value 0.01, CI= -1.57,-2.48) while low Treatment Success was positively associated with personnel(p-value 0.02, CI= 0.06, 0.65)and population(p-value 0.00, CI=0.13, 0.58) but negatively rural clinic(p-value 0.00, CI= -3.07,-1.55) and having no TB clinic(p-value 0.00, CI= -2.10,-0.03). When analyzed by year, both low TB notification and Treatment success were associated with personnel in 2017 and 2018 respectively. While results from quantile regression showed that for facilities at the 25th percentile of case notification or treatment success, having an addition staff was associated with 3 times year increase in notification or treatment success than facilities at all other quartiles. Similarly, results from simple regression using principal component analysis showed that those facilities that had equipment at the 3rd quarter were 2 and 3 times higher to notify TB and treat it compared to those facilities that had equipment at the lower quarters, however, when the equipment variable was run in a multiple regression, results show that it was insignificant.

Conclusion: Low TB case notification and treatment success still remains a challenge in health facilities of Zambia. Using systems thinking approach is thus cardinal in understanding and tackling health systems barriers affecting TB control programs.

DEDICATION

I dedicate this research to my mother who has been my pillar and motivation to carry on even when pressure seemed unbearable, I was encouraged to forge ahead knowing she was looking up to me to set an example to my young brother. And to my family and support system, this would not have been possible without you.

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ABBREVIATIONS AND STATISTICAL TERMS USED

AIDS	Acquired Immunodeficiency Syndrome
CDL	Chest Disease Laboratory
CIP	Capital Investment Plan
DOTS	Direct Observed Treatment Short Course
DR-TB	Drug Resistant Tuberculosis
DST	Drug Susceptibility Testing
HCW	Health Care Worker
HIV	Human Immunodeficiency Virus
HMIS	Health Management Information System
JICA	Japan International Co-operative Agency
MDR	Multi Drug Resistant
NGO	Non Governmental Organization
NHSP	National Health Strategic Plan
NTP	National Tuberculosis Program
OLR	Ordinary Linear Regression
PCA	Principal Component Analysis
TB	Tuberculosis
TSR	Treatment Success Rate
TDRC	Tropical Disease Research Centre
UN	United Nations
UNZABREC	University of Zambia Biomedical Research Ethics
UHC	Universal Health Coverage
UTH	University Teaching Hospital
WHA	World Health Assembly
WHO	World Health Organization

LIST OF DEFINITIONS

Drug –resistant TB (XDR TB) is a rare type of Multi-Drug Resistant Tuberculosis that is resistant to isoniazid and rifampin, plus flouroquinolone and at least one of the three injectable second-line drugs.

Extra pulmonary TB (EPTB) is diagnosed by one culture-positive specimen from an extra pulmonary site or histo-pathological evidence from a biopsy, which is based on strong clinical evidence consistent with active EPTB by a clinician's decision. However, most health facilities diagnose the disease based on a clinician's decision because there are inadequate laboratory facilities for sputum culture or histopathology.

Multi-Drug Resistant TB (MDR-TB) is TB that does not respond to at least isonniazid and rifampicin, the 2 most powerful anti TB drugs.

TB case notification is defined as the number of new and relapse cases of TB in a specified time period.

TB case notification rate is defined as the number of TB cases (new and relapse) notified to the national health authorities during a specified period of time per 100,000 population.

TB cure rate is the percentage of TB cases registered in a specified period that successfully were cured.

TB treatment success is defined as the proportion of new smear-positive TB cases registered in a given year that successfully completed treatment, whether with bacteriologic evidence of success cured or without treatment completed.

Smear-positive pulmonary TB (PTB+) is diagnosed with at least two positive initial sputum smears for Acid Fast Bacilli (AFB) by direct microscopy, or one positive smear for AFB by direct microscopy and culture positive or one positive smear for AFB by direct microscopy and radiographic abnormalities consistent with active TB as determined by a clinician.

Smear-negative TB (PTB-) is diagnosed when the patient is presented with symptoms suggestive of TB, has at least three initial smear examinations negative for AFB, no response to antibiotics, repeat smear-negative and radiological abnormalities consistent with pulmonary TB, as well as a clinician's decision.

CHAPTER ONE: INTRODUCTION

1.0 INTRODUCTION

1.1 Background

Tuberculosis (TB) remains one of the world‘s deadliest communicable diseases after HIV/AIDs making it a major public health burden (WHO TB Report 2017). Although TB, an infectious disease caused by bacteria (*Mycobacterium tuberculosis*) affects millions of people worldwide and is mostly spread from person to person through the air, it mainly affects people from poor resource limited settings with high TB risk factors such as HIV, poor living conditions and under nutrition. Access to quality essential health services without suffering financial hardships is hence key in achieving Universal Health Coverage (UHC).Yet, fair distribution of resources to health care still remains challenging in many low middle income countries(LMIC) globally thus affecting their health systems(Li et al., 2017).

1.1.1 Global Tuberculosis Prevalence

Globally, TB is most common in Africa, the West Pacific, and Eastern Europe. These regions are plagued with factors that contribute to the spread of TB, including the presence of limited resources, HIV infection, and Multi Drug-Resistant (MDR) TB with seven countries accounting for 64 percent of the total tuberculosis globally, with India leading the count, followed by Indonesia, China, Philippines, Pakistan, Nigeria, and South Africa (WHO TB Report 2017). Although international public health efforts have put a huge curb on the rate of increase in TB, these regions account for the continued increase in global TB with an estimated 2 billion people being infected with *Mycobacterium tuberculosis* (Gabriel et al., 2011).

In 2017 for instance, 10.4 million people fell ill with TB but only 6.4 million TB cases were reported leaving a total of 4 million TB cases not notified and put on TB treatment, further increasing the global TB burden on already struggling health systems. In addition, there has been a global increase in the development of Drug Resistant Tuberculosis (DR-TB) which has had a negative impact on TB treatment success, with only one in three of the approximately half a million people with drug resistant TB enrolled into care in 2018.

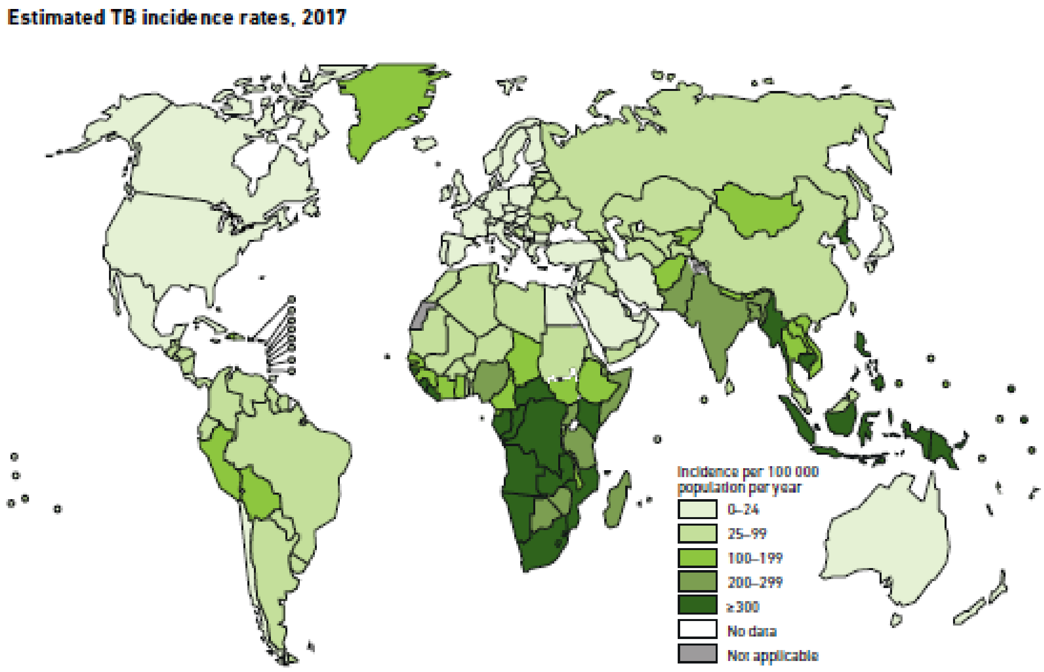


Figure 1: Global Tuberculosis Prevalence 2017: *Global TB Report 2018*

1.1.2 TB and Global Health Systems

Various global interventions have been made to control the TB endemic. For instance in 2000, to drive progress against TB, the United Nations Millennium Development Goals committed to halt and begun to reverse the global TB epidemic by 2015. The world met that goal, and TB programmes saved some 43 million lives worldwide between 2000 and 2014(Global Plan to End TB Report). However, the Stop TB Partnership's targets of halving TB prevalence and death rates by 2015 were not met in all regions of the world. Between 2000 and 2014, TB incidence fell by an average of only 1.5 percent a year, an unacceptably slow rate of decline for a preventable and curable disease (Classeus et al 2016). While a 2014 prevalence survey showed that TB prevalence in several high-burden countries were even greater than previously estimated (Global Plan to end TB report 2015).

For this reason, in 2014, the World Health Assembly (WHA) unanimously approved the End TB Strategy, a 20-year strategy to end the global TB epidemic, with the vision of a world with "zero deaths, disease and suffering due to TB". Whilst progress has been made globally towards the 2020 targets to halt and reverse the TB epidemic and to reduce by half deaths from TB from the baseline 1990, the Africa region has not been on course to achieve these targets and is contributing to the slow decline in incident TB. The major driver of TB in the Africa region has been the HIV epidemic and failure to timely diagnosis TB with appropriate treatment (Global Plan to end TB report, 2015). Most recently, as a measure to support countries close gaps in these TB detection and treatment, in 2018 World Health Organization (WHO), in collaboration with the Stop TB Partnership and the Global Fund to Fight AIDS, Tuberculosis and Malaria, launched an initiative called ‘Find. Treat. All’, an initiative whose target is to detect and treat 40 million people with TB between 2018 and 2022 (Global Tuberculosis Report 2018).

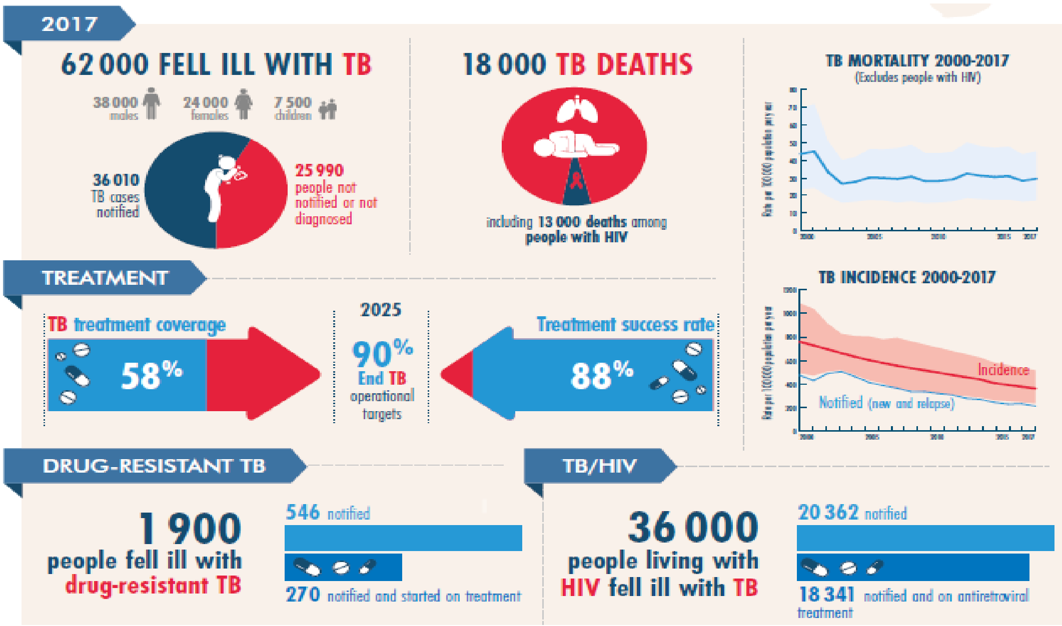
Well functioning health systems are thus required for effective implementation of these TB programs. This is because the six elements necessary to create a health system: leadership and governance, health care financing, health workforce, medical products and technologies, information and research and, service delivery are all essential to achieve the goals of a health system in order to create better health, awareness and response to the needs of global communities and financial protection against high medical service costs (WHO 2014 Report).

1.1.3 Tuberculosis in Zambia

According to Kapata et al .(2015), Zambia ranks 13th in the world in terms of TB prevalence with 70 per cent of the identified TB patients being co-infected with HIV making it a double public health burden. In 2017 for instance, over 62 000 people fell in with TB making it among one of the highest burden countries in the world (WHO TB Global TB Report 2018). However, only about half of these (36 010) cases were notified leaving the other half not notified or diagnosed. Similarly, 36 000 cases were co-infected with HIV (218/100 000).

Treatment coverage stood at 58 percent against the global treatment coverage of 90 percent set to end TB by 2025 with 1900 people falling ill with drug resistant TB. This low treatment coverage resulted in 1800 TB deaths occurring in 2017 including 1300 deaths among people living with HIV (Global TB Report 2018).

Factors leading to this gap in TB notification and treatment success could be due to both supply and demand factors as the gap in notification and treatment success could be as a result of stigma, distance to health facilities, inadequate human resource, financing, equipment and infrastructure. Improving diagnosis and treatment is hence critical.



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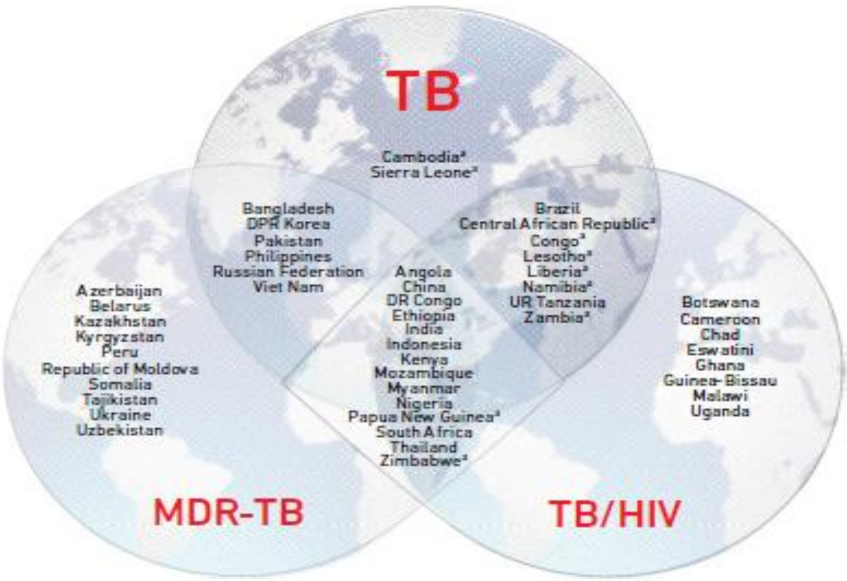

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Figures 2 (a, b): TB in Zambia, *Global Tuberculosis Report 2018.*

1.1.4 National Tuberculosis Interventions and health systems barriers

In Zambia, the first TB control programme was launched more than 40 years ago with one of the most prominent TB control being the Direct Observed Treatment Short course (DOTS). The DOTS strategy was adopted in Zambia as the primary approach to TB control in 1993. The DOTS strategy focuses on five main points of action. These include government commitment to control TB, diagnosis based on sputum-smear microscopy tests done on patients who actively report TB symptoms, direct observation short-course chemotherapy treatments, a definite supply of drugs, and standardized reporting and recording of cases and treatment outcomes.

The WHO advises that all TB patients should have at least the first two months of their therapy observed (and preferably the whole of it observed) (Gabriel et al 2011). By the year 2003 the country had attained 100 percent DOTS coverage in all of the then nine provinces (Zambia TB program Report 2007).

In 2006, the country adopted the STOP TB strategy for which the DOTS remain the corner stone. The Stop TB strategy involves the improvement of service delivery through the provision of high quality DOT expansion, addressing TB/HIV challenges and health systems strengthening and forms part of the national TB program in Zambia.

Zambia for instance is administratively divided into 10 provinces (increased from 9 in 2010), which are further divided into 106 districts as of 2010. In these districts delivery of health care follows a 3-tier system, namely, primary, secondary, and tertiary level, and the referral system follows these levels. The primary level consists of health posts, health centres, and first-level hospitals. A few districts have first-level hospitals but second-level and third-level hospitals are restricted to a few of the 10 provinces (MoH 2011). The National TB Program structure therefore coordinates TB programs from national, provincial, district, facility and community level. Effective TB case notification and treatment success therefore depends on health systems strengthening at all these various levels.

Structure of the National Tuberculosis Program in Zambia

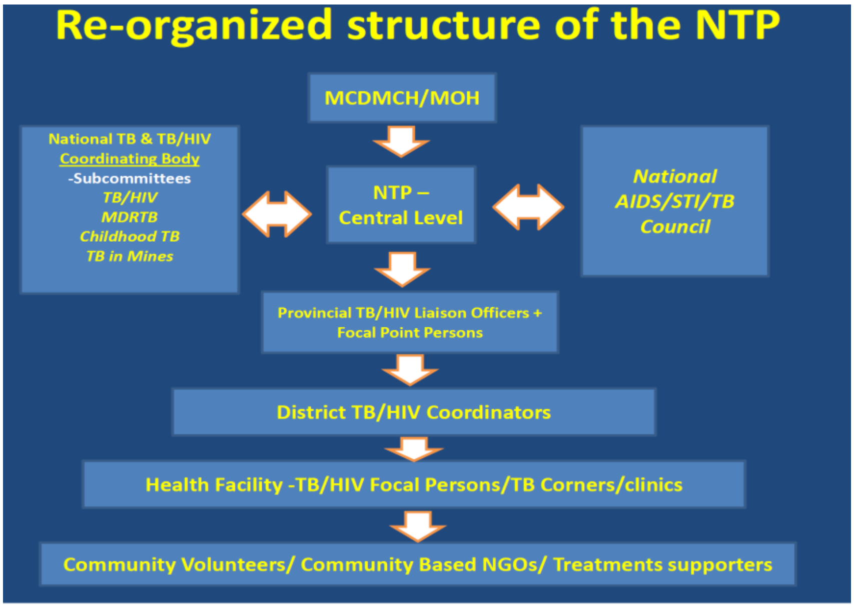

Figure 3: Implementation stages of the National Tuberculosis Program of Zambia

Kapata et al. 2015)

On one hand, several countries that have implemented the STOP TB strategy have seen progress in TB case notification and treatment success. For instance a study by Dememew et al. (2016) in Ethiopia found that tuberculosis case notification had stabilized with treatment success rates (TSRs) having improved, reaching a peak of 86 percent in 2014. Dememew et al. (2016) further states that this success is attributable to the effective implementation of the DOTS strategy at national level, a key component of the Stop TB and End TB strategies.

On the other hand however, another study by Hassanain et al. (2018) conducted in Sudan found that there was low TB case notification in the conflict zone from 2004 to 2014. The study also found that high loss to follow up and falling treatment success rates were found in both conflict and non-conflict zones, hence representing a significant public health risk. The study recommended that further analysis of the TB response and surveillance system in both zones is needed to confirm the factors associated with the poor outcomes. Also, using context-sensitive measures and simplified pathways with an emphasis on displaced persons may increase access and case notification in conflict zones, which can help avoid loss to follow up in both zones.
This study therefore aimed to conduct a similar study in Zambian health facilities as the one conducted by Hassanain et al. (2018), using secondary data from the Health Management Information System (HMIS) and the Health Facility Listing Survey 2019 and assess whether there is an association between health systems factors such as floor space, location, health facility type, defaulter tracing, contact tracing, equipment, personnel, facility beds, low TB case notification and treatment success in 81 health facilities from 18 districts of Zambia using linear regression to determine the associations between the dependent and independent variables and quantile and principal component analysis to determine the variations in the effect size of the associations.

1.2 Statement of the Problem

Despite various structures of the Zambia National Tuberculosis Program being put in place, many health systems gaps hinder the effective implementation of the programs. High proportions of TB cases not notified and low treatment success rates over the decade have not improved (Kapata et al. 2015). It is not clear whether these gaps in notification and treatment success (stipulated in the background) could be due to health system challenges such as human resources, financing, infrastructure, equipment and service delivery. For example, in 2017, 40 percent of the national TB budget was unfunded, 51 percent was internationally funded and only 9 percent was funded from domestic sources (WHO2017). Similarly, most health facilities do not have full capacity to diagnose and treat TB with parastatal and government facilities having only 50 percent capacity to diagnose TB while private facilities having only 30 percent capacity (Chongwe et al 2015). This is despite the fact that 80 percent of health facilities are owned by government, 6 percent by faith-based organizations (missions) and 14 percent are private-for-profit (MoH 2011). Poor infrastructure further contributes to the spread of tuberculosis in clinical settings and prisons and other congregate settings due to overcrowding (Kapata et al. 2016).

Furthermore, nearly all other aspects of the health systems in Zambia are strained by the continuously increasing demands placed upon them by demographic and epidemiologic transitions along with technological advances and rising public expectations. Like most LMIC in the region, Zambia is in the process of attempting to reform its health care system in a responsible manner, further squeezing the limited resources available for badly needed TB case notification and treatment success in Zambia. In addition, there are few LMIC TB derived models that meet the contextual challenges faced by the country (Li et al., 2017).

Thus to avoid further spread of TB, reduce the development of MDR TB and improve survival, there is need to improve TB case notification and treatment success. Yet, limited knowledge on the importance of various facility level factors that are associated with TB case notification and treatment success in Zambia has been generated. Thus the study seeks to provide an understanding of the factors associated with low TB case notification and treatment success at health facility level in Zambia as this would serve as an indicator to assess the effectiveness of TB control programs as it would provide one of the indications for the ongoing transmission of the disease in a community. Therefore, generating information from surveillance data would be useful for understanding the burden of the disease in a community and such information could provide essential evidence for improving TB programs thus contributing towards global TB elimination targets.

1.3 Rationale of the Study

The findings of the study seek to provide knowledge on why TB case notification and treatment success is low in Zambia and provide an indication whether there was an association between the location(rural/urban), floor space, facility beds, facility type, ownership TB clinic, defaulter tracing, contact tracing, equipment and population with the low TB notification and treatment success. This study is important as it sought to determine health systems factors associated with low TB case notification and treatment success in order to better notify and treat TB in Zambia and provide information for the Zambian National TB program as well as policy makers for targeted TB interventions towards the attainment of the End TB strategy of 2020.

1.4 Research Question

The research question for this study was:

What factors are associated with low tuberculosis case notification and treatment success in Zambia?

1.5 STUDY OBJECTIVES

1.5.1 General Objectives

To determine health systems factors associated with low tuberculosis case notification and treatment success in health facilities of Zambia.

1.5.2 Specific Objectives

1. To identify and compare the distribution of TB case notification and treatment success by district.
2. To examine supply side factors associated with low TB case notification and treatment success using linear regression.
3. To determine differences in the magnitude of associations driving TB case notification and treatment success at various levels of case notification and treatment success (low and high performers) using quantile regression.

1.6 Conceptual Framework

A conceptual framework was adopted to facilitate the understanding of the tuberculosis program in a comprehensive way. The conceptual framework for the study is illustrated in **Figure 1** (below) and was used to help answer and analyze the data related to general and specific objectives.

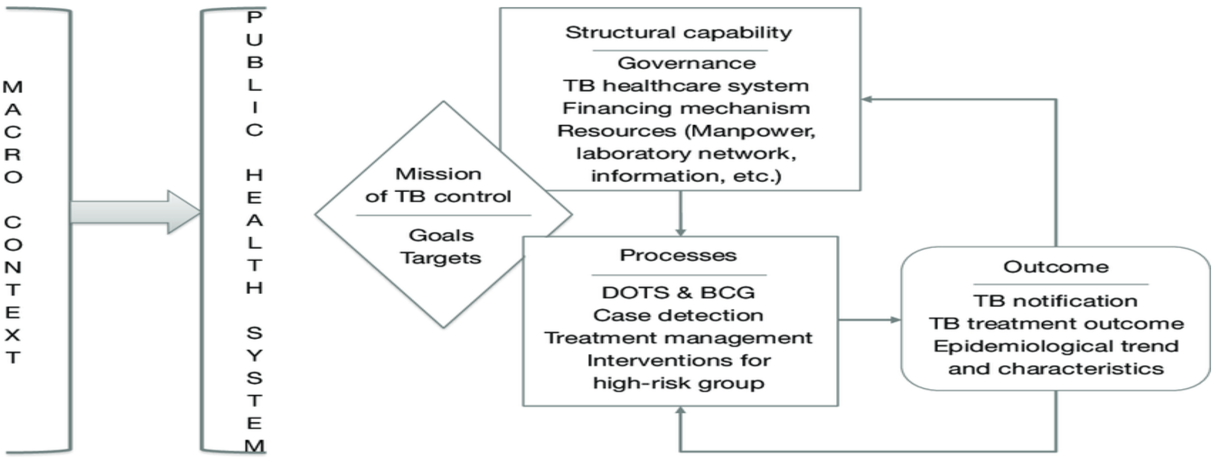

Figure 4: *Conceptual Framework (Adopted from the TB Control Program in Public Health System 2011*)

It is important to understand that the success of Tuberculosis interventions is affected by various health systems factors. The above conceptual framework can be explained as follows:

Macro context: Various macro level factors such as policies, political stability, socio-economic factors and population growth can affect efficient running of health systems particularly in low middle income countries such as Zambia which may affect the performance of TB programs. For instance, the large population size (18 million, CSO 2019), high density of population and per capita living space, urbanization, people living with high-risk factors for TB (such as HIV, poor living conditions, poorly ventilated homes, overcrowded , under nutrition) could pose new challenges for the TB control programs leading to poor implementation of these programs (Li et al., 2017).

Public Health System: Furthermore, macro level factors such as political stability and policies could affect the well functioning of the 6 health systems building blocks (service delivery, health workforce, information, medical products (vaccines and technology), financing and leadership and governance) in the TB control program as effective implementation of these depends on political buy-in and policies. However, in Zambia, understanding how these building blocks are interrelated is still a challenge. This is because the concept of systems thinking has not been widely used in Zambian interventions (Mutale et al., 2015).

Outcome: The lack of application of systems thinking subsequently has a negative impact on clear planning, monitoring, management and implementation of set targets thus resulting in poor output (TB case detection and treatment management) of activities/ inputs and leading to poor outcome of TB programs such as TB notification, TB treatment outcome as well as epidemiological trend and characteristics (Chaing et al., 2015)

CHAPTER TWO: LITERATURE REVIEW

2.0 LITERATURE REVIEW

In order to understand the link between TB case notification, treatment success and health systems factors, some literatures were reviewed.

2.1 TB distribution patterns

Studies have been done globally to understand the distribution patterns of TB in order to understand which areas have high TB burden. A study conducted in Brazil found TB rates were notably high in urban areas on the Eastern sea board and in the Western parts of the country These high TB rates were associated with high population density, poor economic conditions, household crowding, non-white populations and poor health and health care indicators(Harling 2014). While the study highlights that the poverty partially confounded these associations, it does not provide insights on how this could have controlled (i.e. how the confounders could have been controlled).

Similarly, a systematic review on conducted by Ashad et al 2010 found that active screening of TB among new immigrants in immigration entry points had relatively high yield of TB detection. For instance, the review found that the yield for pulmonary tuberculosis was 3.5 cases per 1,000 screened. Refugees, asylum seekers and regular immigrants had 11.9, 2.8 and 2.7 yield for pulmonary TB, respectively. While the yield estimates for immigrants from Europe, Africa and Asia were 2.4, 6.5 and 11.2 respectively. Despite the study results being useful data for informing the development of coherent policies and rational screening services for the detection of immigrant associated tuberculosis, the study excluded studies which looked at TB detection in children less than 16 years old, Drug resistant TB and studies that looked at prevalence of TB in migrants moving from low incident areas, which could have given a broad idea of TB patterns in migrant children and people migrating from low incident areas. More research is therefore needed to be conducted in refugee camps and immigration entry points to determine the TB prevalence of immigrants/refugees as they migrate to new countries. Such a study would particularly be beneficial as the country hosts over 10 000 refugees from neighbouring war tone countries such as Congo DRC and Angola.

2.2 Health systems factors (facility level)

While individual factors (demand side) such as HIV co-infections and stigma are associated with low TB case notification and treatment success, studies have shown that supply side factors (health systems factors such as human resource, finance, infrastructure, equipment) also play a key role in low TB case notification and treatment success(Hearce et.al 2018).

A study by Colson et al (2015) to benchmark the performance of health systems performance in districts of Zambia found that despite the country making progress towards service delivery over the last few decades, sub-national variations across districts and interventions still existe. The study Hence recommande that benchmarking performance of health systems at sub-national level was cardinal for policy makers in order for them to prioritize areas of need in order to increase accountability at local, regional and national levels. There is therefore need for more health systems performance studies to be conducted at community, facility, district and national levels in order to inform policy decisions.

2.2.1 TB Diagnostic tools

A cross sectional study conducted by Dangisso et al (2015) to assess factors associated with low notification rates of childhood tuberculosis in Southern Ethiopia found that the TB notification rates were low in children less than 15 due to poor TB diagnostic techniques at facility level. Thus the study recommended that more efforts need to be made in order to improve the diagnosis and treatment of TB among children globally particularly in developing countries. A similar study on the importance of appropriate TB diagnostic tools for resource limited setting was conducted by Muyoyeta et al (2015) and found that routine use of Xpert (a TB diagnostic tool) in a resource limited setting at primary care level resulted in additional cases of confirmed TB patients starting treatment expectedly and increased notification rates of bacteriologically confirmed TB cases in Zambian health facilities. The study also found that same day diagnosis and treatment commencement was achieved for both bacteriologically confirmed and empirically diagnosed patients where Xpert was used in conjunction with CXR. This study therefore indicates the need for cost-effective TB diagnostic tools in order to improve TB case notification and treatment success.

Another study by Charles et al (2017) was conducted to examine the trends in tuberculosis case notification and treatment success in Haiti. The study examined trends in TB case notification in Haiti from the aggregated data reported by the National TB Control Program to understand the effects of such efforts. . The study found that case notification rates of all forms of TB increased from 142.7/100,000 in 2010 to 153.4 in 2015, peaking at 163.4/100,000 in 2013. Case notification for smear-positive pulmonary TB increased from 85.5/100,000 to 105.7/100,000, whereas treatment success rates remained stable at 79–80 percent during the period. Lastly, the study found that active TB case finding efforts in high-risk communities and the introduction of new diagnostics have contributed to increasing TB case notification trends in Haiti from 2010 to 2015 and that targeted interventions and novel strategies are being implemented to reach high-risk populations and underserved communities. Additionally, from the study, it is evidenced that the use of diagnostic tools in TB detection increases the case notification rates of TB. There is however little or no change between increased TB notification and Treatment Success, hence more needs to be done to ensure that notified TB cases result in TB treatment success.

Furthermore, a study in Zambia by Kapata et al. (2016) to determine the prevalence of TB in Zambia was conducted and found that there was need to improve TB diagnostic programs order to increase the TB case detection and treatment in Zambia.

2.2.2 Active community contact tracing.

Contact tracing plays another vital role in strengthening TB detection thus reducing the burden of the disease. For instance, a similar study conducted by Karamagi et al. (2018) found that TB case notification in study intervention districts improved from 171 to 223 per 100,000 population between the baseline months of October–December 2016 and end line month of April–June 2017 as a result of active contact tracing. This was because TB patient contacts had the majority of TB positive cases identified during active case finding (40, 6.1%). This study therefore shows the significance of contact tracing particularly in resource limited settings such as Zambia where access to health services is limited due to financial constraints.

An advantage of community contact tracing is the fact that most communities are overcrowded hence TB is easily transmitted from one person to the other. This is particularly true in compounds and prisons In Zambia for instance, prisoners account for one of the highest number of TB positive cases. A study conducted by Hatwiinda et al 2017 in Zambian prisons found that from the 6282 inmates from 6 prisons who were screened for TB, 374 (6.0%) were diagnosed. TB treatment was initiated in 345 of 374 (92%) inmates. Of those, 66% were cured or completed treatment, 5% died and 29% were lost to follow-up. The study also found that among those lost to follow-up, 11% were released into the community and 13% were transferred to other prisons. Contact tracing therefore becomes cardinal in TB detection and treatment.

2.2.3 Lack of available equipment

Lack of availability of equipment in low resource settings is among the barriers to TB notification and treatment. A study in 2012 for instance found that at the secondary and tertiary level, 18 percent of hospitals had no blood pressure measuring equipment, 22 percent had no X-ray machines, and 33 percent had no ultrasound machines (Institute for Health Metrics & Evaluation, 2014). In Zambia, the situation is even more severe at the primary level where about 40 percent of health centres, run by government or faith-based organizations, had no qualified staff, and most of these were in rural areas (Hangoma et al 2017). Furthermore, lack of personal protective equipment of health care workers means that health care workers in the frontline of TB interventions stand a higher risk of contracting the disease. For example, a retrospective study by Klimu et al. (2014) to determine the prevalence of TB among health care workers (HCWs) along with patient characteristics, treatment outcomes and drug resistance patterns between 2008 and 2012 found that there were 116 HCWs with TB. Additionally, the study found that the case notification rates were higher among HCWs than in the general population (349 vs. 40/100 000 in 2012). This study therefore showed that there was high prevalence of recorded TB in HCWs in TB health facilities in Belarus thus suggesting that workers were at high risk of getting infected with Tuberculosis.

2.2.4 Personnel

It is also significant to note that delayed diagnosis of TB, particularly in LMICs with weak health systems significantly contribute to poor quality of life. For example, a systematic review of three studies conducted in different time periods in Turkey found that delayed action in the health system was the main source of TB delay in identifying the disease early and making it more treatable (Yilmaz et al 2001). This was because health care providers were slow in detecting TB as the tools for TB diagnosis were underutilized. The paper also identified on average five health care providers in the region available to TB patients for treatment (range= 2-12) and a minimum of two visits to each patient before a diagnosis of TB is confirmed(Yilmal et all., 2001).

2.2.5 Lack of ressources

Limited resources directed at improving TB programs still remain a challenge. On average for instance, studies have found that Middle East and North African governments spent about 8.2 per cent of their budget on health care compared to 80 per cent on the military forces in some countries. Furthermore, in 2011, Saudi Arabia and the United Arab Emirates, considered as wealthy countries, spent 2.3 per cent and 4.1 per cent respectively of their gross domestic product (GDP) on health care. This resulted in high costs for families in the region who had to pay almost 40 per cent of all health care costs (World Bank Report 2014).

Zambia for instance, has a mixed health care financing system with a heavy reliance on external financing with a third to half of total health expenditure is from external sources (Ministry of Health, 2009, World Health Organization, 2015). Additionally, Zambia spends US$86 per capita on health and 38 percent of this is from household further promoting inequities as majority of Zambian households live below the poverty datum line (World Health Organization, 2015).

Similarly, for a long time, Zambia government spending on health has fallen far below the Abuja target of 15 percent with health financing challenges having resulted in severe capacity constraints which have been driving most individuals utilizing publicly supported facilities to the private market for drugs and diagnostics (Hangoma et al 2017). This is despite the fact that in terms of ownership, 80 percent of health facilities are owned by government, 6 percent by faith-based organizations (missions) and only 14 percent are private-for-profit (MoH 2011). This makes it difficult for TB interventions such as contact tracing and defaulter tracing to be effectively implemented as there are limited resource to recruit more personnels in the health facilities.

In conclusion, various health systems factors hinder TB case notification and treatment particularly in low middle income countries such as Zambia. This study seeks to further understand the health systems factors associated with low TB case notification and treatment success in health facilities of Zambia. This shall be done using a systems thinking approach to evaluate health interventions by assessing the 6 health systems building blocks as being interrelated and interdependent rather than as silos (Mutale et al 2015).

CHAPTER THREE: METHODOLOGY

3.0 METHODOLOGY

This section shall discuss the study design, study site, study population, variables, and sources of information, sampling techniques, research instruments, data collection and data analysis used in the research.

3.1 Study design

This study used a quantitative approach to answer the research question at hand. The study used a cross sectional study design. This is because the study reviewed secondary data from two data sets namely: the Health Facility Listing Survey 2019 data set and the Health Management Information Systems (HMIS) 2017 and 2018 Tuberculosis quarterly reports data sets. Hence, the study retrospectively reviewed data from these two data sets and extracted dependent and independent variables for the study.

3.2 Study Setting

Secondary data for the dependent variables(TB case notification and treatment success) was extracted from the HMIS through the assistance of TB focal point persons from 18 districts(81 health facilities TB data extracted) from 8 provinces of Zambia namely, Lusaka, Central, Western, North-Western, Eastern, Northern, Muchinga and Southern provinces. While the Health Facility survey data set was collected from the Ministry of Health (Provincial Health office) and TB focal point persons from. The research focused on extracted data from 81 facilities that had notified and treated TB using the Health Management Information System between 2017 and 2018. The facilities included in the study comprised of 1^{st} level, 2^{nd} level, 3^{rd} level, urban clinics, rural health posts, military and mission hospitals that were part of the Health Facility Listing Survey and had the study independent variables.

3.3 Study Population

The study population comprised of health systems factors(Personnel, location, floor space, facility beds, facility type, ownership, TB clinic, defaulter tracing, Contact tracing and equipment) from 81 TB diagnostic health facilities in 18 districts(8 provinces) of Zambia. These districts included Sesheke, Mongu, Limulunga, Lukulu, Kaoma, Monze, Mumbwa, Lusaka, Kafue, Mfumbwe, Chongwe, Nyimba, Sinda, Katete, Mambwe, Chipata, Chama and Mbala

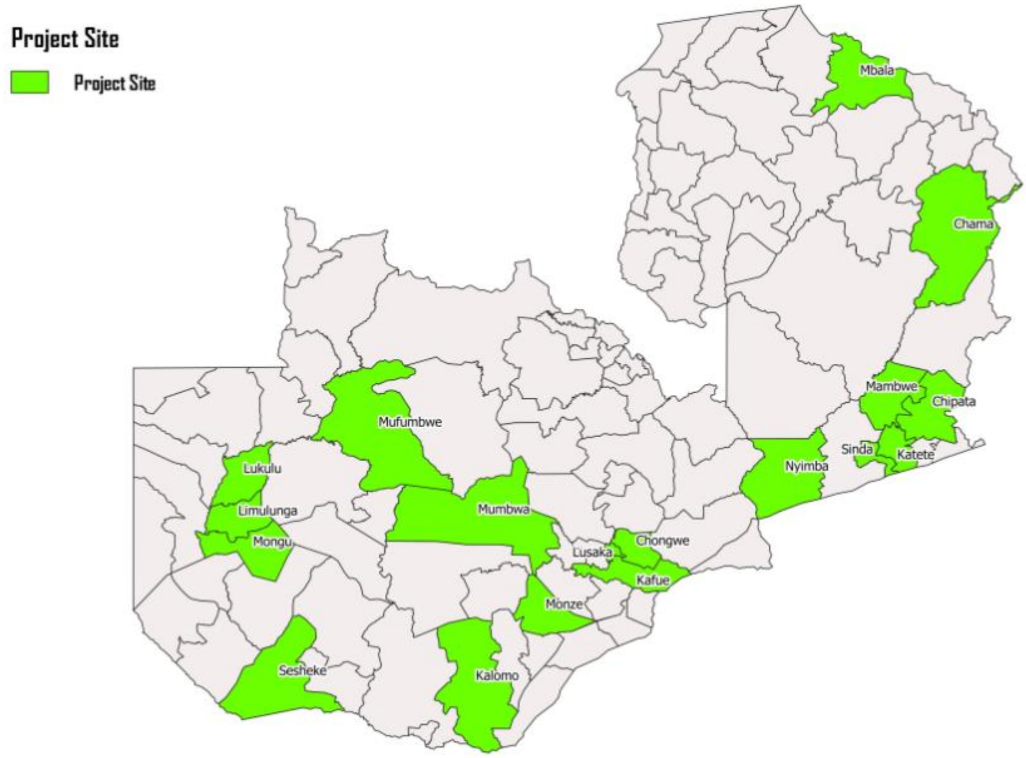

Figure 5: Map of Project setting (*derived using GIS mapping*)

3.4 Sampling Frame

The study used total sampling of 81 health facilities in the Health Facility Listing Survey that could be matched with the HMIS 2017 and 2018 TB data sets. The sampling frame included dependent variables TB case notification and treatment success as well as independent variables (Personnel, location, floor space, facility beds, facility type, ownership, TB clinic, defaulter tracing, Contact tracing and equipment) from the 81 health facilities. Both the HMIS data sets and the Health Facility Listing Survey sampling frames were obtained from the Ministry of Health. Cases with all parameters required for a TB notification rate and treatment success were included in the study while cases with missing parameters as well as individuals without cases of TB notification and treatment success were excluded from the study. Hence from the 81 Health Facility Listing Survey health facilities selected, independent variables (Personnel, location, floor space, facility beds, facility type, ownership, TB clinic, defaulter tracing, Contact tracing and equipment)were extracted and matched with the dependent variables from the HMIS(case notification and treatment success).

3.5 Data Collection

This section describes the sources of data for the study which were collected from November, 2018 to June, 2019 and outlines how data was collected.

3.5.1 Surveillance Data

Surveillance data was obtained from the Ministry of Health's electronic database. The Health Management Information System (HMIS) was established in 1996 and covers health facilities in all the districts of Zambia. It captures data on disease morbidity and mortality, maternal and child health services, service delivery, surveillance and financial services. HMIS data collection is conducted at the health facility level using a paper based system and is aggregated and computerized from district to national level. The study extracted recorded TB case notifications and treatment success in Zambia from 81 health facilities captured in the database between 2017 and 2018.

3.5.2 Health Facility Listing Survey 2017/2018

The Health Facility Listing Survey was conducted by the Ministry of Health; University of Zambia School of Public Health with support from the Japan International Co-operative Agency (JICA) conducted the survey between June 2017 and March 2018. The main purpose of the census was to collect information from public health facilities on five thematic areas such as 1) infrastructure, 2) utility 3) transport 4) medical equipment and 5) human resources as well as general facility information and service provision. The census aimed to collect adequate and updated data for MOH to develop National Health Capital Investment Plan (CIP) in line with National Health Strategic Plan (NHSP). The survey targeted all health facilities owned by Government, Non-Governmental Organizations (NGOs) and faith-based operated in all ten provinces of Zambia. Data was collected using electronic data collection forms uploaded onto tablets with GPS functionality to enable collection of data on GPS coordinates for all the health facilities surveyed. A total of 2,468 facilities were physically enumerated in the census whereas a total of 2,479 facilities were recorded as final dataset after the MOH headquarters and all the ten Provincial Health Offices verified and finalized the collected data. This means that the census omitted a total of 11 health facilities from the physical count. Therefore, the study extracted independent variables (Personnel, location, floor space, facility beds, facility type, ownership, TB clinic, defaulter tracing, Contact tracing and equipment) from 81 health facilities from the 2019 survey findings which were then matched with the 2017 and 2018 HMIS data and was used for the study.

3.6 Inclusion and Exclusion Criterion

The study included all facilities that had all the dependent variables (TB case notification and treatment success) of interest were included in the study while facilities that did not have all the dependent variables were excluded. In addition facilities that had at least 95% of the independent variables were included in the study while facilities that did not have 95% of the independent variables were dropped from the study.

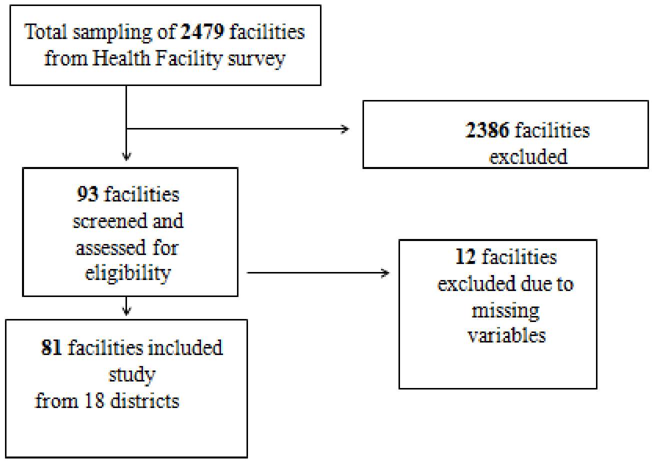

Figure 6: Inclusion and Exclusion Criteria of study health facilities

3.7 Study Variables

The study used TB case notification and treatment success as the dependent or outcome variables while the study used personnel, location, floor space, facility beds, facility type, TB clinic, defaulter tracing, Contact tracing and equipment as independent variables. A list of variables is shown below in table 1.

3.7.2 List of variables

	Variable	**Indicator**	**Variable Type**	**Scale of measure**
Dependent variable	TB Case Notification	TB incidence rate	Continuous	Nominal
	TB Treatment Success	TB prevalence Rate	Continuous	Nominal
Independent variables	Floor space	Size of health facility	Continuous	Nominal
	Personnel	Number of health workers	Continuous	Nominal
	Location	Rural/ Urban	Discrete	Ordinal
	Equipment	Number of equipment used by facility	Continuous	Nominal
	TB Clinic	Number of TB clinics	Discrete	Ordinal
	Defaulter tracing	Number of patients traced through defaulter tracing	Discrete	Ordinal
	Contact Tracing	Number of patients contacted through tracing	Discrete	Ordinal
	Facility type	Types of health facility	Categorical	Ordinal
	Ownership	Type of ownership	Categorical	Ordinal

Table 1: List of dependent and Independent variables

3.8 Data Collection and Analysis

3.8.1 Data extraction and cleaning

Research data on the variables of interest was extracted from the HMIS data sets and Health Facility Listing survey excel data sets using a data extraction tool. This involved the extraction of quarterly TB cases notified and treated from individual TB diagnostic health facilities. The notified TB cases included the new and relapse TB cases recorded per quarter while the TB treatment success included bacteriological confirmed cured TB cases as well as cases that had been completed whether confirmed bacteriological or not. Once this extraction of TB case notification and treatment success was done, the health facilities with complete TB case notified and treated from 2017 to 2018 were matched with the Health Facility Listing survey independent variables (personnel, floor space, equipment, contact tracing, location, defaulter tracing, facility type, facility bed, TB clinic). Facilities that did not have complete dependent variables or independent variables were dropped from the study as shown in figure 6 above. The data collected was typed into an excel sheet as well as hand written in an exercise book using a pen. This was followed by data cleaning using Microsoft Excel and STATA version 14.2 using commands such as codebook, duplicate lists, label and drop. Once the data was cleaned and verified, data validation(Internal validation of the data done by using descriptive analyses to check the integrity of the data while external validation was done by verifying the data set with the original HMIS and Health Facility survey data sets)was conducted and the data was declared clean for the analysis.

3.8.2 Data Analysis

The study had 2 dependent variables namely TB case notification and TB treatment success while the independent variables included personnel, location(rural/urban), floor space, facility beds, facility type, ownership, TB clinic, defaulter tracing, contact tracing, equipment, population. Descriptive statistics were used to summarize continuous dependent (TB case notification, treatment success) and independent variables (personnel, floor space, facility beds, population). Descriptive statistics were used to summarize data in an organized manner as they described the relationship between the dependent and independent variables (Kaur 2018). While categorical data was summarized using tabulations (see table 1 of the results).

Thus calculating the descriptive statistics in STATA version 14.2 represented a vital first step for the research descriptive statistics such as the median and inter-quartile range were used to summarize and describe the data as it was not normally distributed (dependent variable data). This was followed by a cross tabulation to determine the overall distribution of predictor

variables by TB Case notification and Treatment success and then stratified by urban and rural areas as well as type of facility, ownership, contact tracing and defaulter tracing.
Since the dependent variables were continuous variables, simple and multiple linear regression models were used. While Poisson model for count variables could have been used as the outcome variables were counts (Kiandifard et al.1995), the model was not used as the model is best used to analyze rare diseases and TB in Zambia is not rare as alluded to in the introduction.

.3.8.3.3 Choice of econometric Model

According to Greenland (1985), in a study of the dependence of a response variable on a set of independent variables, the choice of a model is largely determined by the scale of measurement of the response variable. When a response variable is continuous, linear regression model is commonly used to determine the associations. Wooldridge (2003) further states that Linear regression, when applied to method comparison data, provides useful information about proportional, constant, and random error via, respectively, the slope, intercept, and standard deviation of the residuals. Linear regression data may be used for calibrating a new method against an established one or validating the utility of a method in relation to analytical quality specifications. The classical linear regression model is referred to here as ordinary least square regression (OLS).The regression line is calculated by minimizing the squared residuals in the y direction ('least squares'). OLS assumes an error free x variable and a constant analytical imprecision (sa) of the y variable (also called "homoscedastic" variance), both of which are seldom met in practice.
Quantile regression is a type of regression analysis used in statistics and econometrics. Whereas the method of least squares results in estimates of the conditional mean of the response variable given certain values of the predictor variables, quantile regression aims at estimating either the conditional median or other quantiles of the response variable. Essentially, quantile regression is the extension of linear regression and is used when the conditions of linear regression are not applicable. Quantile regression is also desired if conditional quantile functions are of interest. One advantage of quantile regression, relative to the ordinary least squares regression, is that the quantile regression estimates are more robust against outliers in the response measurements. However, the main attraction of quantile regression goes beyond that as different measures of central tendency and statistical dispersion can be useful to obtain a more comprehensive analysis of the relationship between variables (Roger et al 2001).
Principal Component Analysis (PCA) is a dimension reduction tool that can be used to reduce a large set of variables to a small set that still contains most of the information in the large set.

It transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible. PCA seeks a linear combination of variables such that the maximum variance is extracted from the variables. It then removes this variance and seeks a second linear combination which explains the maximum proportion of the remaining variance, and so on. This is called the principal axis method and results in orthogonal (uncorrelated) factors. PCA analyzes total (common and unique) variance (Rao, 2002).Therefore, the study measured the equipment variable using PCA.

3.8. 2.1Testing for expected value for the estimator and bias

Before simple linear regression and multiple regressions were conducted however, data was first tested for biasness. This is because linear regression is unbiased if the sample size of the research was equal to the population. Hence a number of tests were conducted as follows:

Linearity assumption: This assumption states that in a linear regression, the relationship between the independent and dependent variable is linear. Hence it was important to check for outliers since linear regression is sensitive to outlier effects. Therefore this assumption was tested using scatter plots to test whether the relationship between the dependent variables(TB case notification and treatment success) and the independent variables(personnel, equipment, health facility type etc.) was linear or not.

Normality assumption: Next, in order to test if the TB case notification and treatment success data was normally distributed, a histogram command was conducted to assess if data was normally distributed.

During the analysis, results showed that the data set was not normally distributed. To correct this log transformation of the continuous variables (both dependent continuous variables and independent continuous variables) was done. Log transformation is a method used to transform skewed data to approximately conform to normality thereby reducing outliers (Feng et al, 2014).

Only continuous variables were transformed and these included TB case notification, treatment success, personnel, and floor space, population and facility beds. This was then followed by simple regression of the logged TB case notification and treatment success with the independent variables. Significance at unadjusted univariate regression was set at a p-value of 0.05 and a 95 per cent confidence interval. Similarly for multiple linear regressions, significance was set at a p-value of 0.05 and 95 per cent confidence interval. Variables with that were statistically significant were tabulated.

3.8.2.2 Multiple Linear regression

While the simple linear regression looks at one exposure to explain variation in the outcome variable, multiple regression looks at multiple exposures to explain the variations in the outcome variable/variables hence making it possible to determine causality.

The following multiple regression equation was used:

1. $\hat{Y} = b_0 + b_1 X_1 + b_2 X_2 + \ldots + b_p X_p$

Where $\hat{Y}$ is the predicted or expected value (TB case notification or treatment success) of the dependent variable, X1 through Xp are p distinct independent or predictor variables (personnel, floor space, equipment, contact tracing, location, defaulter tracing, facility type, facility bed, TB clinic), b0 is the value of Y when all of the independent variables (X1 through Xp) are equal to zero, and b1 through bp are the estimated regression coefficients. Each regression coefficient represents the change in Y relative to a one unit change in the respective independent variable. In the multiple regression situation, b1, for example, is the change in Y relative to a one unit change in X1, holding all other independent variables constant (i.e., when the remaining independent variables are held at the same value or are fixed) (Cohen ,1988).

Two multiple linear regression models were run in STATA as follows:

2. *TB case notification*=$\beta_0 + \beta_{1pers1} + \beta_{2own2} + \beta_{3flospa3} + \beta_{4fac\_beds4} + \beta_{5pop5} + \beta_{6TB\_clinic6} + \beta_{7def\_tracing7} + \beta_{8loc8} + \beta_{9cont\_trac} + \beta_{10equip10} + u$,
3. *TB treatment success*=$\beta_0 + \beta_{1pers1} + \beta_{2own2} + \beta_{3flospa3} + \beta_{4fac\_beds4} + \beta_{5pop5} + \beta_{6TB\_clinic6} + \beta_{7def\_tracing7} + \beta_{8loc8} + \beta_{9cont\_trac} + \beta_{10equip10} + u$.

Where: *TB case notification* was the number of TB cases notified, *TB treatment success* was the number of TB cases successfully treated, *pers* was the number of personnel at a given health facility, *own2* was the facility ownership(e.g government, private or mission health facility) at a given health facility, *flospa* was the floor space of a given health facility, *fac_beds* was the number of beds at a given health facility, TB clinic was the number of TB clinics at a given health facility, *def_tracing* was whether a facility conducted defaulter tracing or not, *cont_trac* was whether a given facility conducted contact tracing or not and *equip* is the number of equipment a give facility has.

With the two linear regression model, factors associated with low TB case notification and treatment success were determined

**Note: The dependent variables TB case notification and TB treatment success variables and continuous independent were logged.*

3.8.2.3 Principal component analysis and quantile regression

Principal component analysis was used to manage the large equipment data set as well as determine the variations in the effect size of the associations. While quantile regression was used to answer the third objective in order to determine the variations in the effect size of these associations on the 2 dependent variables using different percentiles of the independent variables (25^{th}, 50^{th}, 75^{th} and 95^{th}) percentiles.

The following quantile regressions equation was used:

$$\sum_{i:y_i \geq x_i\beta}^{N} \tau \left|y_i - x_i\beta\right| + \sum_{i:y_i \leq x_i\beta}^{N} (1-\tau) \left|y_i - x_i\beta\right|$$

4.

Where *y* is the dependent variable, *x* the explanatory variables, β the parameters to be estimated and τ the percentile to be obtained. This technique reveals the effects of each covariate on the different percentiles(25^{th}, 50^{th}, 75^{th} and 95^{th}) of the dependent variables(TB case notification and treatment success), conditional to the value of the other exogenous variables in the model. Four quantile regression were therefore run at the different percentiles (25^{th}, 50^{th}, 75^{th} and 95^{th}) follows :

5. $qcase\ notification = \beta_0 + \beta_{1}pers_1 + \beta_{2}own_2 + \beta_{3}flospa_3 + \beta_{4}fac\_beds_4 + \beta_{5}pop_5 + \beta_{6}TB\_clinic_6 + \beta_{7}def\_tracing_7 + \beta_{8}loc_8 + \beta_{9}cont\_trac + \beta_{10}equip_{10} + quantile(percentile)$
6. $qtreatment\ success = \beta_0 + \beta_{1}pers_1 + \beta_{2}own_2 + \beta_{3}flospa_3 + \beta_{4}fac\_beds_4 + \beta_{5}pop_5 + \beta_{6}TB\_clinic_6 + \beta_{7}def\_tracing_7 + \beta_{8}loc_8 + \beta_{9}cont\_trac + \beta_{10}equip_{10} + quantile(percentile)$

**Note: The dependent variables TB case notification and TB treatment success variables and continuous independent variables were logged.*

3.9 Data management

The secondary data used for the study was extracted using a data extraction tool and used managed using STATA software, version 14.2 (STATA Corporation, TX, and USA). Facility information was de- identified and collected on a completed template as such confidentiality was upheld. The information was stored on a laptop that had a password lock to protect the data collected.

3.9.1 Dissemination of Findings

The is conducted in partial fulfillment of the requirement of the Master's degree program in Public Health, Health Policy and Management therefore, a copy will be submitted to the University of Zambia for accessibility to students for reference when doing research. The results will also be published in a peer reviewed journal. The findings of the study will similarly be disseminated to the health facilities in the districts as well as the Ministry of Health as they are the custodians of the data bases used in the study.

3.9.2 Ethical consideration

During the study, no information regarding names of participants was obtained. However, names of the facilities were obtained but de-identified for the purpose of anonymity when analyzing and presenting data. The data set was only used for purposes of the study and was not given to any other person or organization. Since the study used total sampling method, all facilities eligible for the study were included in the study hence justice was upheld as each facility had a chance to be part of the study. Beneficence and non-maleficence was similarly upheld in the study as all information collected was purely for the research purposes. In addition, since there was no direct contact with participants, as the study involved secondary data, no obvious physical injury to participants were observed. Instead, the study brought out maximum benefits as information obtained and analyzed shall be shared with stakeholders in order to provide knowledge for policy makers. The study sought ethical approval from University of Zambia Biomedical Research Ethics Committee (UNZABREC) prior to the commencement of field work. Further permission was sought from the National Health Research Authority. In order to access information from the Health Facility Listing Survey and HMIS data sets, permission was sought from the Ministry of Health Head Quarters, respective study provinces and districts.

CHAPTER FOUR: RESULTS

4.1 Descriptive statistics of the TB case notification and treatment success from 2017 and 2018

Upon tabulation of the results, the study found that there were a total of 81 TB diagnostic facilities in the 18 study districts in 2017 and 2018. These were categorized into 77 facility types.. These facility types included: rural health clinic (n=37) representing the largest type of facilities (46%). This was followed by 1st level hospitals and urban clinics both (n=17) representing (21 %) of health facility types. Military hospitals represented (5 %) (n=4) of health facility types followed by 3rd level hospitals with (4%) (n=3) and lastly 2nd level hospitals (n=2) representing (2%) of health facility types.

In terms of contact tracing, the study found that, 74 health facilities (94%)(n=81) conducted contact tracing in 2017 and 2018. Similarly, the results found that 72health facilities (n=81) (89%) conducted defaulter tracing in 2017 and 2018. conducted contact tracing. While only 15(n=81) health facilities had TB clinics in 2017 and 2018.In terms of the location where the study health facilities were located, 25 health facilities were located in rural areas (n=81) (31%) while 56 health facilities were located in urban areas (69%). Lastly, 81 health facilities in 2017 and 2018 had a total of 1474 equipment available. These results are summarized in **table 1**.

Table 1: Background characteristics

Variable	Population	%
Facility type 2017 (n= 81)		
1st level hospital	17	21
2nd Level hospital	2	2
3rd Level hospital	3	4
Mission hospital	1	1
Military hospital	4	5
Urban clinic	17	21
Rural health clinics	37	46
Facility type 2018 (n=81)		
1st level hospital	17	21
2nd Level hospital	2	2
3rd Level hospital	3	4
Mission hospital	1	1
Military hospital	4	5
Urban clinic	17	21
Rural health post	37	46
Contact tracing 2017(n=81)		
Yes	74	91
No	7	9
Contact tracing 2018 (n=81)		
Yes	74	91
No	7	9
TB clinic 2017 (n=81)		
Yes	15	19
No	66	81
TB clinic 2018 (n= 81)		
Yes	15	19
No	66	81
Defaulter Tracing 2017 (n= 81)		
Yes	72	89
No	9	11
Defaulter Tracing 2018		
(n=81)	72	89
Yes	9	11
No		
Location 2017 (n=81)		
Rural	25	31
Urban	56	69
Location 2018 (n=81)		
Rural	25	31
Urban	56	69

NOTE: ., *It is important to note that rural health clinics were not only found in rural areas as some urban areas of Lusaka district for instance had some health facilities categorized as being rural health clinics*.

In addition, the total number of health facility personnel was 4261 with both 2017 and 2018 with medians19 (IQR 5-61) (n=81. While the total health facility floor space was 96939 square metres with the median floor 1339 (IQR 612-3416) (n=81) in 2017 and 2018. In addition, the total number of facility beds was 5680 with the median 20 (IQR 7-68) (n=81). This is shown in **table 2** below.

Table 2: **Descriptive statistics using the median**

Variables	2017 Median (IQR)	2017 facilities surveyed	2018 Median (IQR)	2018 facilities surveyed
TB cases notified	35 (5-307)	n=81	26 (2-222)	n=81
TB treatment success	33 (2-288)	n=81	12 (0-187)	n=81
TB number on treatment	62(4, 427)	n=81	12 (1-254)	n=81
TB treatment success rate	90% (76%-100%)	n=81	93% (83%-100%)	n=81
Personnel	19 (5-61)	n=81	19 (5-61)	n=81
Floor space	1339 (IQR 612-3416)	n=81	1339 (IQR 612-3416)	n=81
Facility beds	20 (IQR 7-68)	n=81	20 (IQR 7-68)	n=81
Population	13693(IQR 5240 ,55165)	n=81	13693(IQR 5240 ,55165)	n=81

4. 2 Distribution patterns of TB case notification and Treatment Success

In terms of TB case notification and treatment success patterns across the various health facilities from the 18 study districts, Lusaka and Mongu had the highest TB cases notified while the rest of the districts had between 0 and 500 TB cases notified and treated in both 2017 and 2018 respectively with Limulunga, Lukulu, Mambwe, Mbala, Mfumbwe, Nyimba and Sinda recording extremely low TB cases notified and treated.

For instance, a total of 18611 cases of TB were notified in 2017 with 13652 notified from Lusaka district health facilities representing 73 percent of the cases notified. This was followed by Mongu health facilities with 1394 cases of TB notified representing 7percent while the rest of the TB cases notified were from facilities outside Lusaka and Mongu districts(Chama, Chipata, Chongwe, Kafue, Kalomo, Katete, Sinda, Limulunga, Lukulu, Mambwe, Mbala, Monze, Mfumbwe, Mumbwa, Nyimba and Sesheke districts).

Similarly, in the same year, a total of 17869 cases of TB were treated and 15990 cases in 2018. Of the cases treated in 2017, 14001 were from Lusaka representing 85percent of the cases treated. This was followed by Mongu district with 1180 representing 7percent of the cases treated while the other health facilities from 16 districts in the study represented the 8percent of the TB cases treated. The median TB treatment success was 33 (IQR 2-288) (n=81).

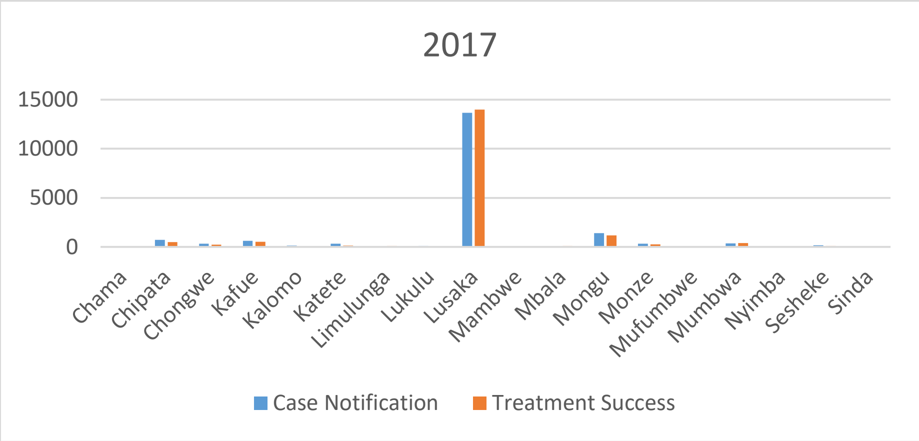

Figure 8: TB Case Notification and Treatment Success distribution pattern in 2017

While 2018 saw a reduction in TB case notification with 15898 cases of TB notified. In addition, of the cases notified, 12525 cases were notified from Lusaka district health facilities representing 79 percent of the cases notified followed by Mongu district health facilities with 634 cases of TB notified representing 4percent of the TB cases notified. The rest of the cases were notified from the rest of the study districts.

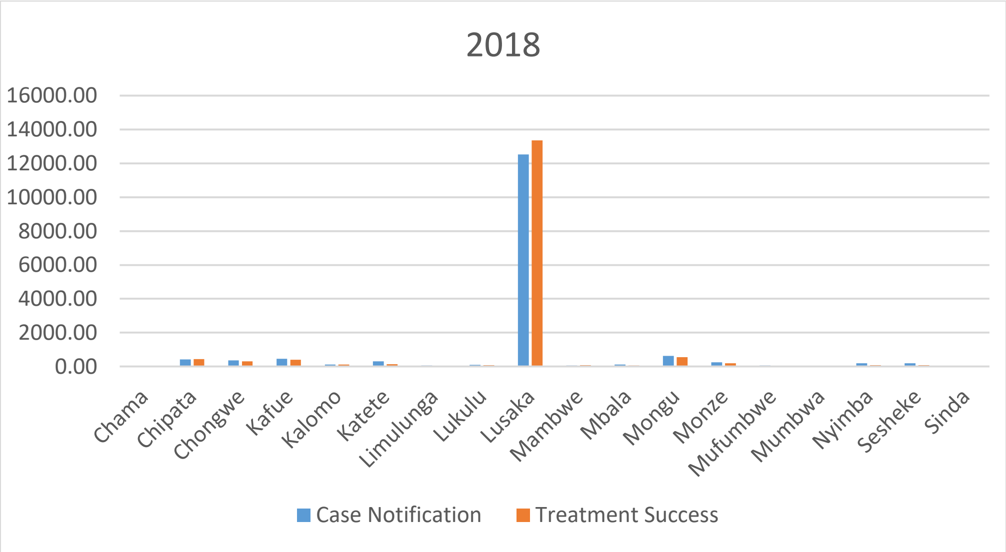

Figure 9: TB Case Notification and Treatment Success distribution pattern in 2018

4.3 Factors associated with low TB case notification and low treatment success

The variables personnel, floor space, facility beds, population, equipment, rural clinic, military hospital and TB clinics were significantly associated with low TB case notification at simple linear regression (Table 3).

Table 3: Unadjusted estimates of logged TB case notification

Factors	Coefficient	P-value	95% Confidence interval
Personnel	1.05	**0.001**	0.88, 1.23
floor space	0.67	**0.001**	0.46, 0.88
facility beds	0.8	**0.001**	0.57, 1.05
Population	0.83	**0.001**	0.64, 1.02
1st Level hospital	Ref	Ref	Ref
Urban clinic	0.1	0.77	(-0.58, 0.78)
Rural clinic	-3.48	**0.001**	(-4.11, -2.86)
2nd level hospital	-0.24	0.77	(-1.71, 1.23)
Military hospital	-1.24	**0.04**	(-2.39, -0.08)
3rd level hospital	-0.9	0.11	(-2.68, 0.26)
Mission hospital		0.52	(-3.71, 1.91)
Urban	Ref	Ref	Ref
Rural	1.18	0.2	-0.63, 2.99
TB Clinic	Ref	Ref	Ref
TB Clinic	3.95	**0.001**	1.98, 5.92
No Defaulter Tracing	Ref	Ref	Ref
Defaulter tracing	0.48	0.73	-2.26, 3.20
No Contact tracing			
Contact tracing	1.16	0.45	-1.86, 4.18
Equipment availability			
1st quarter	Ref		
2nd quarter	1.5	**0.01**	0.33, 2.64
3rd quarter	2.19	**0.001**	1.27, 3.11
4th quarter	1.35	**0.001**	0.43, 2.27

NOTE: P-value ≤ 0.05, REF: Reference group

However, urban clinic, 2nd level hospital, 3rd level hospital, location, defaulter tracing and contact tracing were not significantly associated with low TB case notification at simple linear regression.

At univariate analysis, personnel, floor space, facility beds, population, rural clinic and having no TB clinic were associated with low treatment success while the other independent variables were not statistically significant as shown in table 4 below.

Table 4: Unadjusted estimates of logged treatment success

Factors	Coefficient	P-value	95% Confidence interval
Personnel	1.08	**0.001**	0.90, 1.26
Floor space	0.68	**0.001**	0.47, 0.10
Facility beds	0.81	**0.001**	0.66, 1.06
Population	0.87	**0.001**	0.67, 1.07
1st Level hospital	Ref	Ref	Ref
Urban clinic	0.22	0.53	(-0.46, 0.89)
Rural clinic	(-3.43)	**0.001**	(-4.07, -2.80)
2nd level hospital	(-0.26)	0.73	(-1.70, 1.20)
Military hospital	(-2.45)	0.71	(-1.56, 1.07)
3rd level hospital	(-0.14)	0.86	(-1.51, 1.80)
Mission hospital	(-0.47)	0.74	(-3.25, 2.31)
Location			
Rural	Ref	Ref	Ref
Urban	(-0.20)	0.65	(-1.05, 0.65)
TB Clinic			
Yes	Ref	Ref	Ref
No	-2.14	**0.001**	(-2.95, -1.32)
Contact Tracing			
Yes	Ref	Ref	Ref
No	(-1.24)	0.10	(-2.71, 0.23)
Defaulter			
Yes	Ref	Ref	Ref
No	(-0.45)	0.51	(-1.81, 0.91)
Equipment available			
Quarter 1	Ref	Ref	Ref
Quarter 2	1.28	**0.04**	0.41, 2.51
quarter 3	1.80	**0.001**	0.78, 2.83
quarter 4	1.02	**0.05**	0.24, 2.01

NOTE: P-Value value ≤ 0.05, REF: Reference group

However, when a simple linear regression analysis of equipment using principal component analysis was done, the results showed that health facilities that were in the 3rd quarter, equipment increased TB case notification the most in the quarter by 1.8 percent, this was followed by health facilities in the 2nd quarter (1.28 percent) and lastly health facilities in the 4th quarter (1.02 percent).

Similarly, the adjusted results for TB case notification showed that personnel had a high association with low TB case notification. The results also show that rural health clinics and 3rd level hospitals had less TB case notifications as compared to the other types of health facilities (Urban, mission, military, 1st level and 2nd level hospitals).Other variables (facility beds, equipment, floor space and population) were also not associated with low TB case notification. Having no TB clinic compared to having a TB clinic was associated with low TB case notification as shown in table 5.

Table 5: Adjusted estimates of logged TB case notification

Variables	Coefficient	P-value	95% Confidence interval
Personnel	0.45	**0.01**	0.12, 0.69
Floor space	(-0.18)	0.23	(-0.48, 0.12)
Facility beds	0.18	0.23	(0.12, 0.48)
Population	0.19	0.09	(-0.03,0.41)
1st Level hospital	Ref	Ref	Ref
Urban clinic	(-0.03	0.94	(-0.84, 0.77)
Rural clinic	(-1.88)	**0.001**	(-2.91, -0.84)
2nd level hospital	0.68	0.49	(-1.25, 2.60)
Military hospital	(-1.04)	0.12	(-2.34, 0.26)
3rd level hospital	(-2.55)	**0.05**	(-5.12,0.15)
Mission hospital	0.67	0.59	(-1.77, 3.11)
TB Clinic	Ref	Ref	Ref
No TB clinic	(-0.91	**0.01**	(-1.57, -2.48)
Equipment available			
Quarter 1	Ref	Ref	Ref
Quarter 2	0.49	0.24	(-0.33, 1.31)
quarter 3	0.5	0.14	(-0.17, 1.17)
quarter 4	0.16	0.61	(-0.05, 0.79)

NOTE: P-Value value $\leq$ *0.05, REF: Reference group*

Hence the results showed that for every 1 percent increase in personnel, case notification increased by 0.45 percent (p-value 0.00, CI= 0.12, 0.69) holding all other variables constant. In addition, TB case notification in rural health facilities was 188 percent less (P-value= 0.001, CI=2.91.-0.84) compared to 1st level hospital holding all other variables constant. Furthermore, TB case notification in 3rd level hospitals was 255 percent less (P-value 0.05), (CI= -5.12, 0.15) compared to 1st level hospitals holding all other variables constant. Similarly, for every one unit increase in no TB clinics, TB case notification decreases by 60 percent (P-value 0.01), (CI=(-1.57, -2.48). Although not statistically significant at 5percent, population was statistically significant at 10 percent with every 1percent increase in population seeing an increase of TB case notification by 1.8percent (p-value 0.09, CI =-0.03, 0.41) holding other variables constant. Similarly for the adjusted treatment success associations, the results show that personnel, population, rural health facility, having no TB clinic are associated with low TB treatment success as they are statistically significant at 0.05 while other variables were not significant.

Table 6: Adjusted estimates of logged TB treatment success

Factors	Coefficient	P-value	95% Confidence interval
Personnel	0.34	**0.02**	0.06, 0.63
Floor space	(-0.19)	0.19	(-0.49, 0.10)
Facility beds	0.05)	0.74	(-0.25, 0.35)
Population	0.35	**0.001**	0.13, 0.58
Facility type			
1st level hospital	Ref	Ref	Ref
Urban clinic	(-0.14)	0.73	(-0.92, 0.65)
Rural clinic	(-2.07)	**0.001**	(-3.07, -1.05)
2nd level hospital	1.36	0.16	(-0.53, 0.74)
Military hospital	(-0.67	0.34	(-2.13, 0.74)
3rd level hospital	(-2.22)	0.08	(-4.71, 0.284)
Mission hospital	0.67	0.57	(-1.70, 3.042)
TB clinic			
Yes	Ref	Ref	Ref
No	(-1.45)	**0.001**	(-2.10, -0.03)
Equipment availability			
Quarter 1	Ref	Ref	Ref
Quarter 2	0.073	0.90	(-0.73, 0.88)
Quarter 3	(-0.37)	0.29	(-1.08, 0.33)
Quarter 4	(-0.17)	0.70	(-0.79, 0.46)

NOTE: P-Value value ≤ 0.05, REF: Reference group

Hence the results show that for every 1percent increase in personnel, treatment success increased by 0.34 percent (p-value 0.02, CI=0.06, 0.63) holding all other variables constant.

In the same vein, for every 1percent increase in population, treatment success increased by 0.35percent (P-value 0.00, CI=0.13, 0.58) holding all other variables constant. Furthermore, TB treatment success was 207 percent less in rural health facility,(P-value-0.001), CI= (-3.07, -1.05) compared to 1st level hospitals holding all variables constant.. (CI=-4.71, 0.284) compared to 1st level hospitals holding all variables constant. While for every one unit increase in no TB clinics, treatment success decreased by 77 percent (P-value=0.001), CI= (-2.10, -0.03) holding all other variables constant.

When compared by year, the personnel variable was associated with low TB case notification and treatment success in both 2017 and 2018 as shown in table **7 below.**

Table 7: **TB case notification and treatment success by year**

Dependent variable	Year	Independent variables	Coefficient	P-value	95% Confidence interval
Case notification	2017	Personnel	1.88	0.001	1.01, 2.15
	2018	Personnel	2.17	0.001	1.08,3.27
Treatment success	2017	Personnel	1.27	0.02	0.19, 2.35
	2018	Personnel	2.12	0.001	1.05, 3.18

NOTE: P-Value value ≤ 0.05

For instance, in 2017, for every 1percent increase in personnel, TB case notification and treatment success increased by 2percent and 1.3percent respectively while in 2018, for every 1percent increase in personnel, TB case notification and treatment success both increased by 2percent (p-values=0.001, CI= 1.08,3.27 1.05, 3.18) respectively.

Quantile Regression

Lastly, a quantile regression was run with the continuous variables in order to determine variations of associations between the dependent variables and the independent variables. The results showed that for health facilities at the 25th percentile of notification rate or treatment success, a 1 percent increase in personnel increases case notification and treatment success by 3 percent each at p-values =0.00 at CI=2.08, 4.76 and 2.15, 4.32 respectively. While for health facilities at the 25th percentile of notification rate, a 1 percent increase in population increases treatment success by 1 percent (p-value =0.004, CI=0.04, 2.01). This is shown in table **8 below.**

NOTE: P-Value value ≤ 0.05

Table 8: Quantile regression TB case notification

Dependent variable	Percentile	Independent variables	Coefficient	P-value	95% Confidence interval
Case notification	25	Personnel	3.42	**0.001**	2.08, 4.76
	50	Personnel	1.45	**0.001**	0.66, 2.24
	75	Personnel	0.89	**0.001**	0.48, 1.29
	75	Population	0.39	**0.04**	0.02, 0.77
	95	Personnel	0.91	**0.001**	0.49, 1.33
	95	Population	0.52	**0.01**	0 .13, 0.91

This variation of association between personnel and the dependent variables gradually reduces at the 50th percentiles to about 1.5 percent (p-values 0.001, CI=0.66, 2.24) and 1.7 percent (p-value 0.001, CI=0.65, 2.83) for TB case notification and treatment success respectively. At the 75th percentile, personnel remains similar for both TB case notification and treatment success with both being at 0.90 and 0.96 percent (CI= 0.48, 1.29) and (0.59, 1.32) respectively. However, for health facilities at the 75th percentile, a 1 percent increase in population increases case notification rate by only 0.3 percent (p-value=0.01, CI=0.13, 0.91).

Furthermore, for health facilities at the 95thpercentile of notification rate or treatment success, a 1 percent increase in personnel increases TB case notification by 0.91 percent(p-value=0.001, CI-0.49,1.33) and treatment success by 0.85 percent (p-value=0.001, CI=0.60,1.10).While for health facilities at the 95th percentile of case notification or treatment success, a 1 percent increase in population increases TB case notification by 0.31 percent(p-value= 0.01, CI=0.13,0.91) and treatment success by 0.70 percent(p-value=0.001, CI=0.47,0.93). However, at the same percentile (95th), a 1 percent increase in floor space reduces treatment success by 0.33 percent (p-value=0.04, CI=(-0.65,0.01).

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Quantile regression table 9: Treatment Success

Dependent variable	Percentile	Independent variables	Coefficient	P-value	95% Confidence interval
Treatment Success	25	Personnel	3.25	**0.001**	2.15,4.32
	25	Population	1.02	**0.004**	0.04,2.01
	50	Personnel	1.74	**0.001**	0.65,2.83
	75	Personnel	0.96	**0.001**	0.59,1.32
	75	Facility beds	0.38	**0.09**	(-0.05,0.82)
	75	Population	0.53	**0.001**	0.19, 0.87
	95	Personnel	0.85	**0.001**	0.60,1.10
	95	Floor space	(-0.33)	**0.04**	(-0.65, -0.01)
	95	Population	0.7	**0.001**	0.47, 0.93

Lastly, for health facilities at the 95% percentile of case notification rate, a 1 percent increase in floor space (size of the facility) reduces TB case notification by 0.32% (P-value 0.01, CI= -0.54, -0.09).

CHAPTER FIVE

5.1 Discussion

The study showed that there was a decline in the number of TB cases notified and treated in TB diagnostic health facilities across the 18 study population districts. The study also found that districts outside Lusaka notified and treated TB cases less than those in Lusaka.

Low TB case notification in the multiple regressions was associated with personnel, rural clinic, 3rd level hospital and having no TB clinic. This could be attributed to poor electronic data management (HMIS) from the TB diagnostic health facilities as well as district and national TB program as a number of health facilities were excluded in the study due to incomplete HMIS TB quarterly and annual reports.

In addition, most districts in Zambia generally have few diagnostic TB health facilities/centres which could also attribute to the low TB case notification shown in the study. These results are similar to other studies conducted in other parts of the world. For instance, a study conducted in Ghana by Amenuvegbe et al (2016) found that weak record review systems, inadequate diagnostic centres, lack of trained persons and some level of stigma at the community level were associated with low TB case notification in both community and health facility settings. Another study by Karamagi et al (2018) similarly found that efforts to improve availability of x-ray for TB diagnosis contributed to almost half of the new cases identified.

In addition, low TB treatment success at multiple regressions was associated with personnel, population, rural clinic and no TB clinic. Similar to low case notification, lack of personnel, rural health clinics and TB clinics/diagnostic centres can contribute to low TB cases treated as this will entail that few cases are notified hence those not notified cannot be treated. Low treatment success could also be attributed to few TB diagnostic centres given the large populations. This is usually the case in rural health clinics where there are few personnel despite the large populations. Low treatment success could also be associated with age as shown in a study conducted by Dangisso et al 2015 that found that children were less likely to be notified and treated from TB due to poor diagnostic tools.

The research study found that defaulter tracing and contact tracing were not associated with low TB case notification and Treatment success. This could be attributed to the fact that there has been intensified contact tracing and defaulter tracing activities in most health facilities as evidenced by the number of facilities conducting contact tracing and defaulter tracing. However, more resources need to be provided for contact tracing and defaulter tracing as some health care workers may lack the necessary resources to effectively conduct community TB contact tracing and defaulter tracing due to the limited TB funding currently experienced in Zambia. The study findings are thus similar to a study conducted in Ethiopia by Yassin et al (2013) which found that contact tracing and defaulter tracing improved TB case notification and Treatment success. For instance, the study in Ethiopia found that from the 8,005 contacts visited 1,949 were symptomatic, 1,290 symptomatic were tested and 69 diagnosed with TB. 1,080 children received IPT. Treatment success for smear positive TB increased from 77% to 93% and treatment default decreased from 11% to 3%. Service users and providers hence found these community intervention packages highly acceptable.

When compared by year personnel was associated with both low TB case notification and treatment success. These findings are similar to Charles et al (2017) who found that active TB case finding by health care workers improves TB notification and treatment success. This therefore entails that there is need for more personnel such as lay community health workers such as TB peer counselors and treatment supporters to be enrolled in order to actively trace TB clients and their contacts in order to improve notification and treatment success rates.

Lastly, the study found that, health facilities that had equipment at the 3rd quarter had more TB cases notified and treated more compared to health facilities at the 1st quarters. This therefore entails that there is need to increase equipment availability to health facilities at the other quarters in order for these facilities at these quarters to improve TB notification and treatment success.

Similarly, for health facilities at the 25th percentile, there is need to increase personnel and population as this is where the variation of the effect size for the association is the most compared to the health facility variations at the50th, 75th and 95th percentiles. This means that health facilities at the 25th percentile are able to notify and treat more TB cases than other health facilities hence there is need to redistribute personnel, for instance from other health facilities to these sites as they are the most efficient in TB notification and treatment success.

5.2 Limitations

The study used secondary data from the Health Facility Listing survey which was collected for other purposes other than this study hence posed a challenge in terms of its reliability, quality as well as its validity. Additionally, the study relied on routine surveillance data from health facilities collected through the Health Management Information System, to measure progress towards TB control targets. Furthermore, routine surveillance data may have gaps due to recording and reporting bias thereby affecting the health facility sample size distribution. Another study limitation was that the study used a cross-sectional study hence the cause and effect could not be determined as it only had a snapshot of the information (no before and after information). Lastly, due to missing TB data in the various districts, the research had limited resources to physically collect and verify data particularly in the Copperbelt province which did not have the secondary data readily available despite the province being one of the highest TB burden provinces in Zambia.

5.3 Conclusion

Various health facility factors such as personnel, rural clinics and no TB clinics affect TB case notification and treatment success in Zambian districts particularly districts outside Lusaka province. This could mostly be attributed to weak health systems within TB programs and the health system in general which undermine TB outcomes. Despite efforts made to intensify community TB screening and tracing, the study found that there is no evidence to show that contact tracing and defaulter tracing are associated with TB case notification and treatment success in Zambia. Furthermore, in order to prevent TB transmission and the development of drug resistance, there is need for sufficient numbers of competent staff for health care, reliable health information systems including electronic record keeping, and standard operating procedures to guide surveillance, case-finding and timely treatment initiation and completion. There is also need for TB diagnostic clinics to be constructed particularly in rural health clinics.

The findings therefore suggest that there is need to use a systems thinking approach in order to identify and understand these health systems gaps rather than use a silos approach. The study further found that there is need to measure the efficiencies of these health facilities in order to understand the variations in associations observed at the different percentiles and quarters of the study results. This will provide guidance on how different resources can be redistributed across the various health facilities in order to produce the most efficient outcomes at the minimal costs.

5.4 Recommendations

The following are some recommendations that can assist in improving TB case notification and treatment success in health facilities of Zambia.

1. There is need to increase the number of health personnel in TB diagnostic health facilities in order to increase TB case notification and treatment success.
2. There is need to increase the number of equipment in TB diagnostic health facilities in order to increase TB case notification and treatment success.
3. There is need to construct more TB clinics/corners in health facilities particularly in rural clinics in order to increase TB case notification and treatment success.

4. There is need to intensify contact tracing and defaulter tracing as the study shows that these are in fact not associated with low TB case notification and treatment success and as such should be intensified and scaled up to crowded communities such as compounds and prisons.
5. There is need to measure the efficiencies of health facilities in TB notification and treatment success in order to understand the dimensions in order to redistribute resources so as to promote efficiencies of TB programs in Zambia. .
6. There is need to strengthen district level TB notification and treatment success as most districts in Zambia have low TB case notification and treatment success. This can be done by decentralization and scaling up of TB of diagnostic facilities to remote facilities in order to notify and treat more TB cases
7. Similar to the HIV test and treat policy were all patients in health facilities are tested and treated for HIV during hospital visits, a TB test and treat policy should be introduced in order to notify and treat TB cases in remote districts of Zambia were TB notification and treatment is low.
8. There is further need to conduct a qualitative study in order to understand why these factors in the study are associated with low TB case notification and treatment success.

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APPENDICES

APPENDIX (1): INFORMATION SHEET

THE UNIVERSITY OF ZAMBIA

SCHOOL OF PUBLIC HEALTH

Study Title: Factors associated with low Tuberculosis Case notification and Treatment Success in health facilities of Zambia.

Principal investigator: Tikulirekuti Banda C, School of Public Health, University of Zambia, Contact Details: +260 979195003, tikubandac@gmail.com.

Introduction: You are being requested to provide permission for use of the data base (Health Management Information System (HMIS) and Institute for Health Metrics and Evaluation ABCE health facility survey for Zambia.

Please take time to read the following information carefully. You can ask the Principal Investigator to explain any information that you do not clearly understand. You may ask as many questions as you need. Please feel free to discuss this with your team before you decide to allow the researcher access to the data base**.** The organization has been purposively selected as it is the custodian of the data base. But before authorizing access to the data base, I would like to explain to you the purpose, why the organization was picked, procedure, risks/discomforts, benefits, payment, protecting data confidentiality, and who you can call when you have questions.

Purpose of the research project

I am a Master of Public Health student at the University of Zambia, specializing in Health Policy and Management. I am carrying out a research to assess the factors associated with low Tuberculosis case notification and treatment success in health facilities of Zambia.

The study will use data bases from Ministry of Health as well as the Institute for Health Metrics and Evaluation ABCE health facility survey. From Ministry of Health, the study will require use of the HMIS data base which will help provide number of Tuberculosis cases recorded as well as the number of successfully treated Tuberculosis cases in Zambia between 2010 and 2015 in order to examine the trend in TB case notification and treatment success. While from the Institute for Health Metrics and Evaluation, the study will require to use the ABCE Health Facility Survey data base to help extract independent variables from the study which shall be matched with the health facility variables in the HMIS.

The objective of the study is to assess factors associated with low tuberculosis case notification and treatment success in health facilities of Zambia in order to provide information for policy makers and TB implementers in Zambia. The results of this study will be shared with the Ministry of Health and the Institute for Health Metrics and Evaluation. If you agree to avail information to the researcher, you will be required to sign the authorization form.

Risks/Discomforts

The researcher will use health facilities and these will be de-identified for the purpose of anonymity when analyzing and presenting data. This should not worry you as the research takes the confidentiality clause seriously.

Benefits

There will be no direct and immediate material and financial benefits to you as a research participant. Participating in this study allows understanding of the factors associated with low TB case Notification and Treatment Success among TB patients in Zambia. Understanding these factors will inform policy makers on areas in which to focus on in order to increase the TB notification rate thereby contributing to the early detection and treatment of TB cases in Zambia.

Payment

There is no enumeration of any kind from the study.

Protecting data confidentiality

All information collected in this study will be taken as highly confidential and used only for research purposes.

Who do I call if I have questions?

Call the Principal Investigator: Tikulirekuti Banda C.

Cell: +260 79195003 Email: tikubandac@gmail OR

The Chairperson, the **University of Zambia Biomedical Research Ethics Committee**, P.O Box, 50110, Lusaka. **Tel: +260-1-256067**

What does your signature/thumb print/mark on this consent form mean?

- You have been informed about the project's purpose, procedure and possible benefits and risks.
- You have been given the chance to ask questions before signing.
- You have voluntarily agreed to avail the data sets to the researcher for review and analysis

Appendix III: Letter to Ministry of Health

The University of Zambia
School of Public Health
P.O. BOX 50110
Lusaka.

The Permanent Secretary
Ministry of Health
Lusaka.
Date
Dear Ms/Mr………………………

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

I am a registered Masters of Public Health student in the School of Public Health specializing in Health Policy and Management at the University of Zambia.

The proposed topic of my research is: **Factors associated with Low Tuberculosis Case Notification and Treatment Success in health facilities of Zambia.**

The objectives of the study are:

- To examine factors associated with TB case notification and cure rates.
- To determine differences in the sizes of associations driving TB case notification and cure rates at various levels of case notification and cure rates (low and high performersk).
- To assess rural-urban gap in TB case notification and cure rates.

I am hereby seeking your consent to allow me to use the HMIS data set for data analysis. To assist you in reaching a decision, I have attached to this letter:

(a) A copy of an ethical clearance certificate issued by the University.

(b) A copy of the research instruments to be used in the research.

(c) The information sheet to be used in the study.

Should you require any further information, please do not hesitate to contact the principal investigator or the supervisor.

Upon completion of the study, I will provide you with a bound copy of the dissertation.

Your permission to conduct this study will be greatly appreciated.

Yours sincerely,

Tikulirekuti Banda C.

Contact details:

Principal investigator: Tikulirekuti Banda C.: Cell: +260979195003

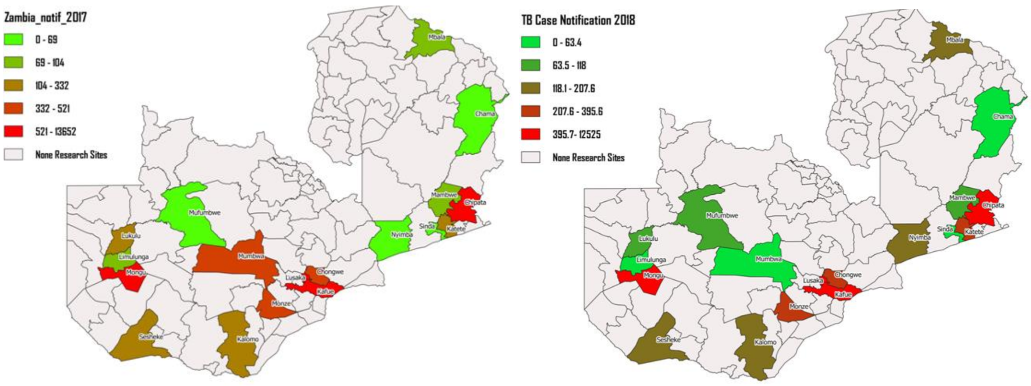
Email: tikubandac@gmail.com

Supervisor: Dr. Peter Hangoma: +260 95560556

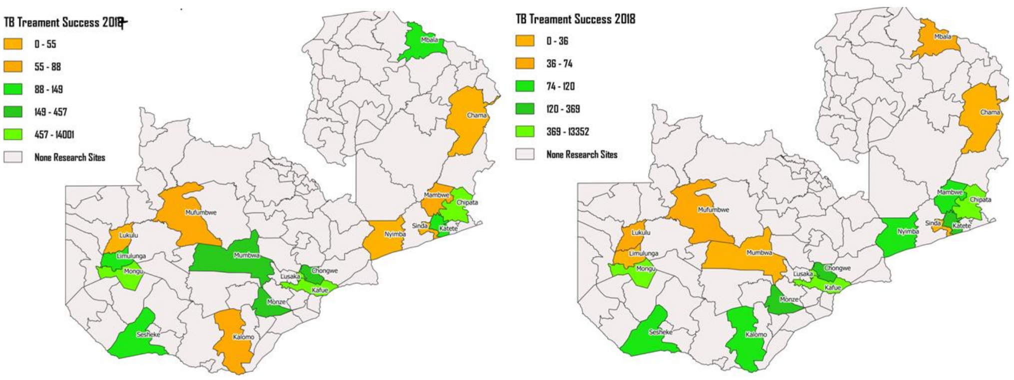
Email: peter.hangoma@unza.zm

APPENDIX V:

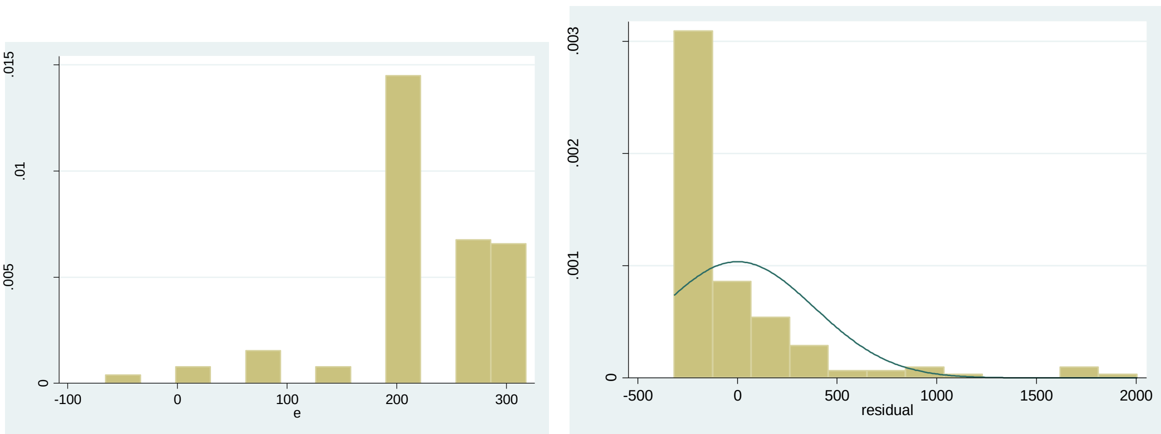
TB case notification and treatment success patterns across study districts



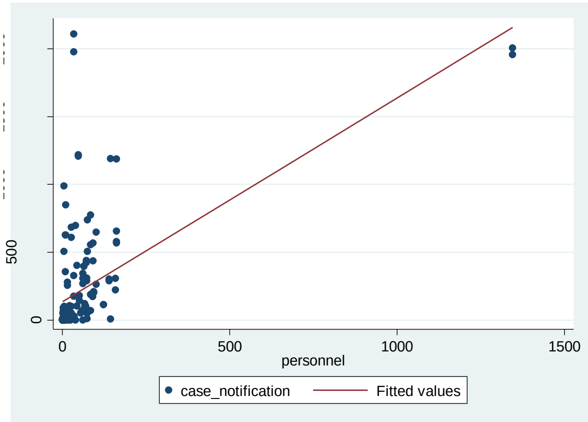
2017 and 2018 TB case notification by district

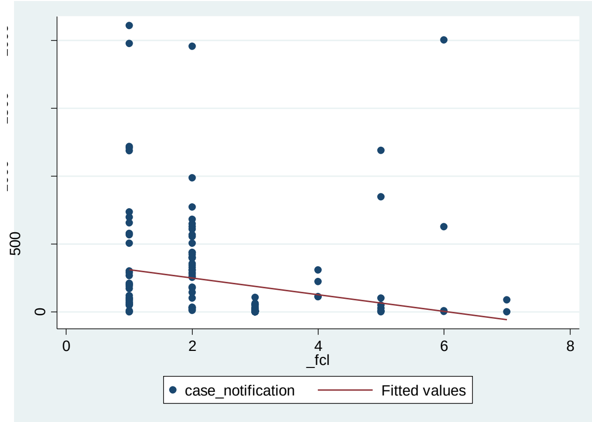


2017 and 2018 case notification by district



Normal distribution tests for dependent variables using histograms





Scatter plot results for case notification and facility beds

TB Case Notification Quantile Regression Results(.25)					
lcase_notifi~n	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
lpersonnel	(3.42)	(0.68)	5.04	0.00	2.08, 4.76
lfloorspace	(-0.48)	(0.87)	(-0.55)	0.58	(-2.21, 1.25)
lfacility_beds	(-0.23)	(0.81)	(-0.27)	0.77	(-1.81, 1.38)
lpopulation	(0.35)	(0.62)	0.56	0.58	(-0.88, 1.58)
_cons	(-8.98)	5.82	-1.54	0.13	(-20.50, 2.55

TB Case Notification Quantile Regression Results(.50)					
lcase_notifi~n	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
lpersonnel	1.45	0.40	3.61	0.00	0.66, 2.24
lfloorspace	(-0.02)	(0.52)	(-0.04)	0.97	(-1.04, 1.00)
lfacility_beds	(-0.02)	(0.48)	(-0.05)	0.96	(-0.97,0.92)
lpopulation	(0.24)	(0.37)	(0.66)	0.51	(-0.49, 0.97)
_cons	(-3.54)	(3.44)	(-1.03)	0.31	(-10.35, 3.27)

TB Case Notification Quantile Regression Results(.75)						
lcase_notifi~n	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lpersonnel	0.89	0.21	4.31	0.00	0.48	1.29
lfloorspace	-0.14	0.27	-0.55	0.59	-0.67	0.38
lfacility_beds	0.38	0.24	1.54	0.13	-0.12	0.86
lpopulation	0.39	0.19	2.08	0.04	0.02	0.77
_cons	-2.32	1.77	-1.31	0.19	-5.82	1.17

TB Case Notification Quantile Regression Results(.95)						
lcase_notifi~n	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lpersonnel	0.91	0.21	4.27	0.00	0.49	1.33
lfloorspace	-0.44	0.27	-1.61	0.11	-0.99	0.10
lfacility_beds	0.25	0.25	0.99	0.32	-0.25	0.75
lpopulation	0.52	0.20	2.65	0.01	0.13	0.91
_cons	-0.00	1.83	-0.00	0.10	-3.63	3.62

TB Treatment Success Quantile Regression Results(.25)						
ltreatment_s~s	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lpersonnel	3.25	0.54	6.02	0.00	2.18	4.32
lfloorspace	-0.02	0.70	-0.02	0.98	-1.40	1.36
lfacility_beds	-0.77	0.64	-1.20	0.23	-2.04	0.50
lpopulation	1.02	0.50	2.06	0.04	0.04	2.01
_cons	-18.26	4.65	-3.93	0.00	-27.45	-9.06

TB Treatment Success Quantile Regression Results(.50)						
ltreatment_s~s	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lpersonnel	1.74	0.55	3.17	0.00	0.65	2.83
lfloorspace	0.12	0.72	0.15	0.88	-1.29	1.51
lfacility_beds	-0.48	0.65	-0.74	0.46	-1.77	0.81
lpopulation	0.43	0.51	0.85	0.40	-0.57	1.43
_cons	-6.29	4.72	-1.33	0.19	-15.63	3.05

TB Treatment Success Quantile Regression Result (.75)						
ltreatment_s~s	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lpersonnel	0.96	0.19	5.15	0.00	0.59	1.32
lfloorspace	-0.17	0.24	-0.72	0.47	-0.64	0.30
lfacility_beds	0.38	0.22	1.73	0.09	-0.05	0.82
lpopulation	0.53	0.17	3.10	0.00	0.19	0.87
_cons	-4.03	1.60	-2.52	0.01	-7.20	-0.87

TB Treatment Success Quantile Regression Result(.95)						
ltreatment_s~s	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lpersonnel	0.85	0.13	6.78	0.00	0.60	1.10
lfloorspace	-0.33	0.16	-2.03	0.04	-0.65	-0.01
lfacility_beds	0.18	0.15	1.22	0.22	-0.11	0.48
lpopulation	0.70	0.12	6.05	0.00	0.47	0.93
_cons	-2.29	1.07	-2.12	0.03	-4.42	-0.15